PROJECT S.A.I.C

Hancis Bogdan

Group 2331

Cuprins :

1. Specificatii individuale :

Etaj 1						Etaj 2					Etaj 3						Etaj 4		AO
Sursa semnal	amplitudine minima (pt castig maxim PGA)	amplitudine maxima (pt castig minim PGA)	unitate masura	Tip Etaj 1	|Castig| etaj 1 (liniar)	tip Etaj 2	|H0| castig liniar in banda de trecere	Rintrare minim	Banda	Q	tip Etaj 3	castig minim [dB]	rezolutie (pas minim) [dB]	nr pasi	castig maxim [dB]	Rintrare minim	tip Etaj 4	|Castig| etaj 4 (liniar)	Tip AO
2	6.29E-03	2.51E-02	V (differe	4	10	8	depinde	2.00E+03	2.00E+03	1.41	6	6	3	5	18		10	2	12

Specificatii generale :

Etaj 1 - amplificator										
Sursa semnal nr.	nr	semnal Intrare	semnal iesire	tip	|Castig| (liniar) [V/V, I/V, V/I]	Rin_min [Ohms]	reglaj Out_DC	banda*	liniaritate	
2	4	tensiune	tensiune	Amplificator instrumentatie cu 2 AO neinversor	spec individual			> fin_max	fara distorsiuni la fin_max pt ampl_in*castig (SR, THD<1%)	

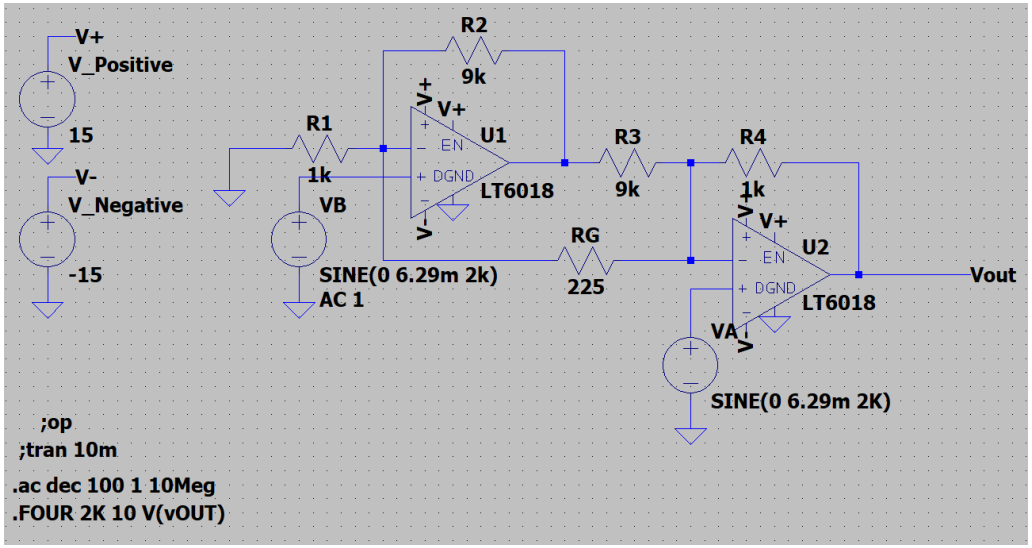
Etaj 2 - Filtru											
Etaj 1	nr	semnal Intrare	semnal iesire	tip functie de transfer	topologie	H0 castig in banda de trecere [V/V sau I/V]	Rin_min	BW	f0 frecventa centrala filtru trece-banda	Q	liniaritate
1,2,3,4,5,6,7,10	8	tensiune	tensiune	trece-banda BPF	Rauch	depinde de Q	2.00E+03	spec individual	BW*Q	spec individual	amplitudinea de la iesire = (amplitudinea de la intrare)X(castigul in banda de trecere) pentru un semnal armonic cu frecventa = frecventa centrala BPF

Etaj 3 - PGA								
Nr	tip	castig minim [dB]	rezolutie (pas minim) [dB]	numar pasi	castig maxim [dB]	Rin_min [Ohms]	banda	liniaritate
6	neinversor, comutatoare in afara caii de semnal	spec individual	spec individual	spec individual	spec individual		> Fin_max	fara distorsiuni la fin_max pt ampl_in_min*castig_max_PGA si ampli_in_max*castig_min_PGA (THD<1%)

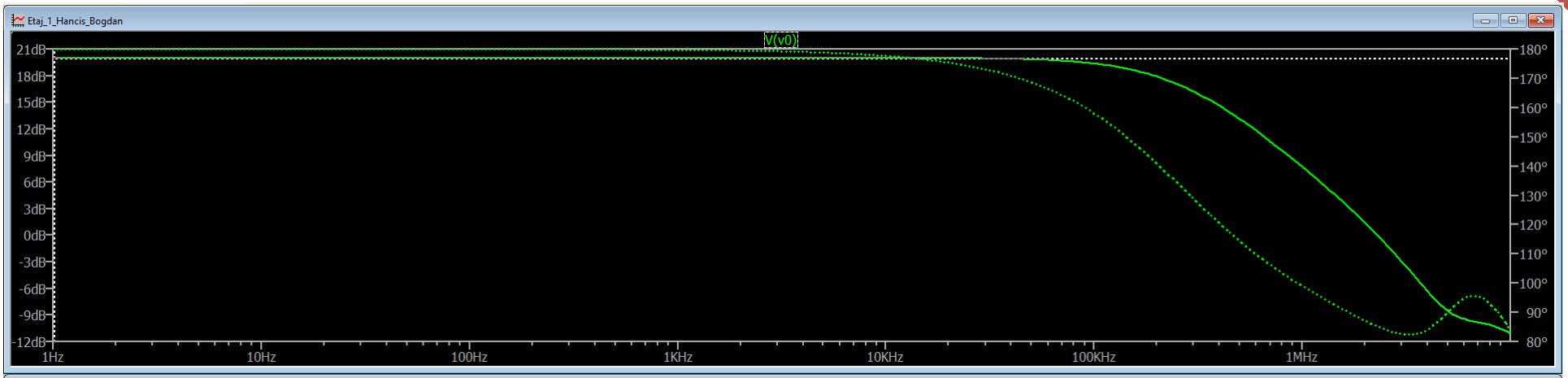
Etaj 4 - Redresor/Convertor AC-DC/Detector de varf		
tip	castig [V/V]	semnal mare - circuitul are functia dorita pe domeniul=
Redresor dubla alternanta FWR v10	spec individual	vin_max*castig

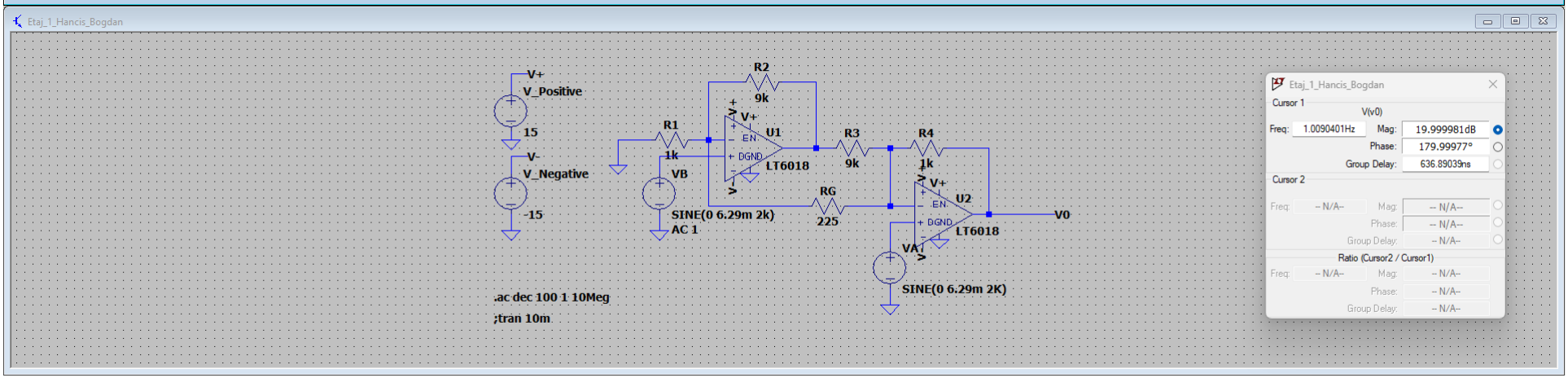
Tip Amplificator Operational AO	
LT6018	+/-15V

2. Etaj 1 - Amplifier

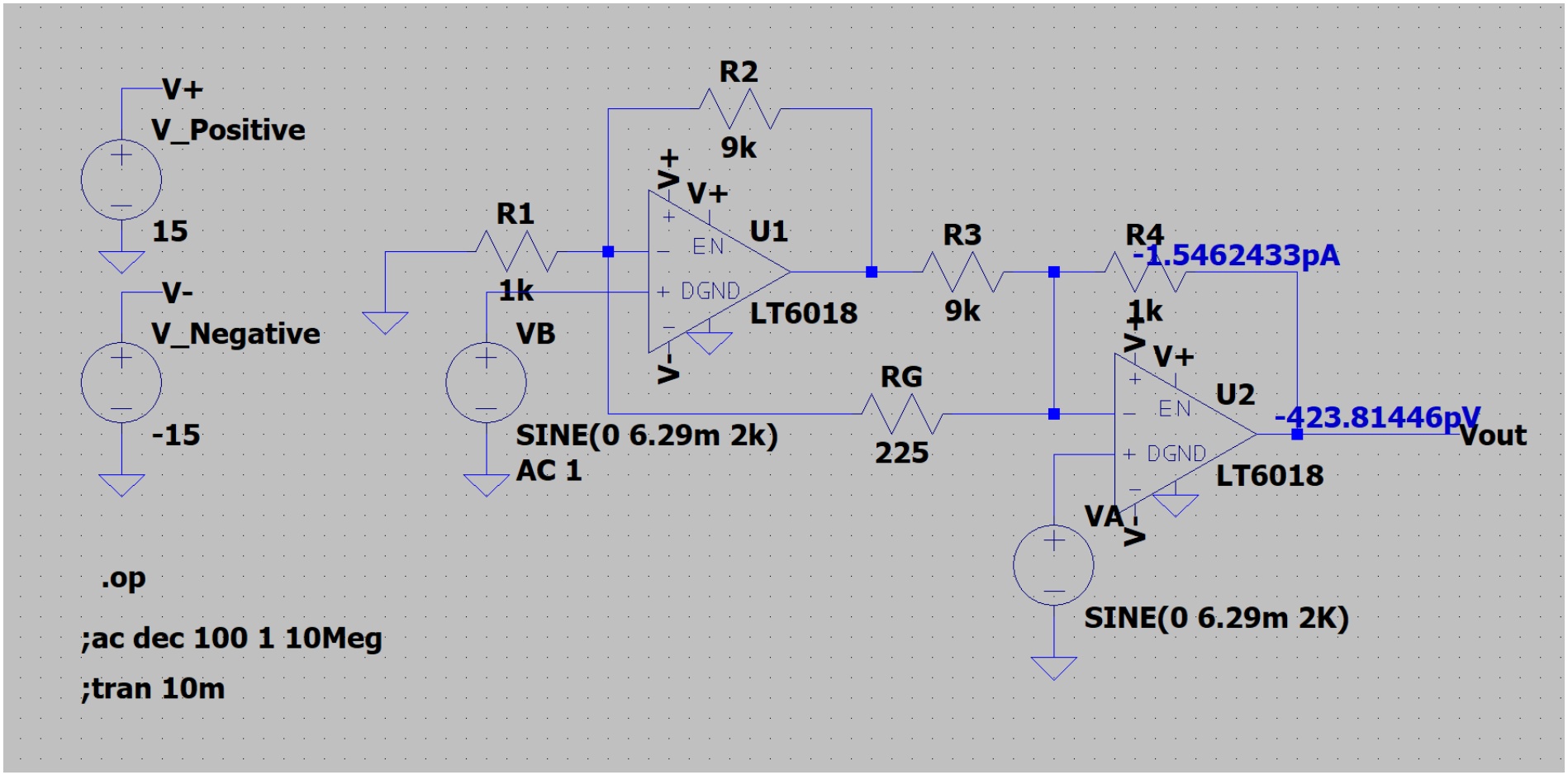


Original circuit :

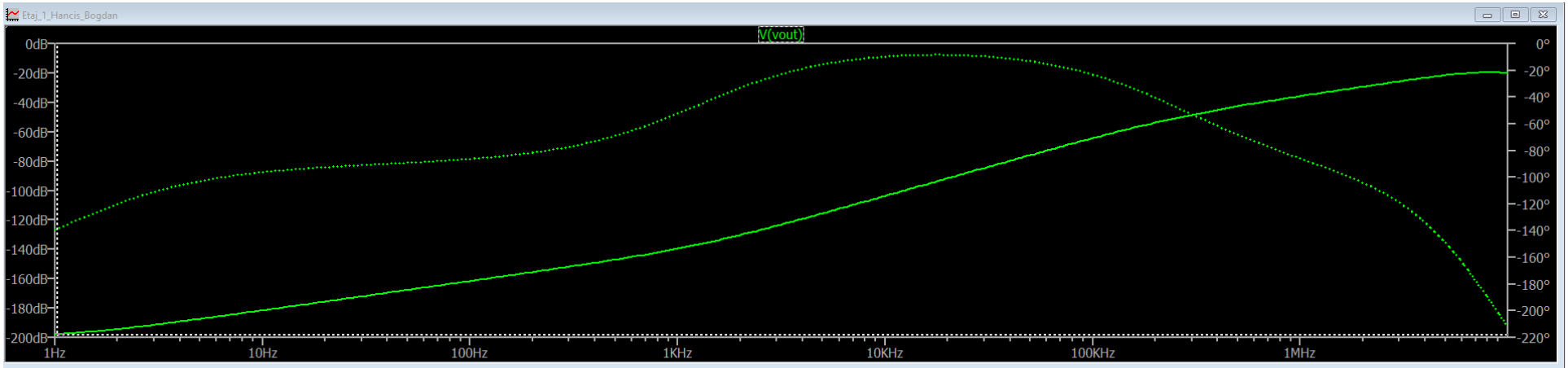


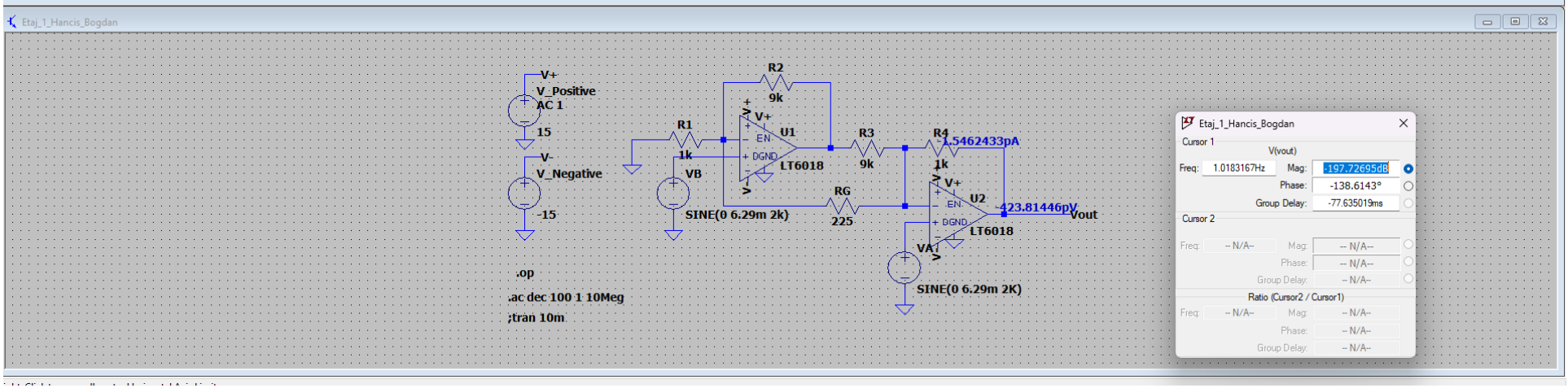


->compensarea

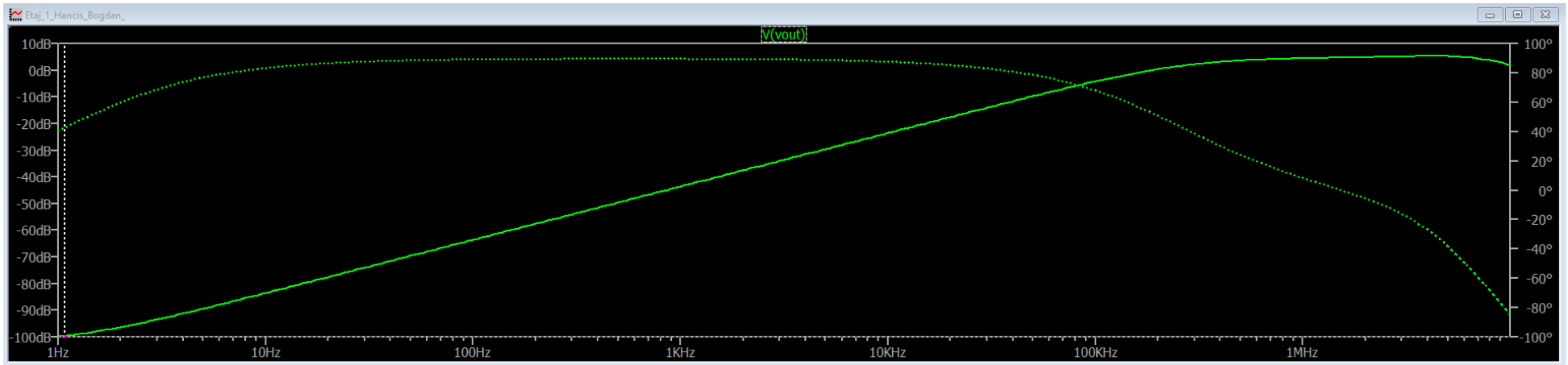


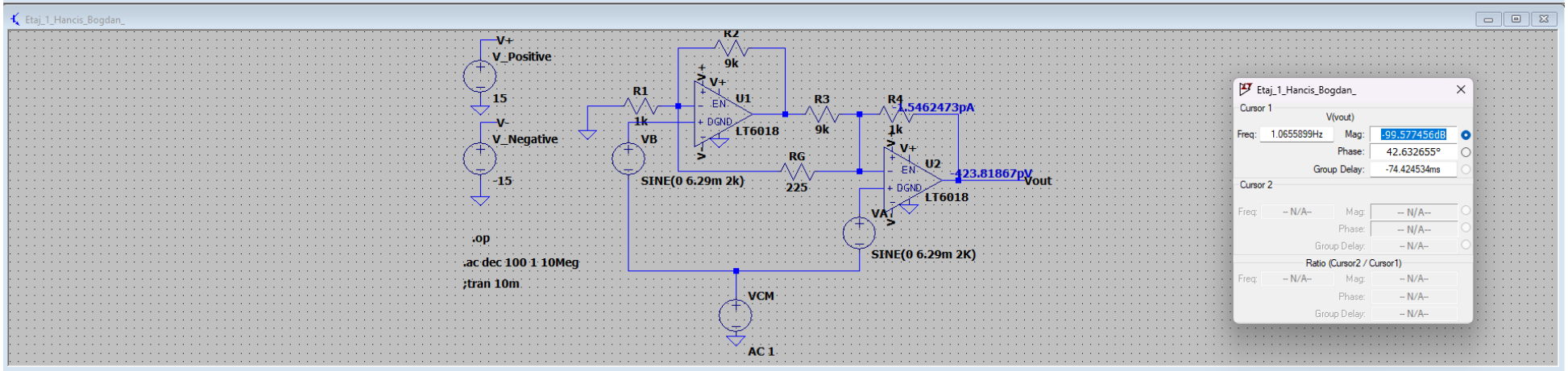
→PSRR=20dB-aps



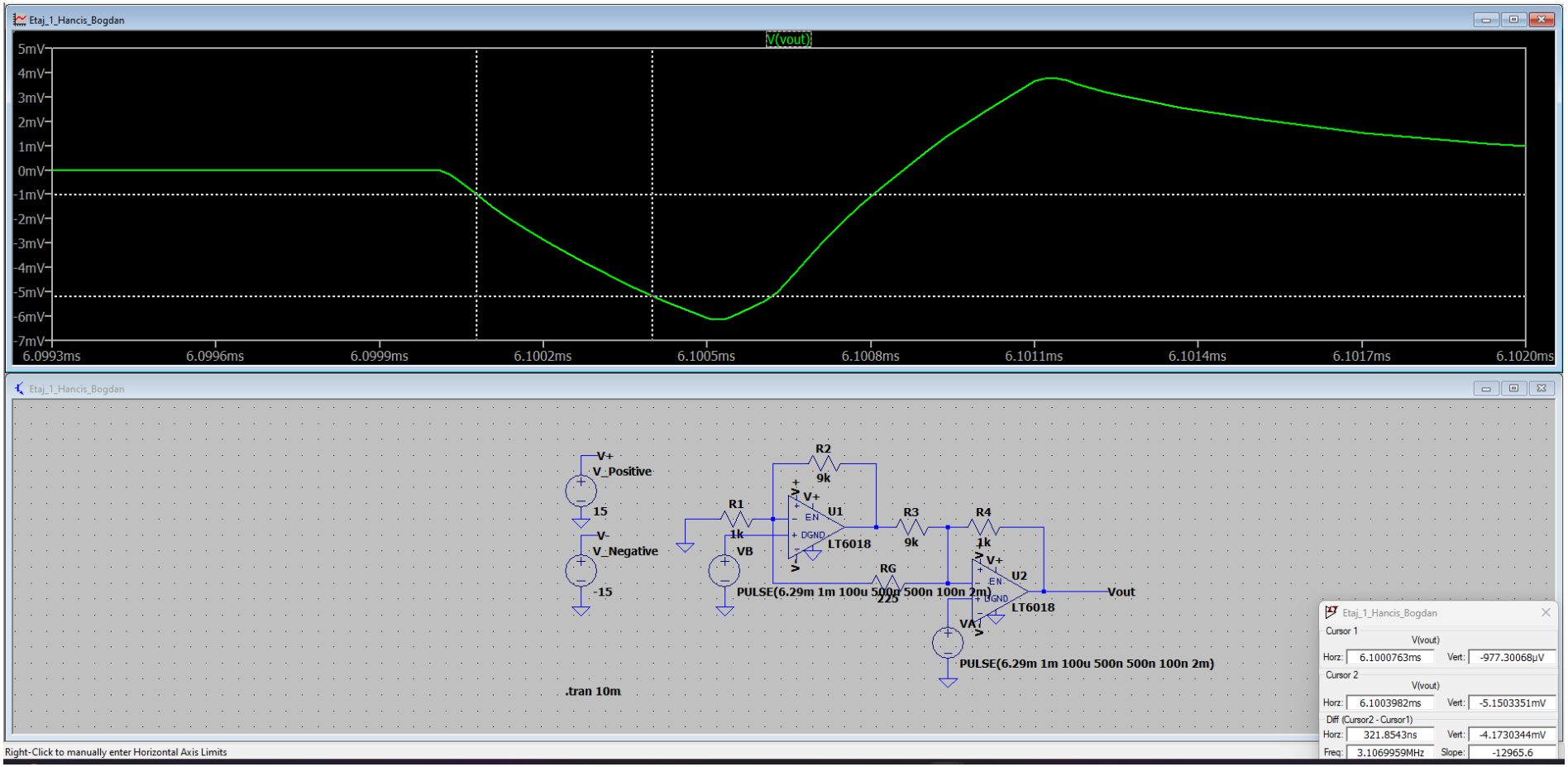


→CMRR


Etaj_1_Hancis_Bogdan_
V(vout)
10dB
0dB
-10dB
-20dB
-30dB
-40dB
-50dB
-60dB
-70dB
-80dB
-90dB
-100dB
100°
80°
60°
40°
20°
0°
-20°
-40°
-60°
-80°
-100°
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz

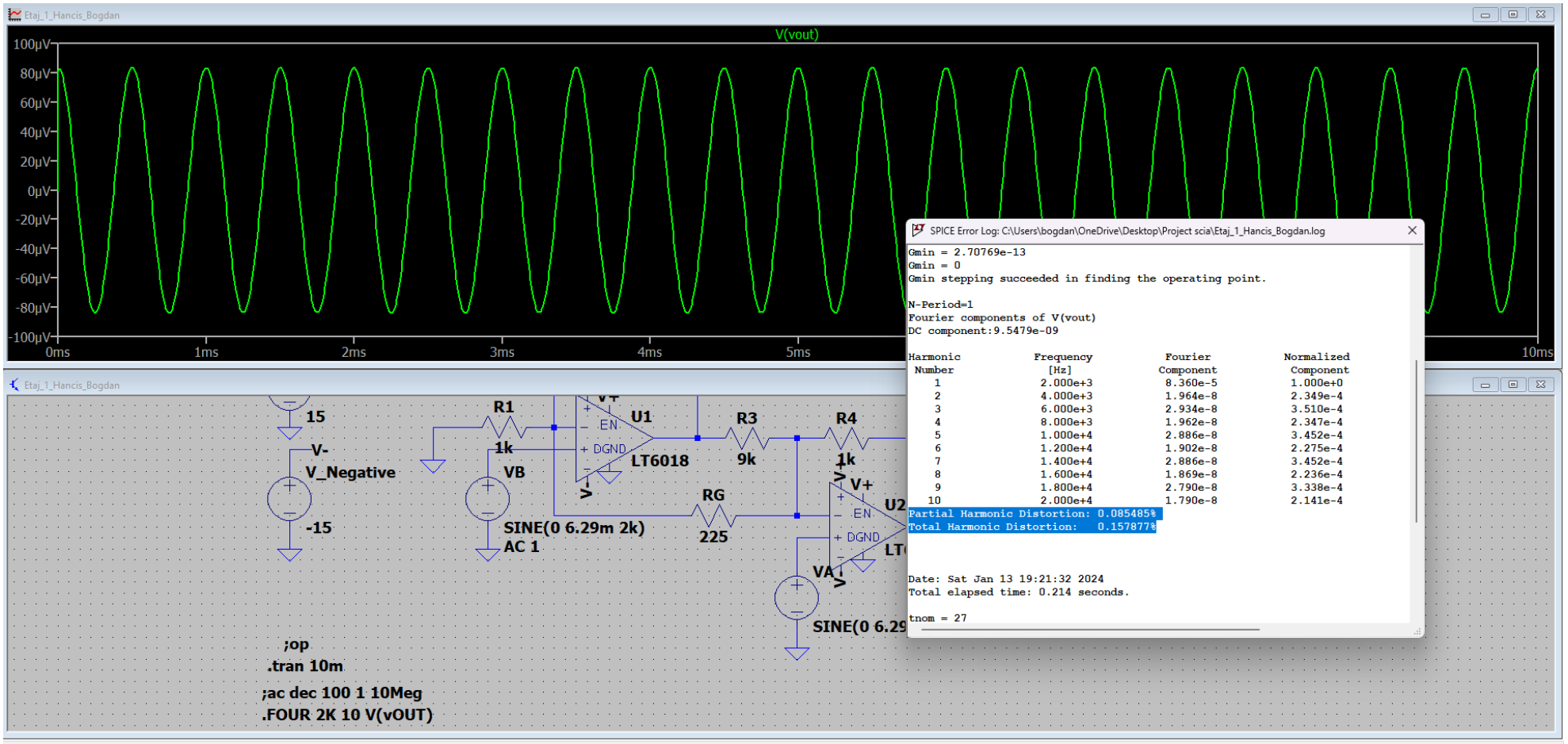

Etaj_1_Hancis_Bogdan_
V+
V_Positive
15
V-
V_Negative
-15
.op
.ac dec 100 1 10Meg
;tran 10m
R1
1k
VB
SINE(0 6.29m 2k)
R2
9k
U1
LT6018
R3
9k
R4
1k
1.5462473pA
RG
225
U2
LT6018
423.81867pV
Vout
VA
SINE(0 6.29m 2K)
VCM
AC 1
Etaj_1_Hancis_Bogdan_
Cursor 1
V(vout)
Freq: 1.0655899Hz
Mag: -99.577456dB
Phase: 42.632655°
Group Delay: -74.424534ms
Cursor 2
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Ratio (Cursor2 / Cursor1)
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--

→Slew-Rate



For this circuit from “Etaj 1” we need to add a Voltage Source as Pulse , with specific parameters .

➔ **THD < 1%**


Etaj_1_Hancis_Bogdan
V(vout)
100µV
80µV
60µV
40µV
20µV
0µV
-20µV
-40µV
-60µV
-80µV
-100µV
0ms
1ms
2ms
3ms
4ms
5ms
10ms
SPICE Error Log: C:\Users\bogdan\OneDrive\Desktop\Project scia\Etaj_1_Hancis_Bogdan.log
Gmin = 2.70769e-13
Gmin = 0
Gmin stepping succeeded in finding the operating point.
N-Period=1
Fourier components of V(vout)
DC component:9.5479e-09
Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component
1 | 2.000e+3 | 8.360e-5 | 1.000e+0
2 | 4.000e+3 | 1.964e-8 | 2.349e-4
3 | 6.000e+3 | 2.934e-8 | 3.510e-4
4 | 8.000e+3 | 1.962e-8 | 2.347e-4
5 | 1.000e+4 | 2.886e-8 | 3.452e-4
6 | 1.200e+4 | 1.902e-8 | 2.275e-4
7 | 1.400e+4 | 2.886e-8 | 3.452e-4
8 | 1.600e+4 | 1.869e-8 | 2.236e-4
9 | 1.800e+4 | 2.790e-8 | 3.338e-4
10 | 2.000e+4 | 1.790e-8 | 2.141e-4
Partial Harmonic Distortion: 0.085485%
Total Harmonic Distortion: 0.157877%
Date: Sat Jan 13 19:21:32 2024
Total elapsed time: 0.214 seconds.
tnom = 27
Etaj_1_Hancis_Bogdan
15
V-
V_Negative
-15
R1
1k
VB
SINE(0 6.29m 2k)
AC 1
U1
EN
DGND
LT6018
V-
V+
R3
9k
RG
225
R4
1k
U2
VA
SINE(0 6.29
;op
.tran 10m
;ac dec 100 1 10Meg
.FOUR 2K 10 V(vOUT)

3. Etaj 2 - Filter

→**Parameters** :

C= C1=C2= 1nF

Q=1.41

BW= 2kHz

F0= BW *Q = > F0 = 2,82 kHz

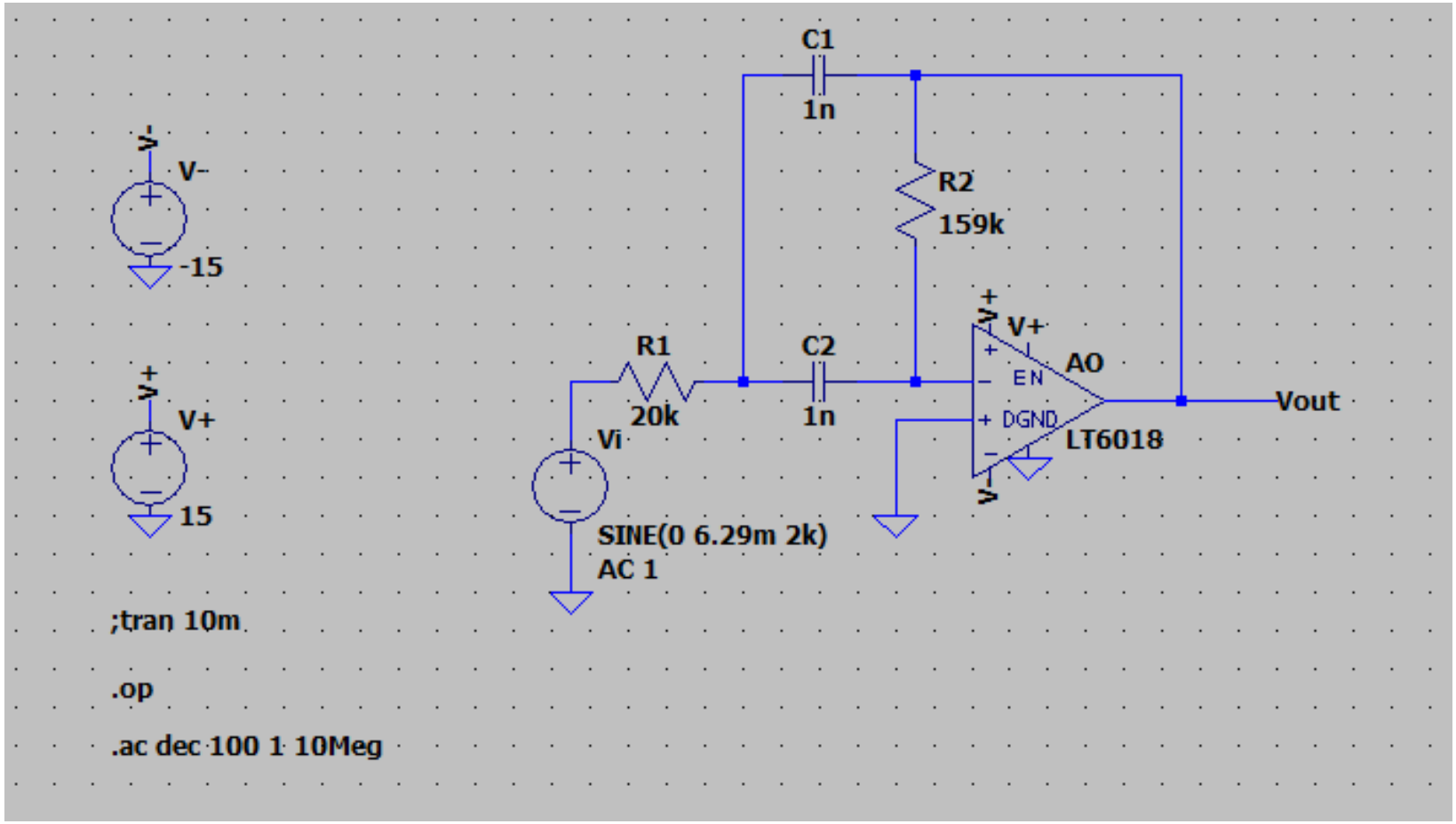
ω_0= 2 * π * F0 => ω_0 = 17709,6 rad/s

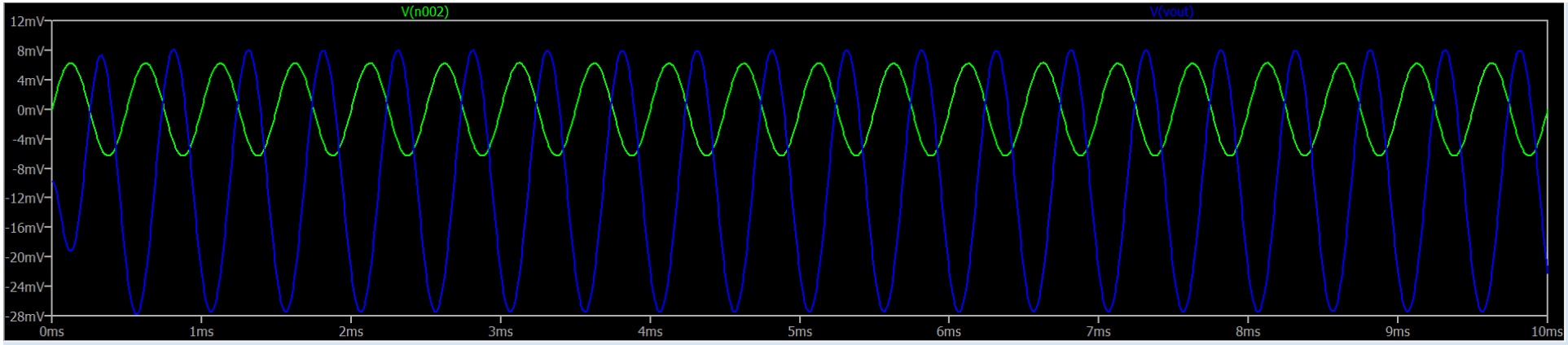
$H_0 < 2 * Q^2$ => H_0 < -3,97

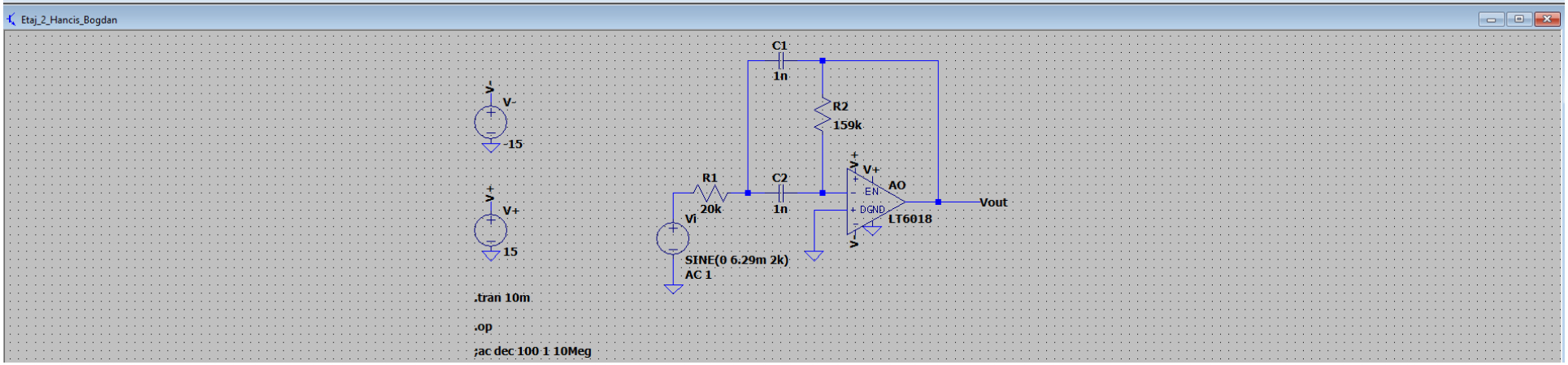
$R1 = \frac{1}{2*\omega_0*Q*C}$ => R1 = 20k

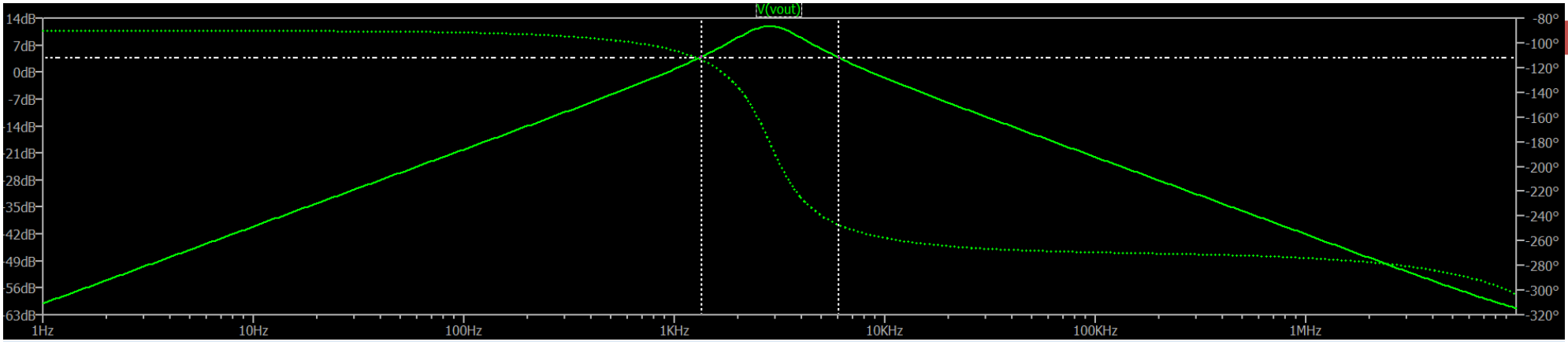
$R2 = \frac{2*Q}{\omega_0*C}$ => R2 = 159k

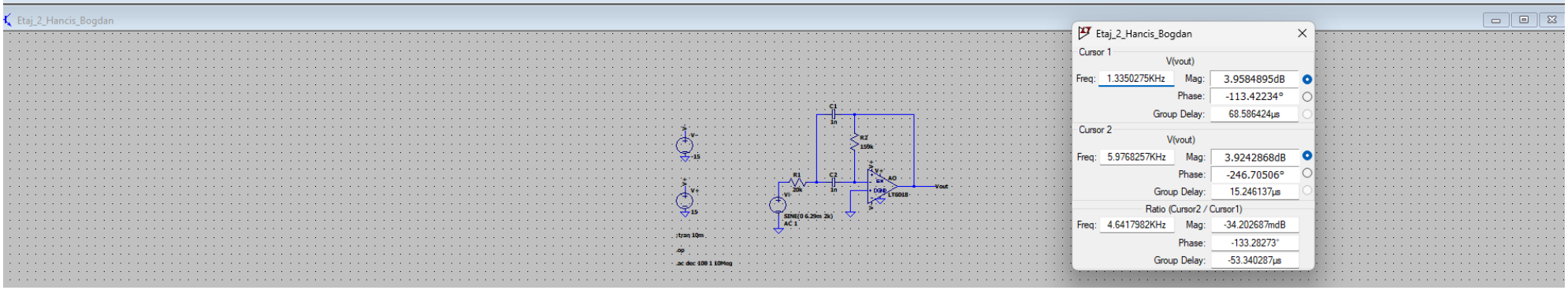
→ Original circuit




V(n002)
V(vout)
12mV
8mV
4mV
0mV
-4mV
-8mV
-12mV
-16mV
-20mV
-24mV
-28mV
0ms
1ms
2ms
3ms
4ms
5ms
6ms
7ms
8ms
9ms
10ms

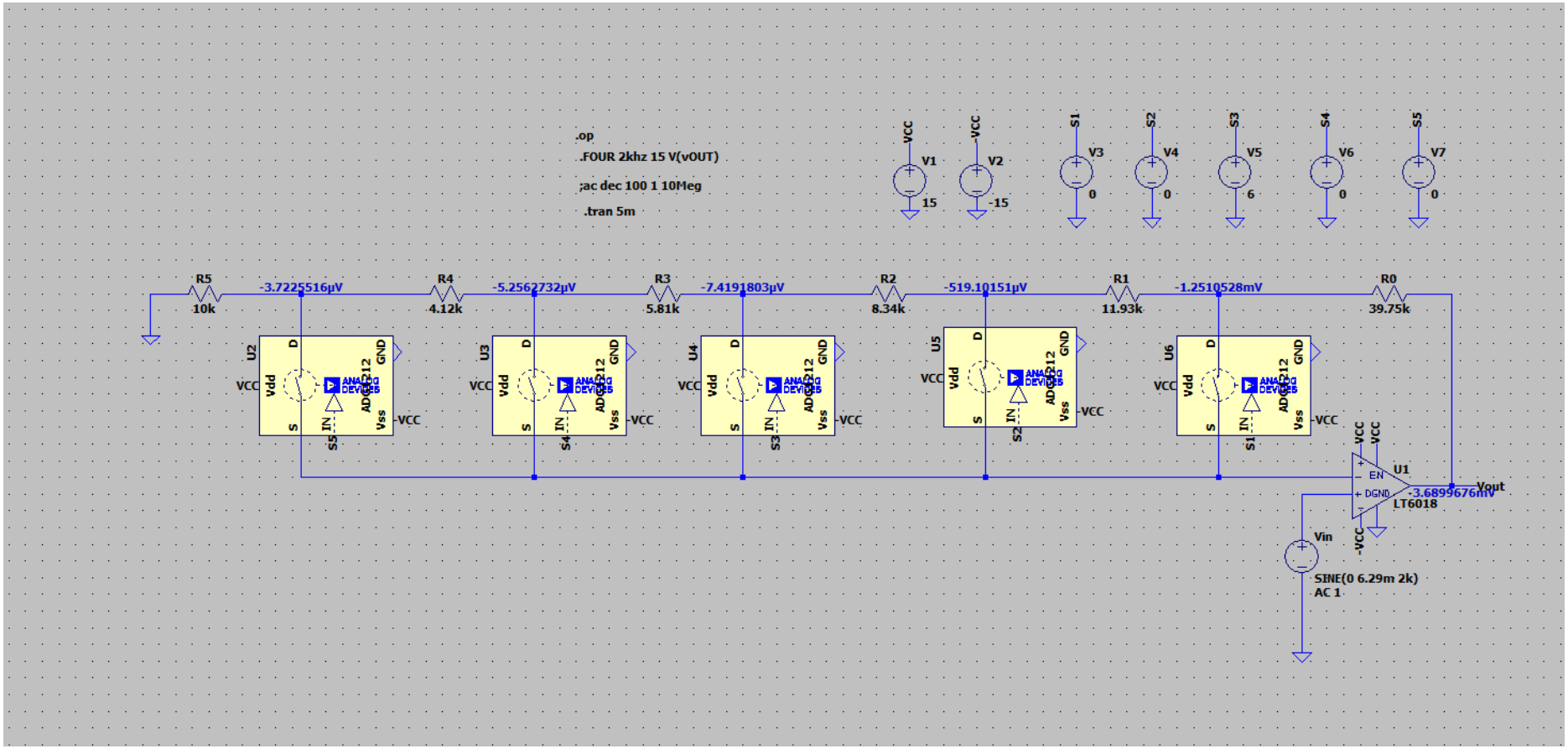

Etaj_2_Hancis_Bogdan
C1
1n
R2
159k
V-
-15
V+
15
R1
20k
C2
1n
Vi
SINE(0 6.29m 2k)
AC 1
AO
EN
DGND
LT6018
Vout
.tran 10m
.op
;ac dec 100 1 10Meg


V(vout)
14dB
7dB
0dB
-7dB
-14dB
-21dB
-28dB
-35dB
-42dB
-49dB
-56dB
-63dB
-80°
-100°
-120°
-140°
-160°
-180°
-200°
-220°
-240°
-260°
-280°
-300°
-320°
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz

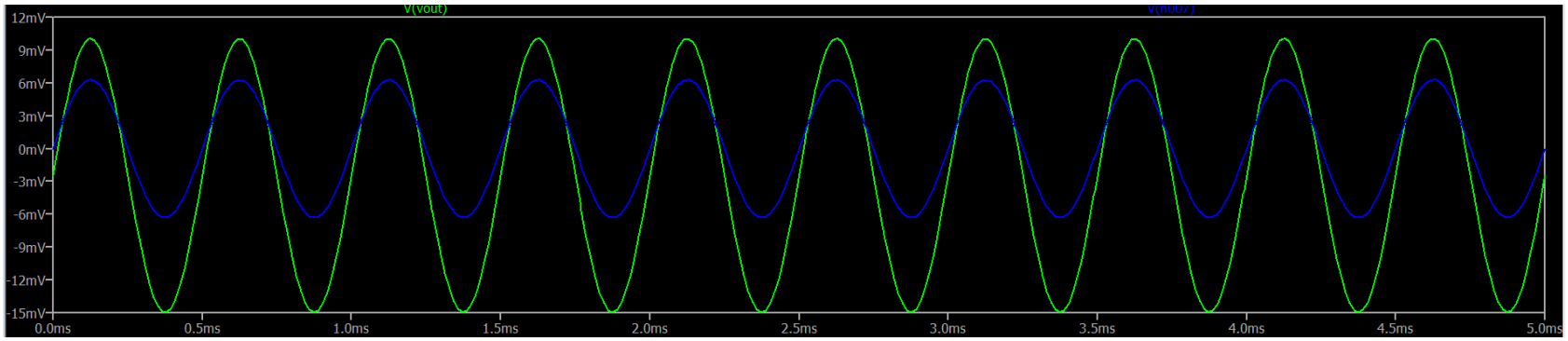

Etaj_2_Hancis_Bogdan
C1
1n
R2
159k
R1
20k
C2
1n
Vout
AO
LT6018
-15
15
SINE(0 6.25m 2k)
AC 1
.tran 10m
.op
.ac dec 100 1 10Meg
Etaj_2_Hancis_Bogdan
Cursor 1
V(vout)
Freq: 1.3350275KHz
Mag: 3.9584895dB
Phase: -113.42234°
Group Delay: 68.586424µs
Cursor 2
V(vout)
Freq: 5.9768257KHz
Mag: 3.9242868dB
Phase: -246.70506°
Group Delay: 15.246137µs
Ratio (Cursor2 / Cursor1)
Freq: 4.6417982KHz
Mag: -34.202687mdB
Phase: -133.28273°
Group Delay: -53.340287µs

3.Etaj 3 - PGA

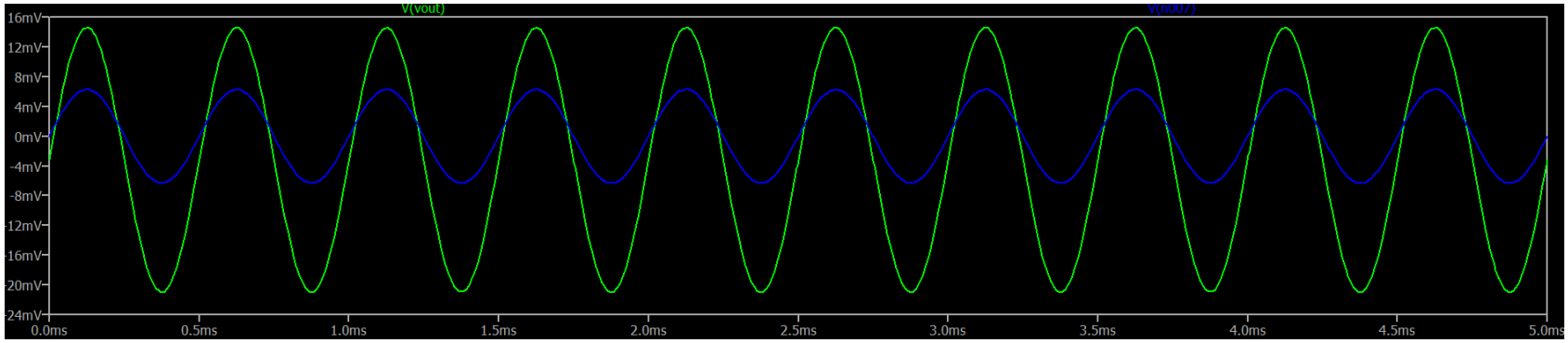
We have different cases :



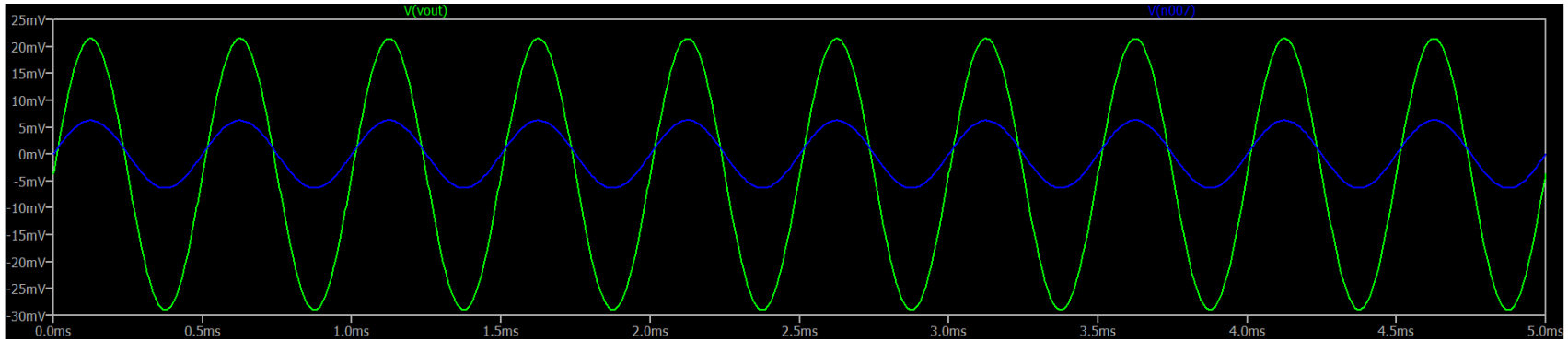
First switch open :



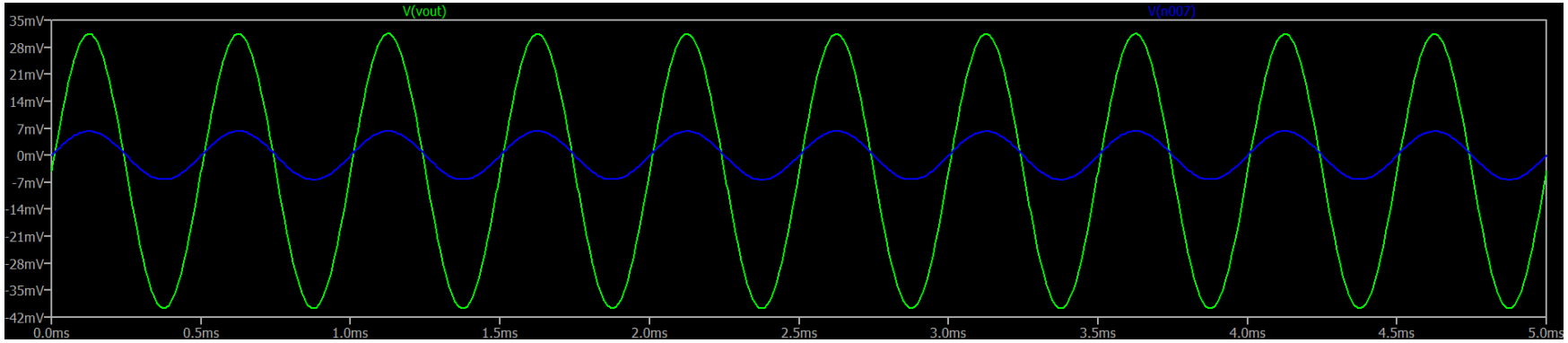
Second switch :



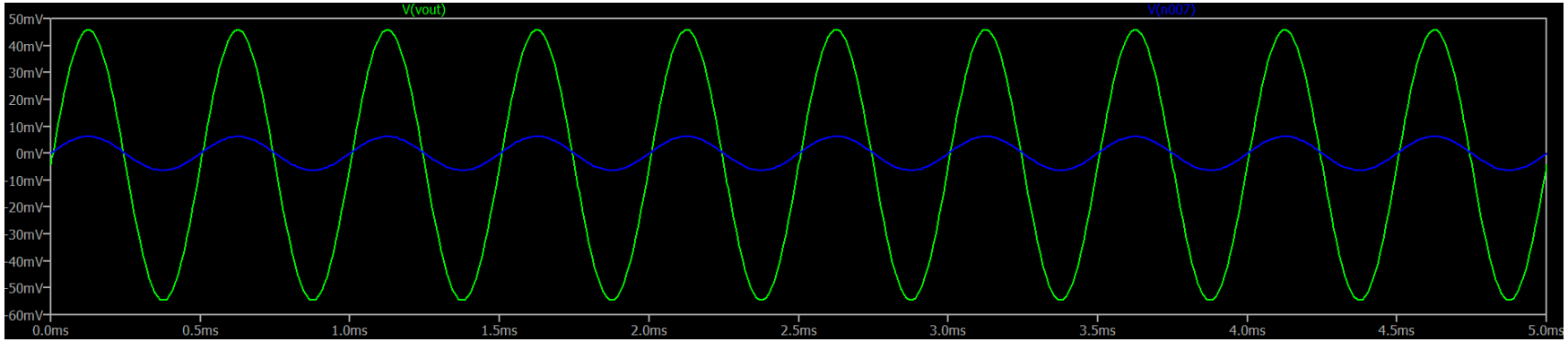
Third Switch :

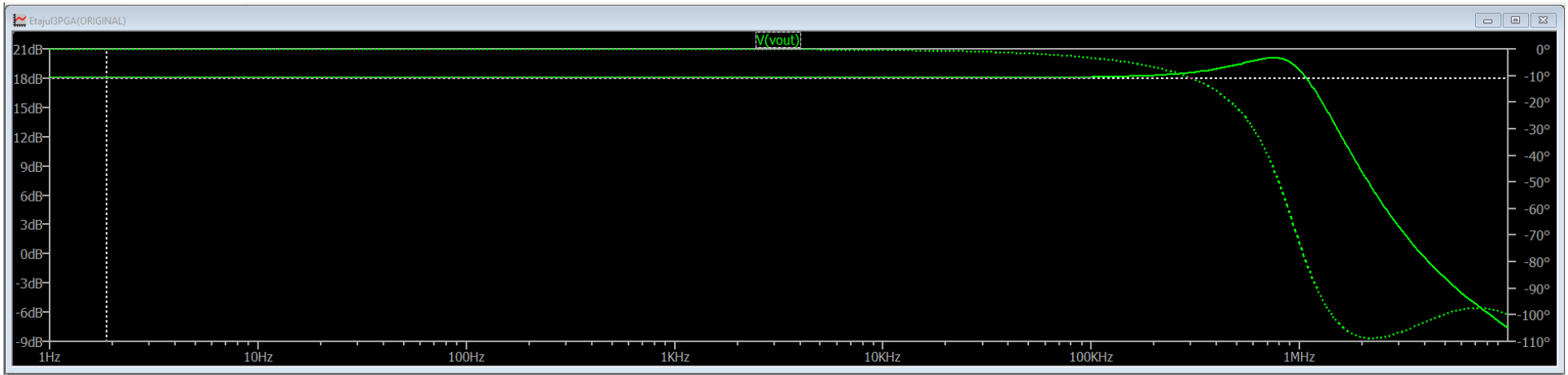


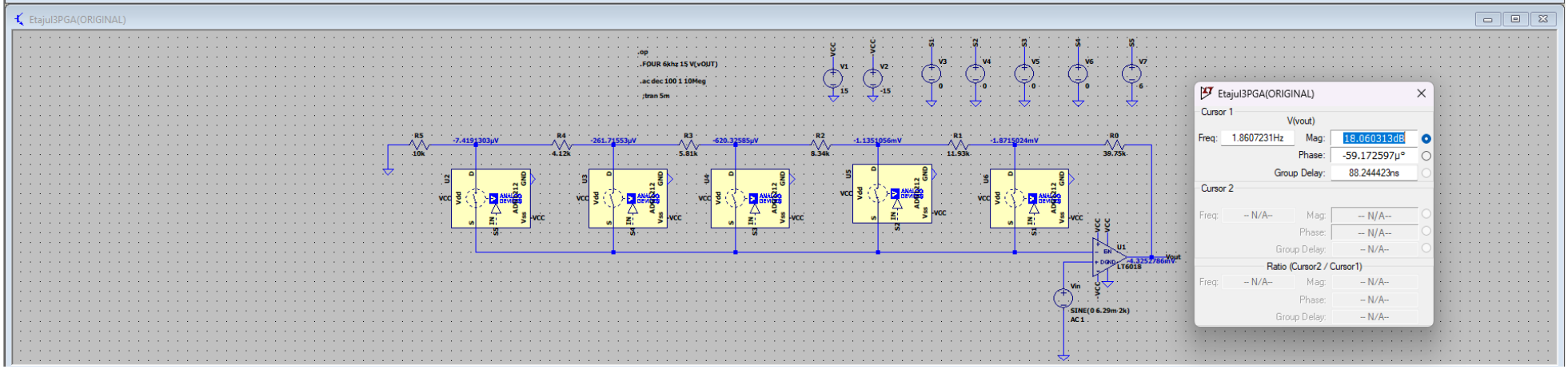
Fourth Switch :

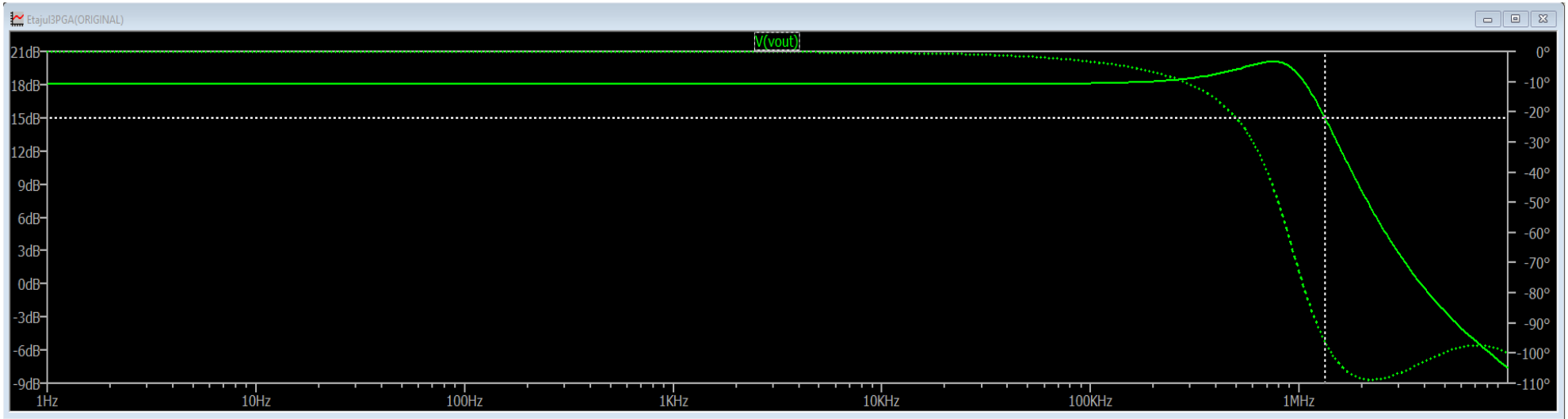


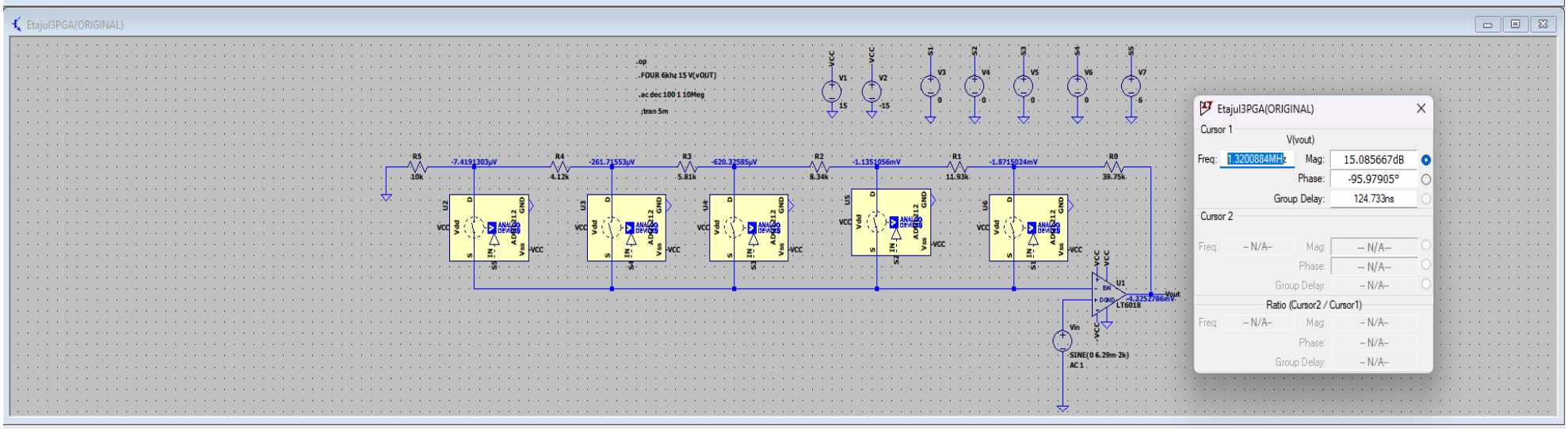
Fifth Switch :



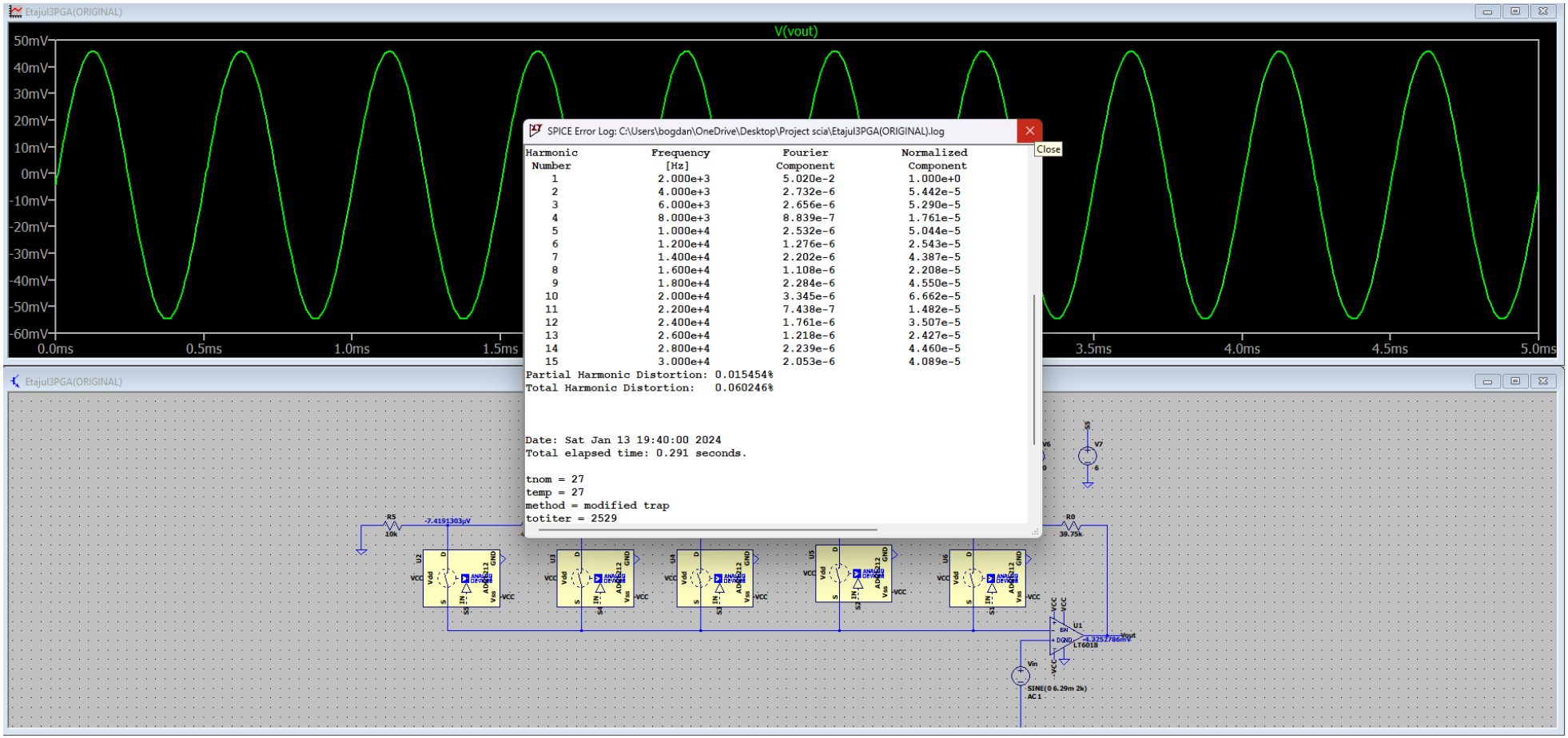

Etajul3PGA(ORIGINAL)
V(vout)
21dB
18dB
15dB
12dB
9dB
6dB
3dB
0dB
-3dB
-6dB
-9dB
0°
-10°
-20°
-30°
-40°
-50°
-60°
-70°
-80°
-90°
-100°
-110°
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz


Etajul3PGA(ORIGINAL)
.op
.FOUR 6khz 15 V(vOUT)
.ac dec 100 1 10Meg
;tran 5m
R5
R4
R3
R2
R1
R0
U1
LT6018
Vin
SINE(0 6.29m 2k)
.AC 1
Etajul3PGA(ORIGINAL)
Cursor 1
V(vout)
Freq: 1.8607231Hz
Mag: 18.060313dB
Phase: -59.172597µ°
Group Delay: 88.244423ns
Cursor 2
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Ratio (Cursor2 / Cursor1)
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--

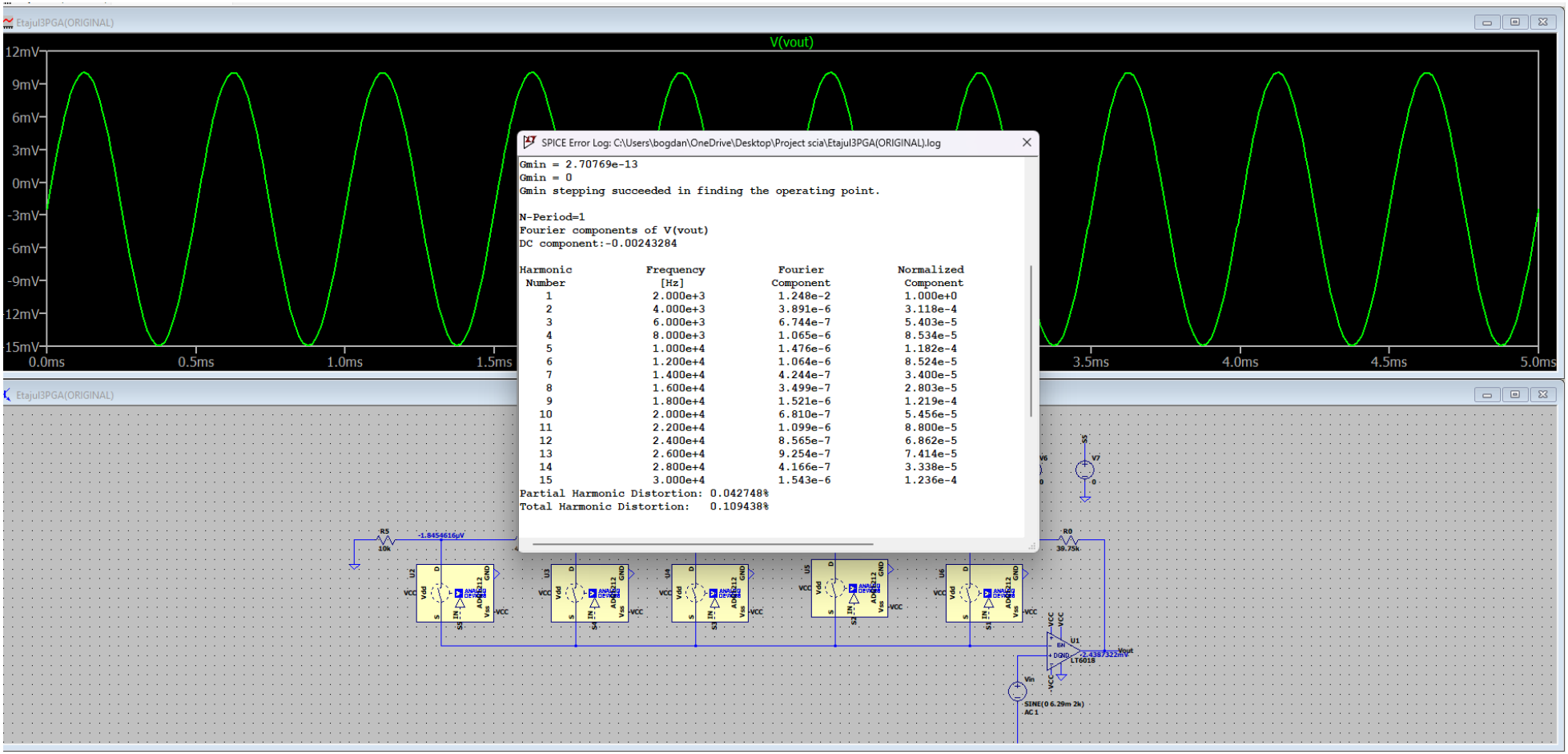

EtajuI3PGA(ORIGINAL)
V(vout)
21dB
18dB
15dB
12dB
9dB
6dB
3dB
0dB
-3dB
-6dB
-9dB
0°
-10°
-20°
-30°
-40°
-50°
-60°
-70°
-80°
-90°
-100°
-110°
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz


EtajuI3PGA(ORIGINAL)
.op
.FOUR 6khz 15 V(vOUT)
.ac dec 100 1 10Meg
;tran 5m
R5
10k
-7.419303µV
R4
4.12k
-261.71553µV
R3
5.81k
-620.32585µV
R2
8.34k
-1.1351056mV
R1
11.93k
-1.8715024mV
R0
39.75k
U1
LT6018
Vout
-4.3252786mV
Vin
SINE(0 6.29m 2k)
AC 1
EtajuI3PGA(ORIGINAL)
Cursor 1
V(vout)
Freq: 1.3200884MHz
Mag: 15.085667dB
Phase: -95.97905°
Group Delay: 124.733ns
Cursor 2
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Ratio (Cursor2 / Cursor1)
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--

→ Switch max

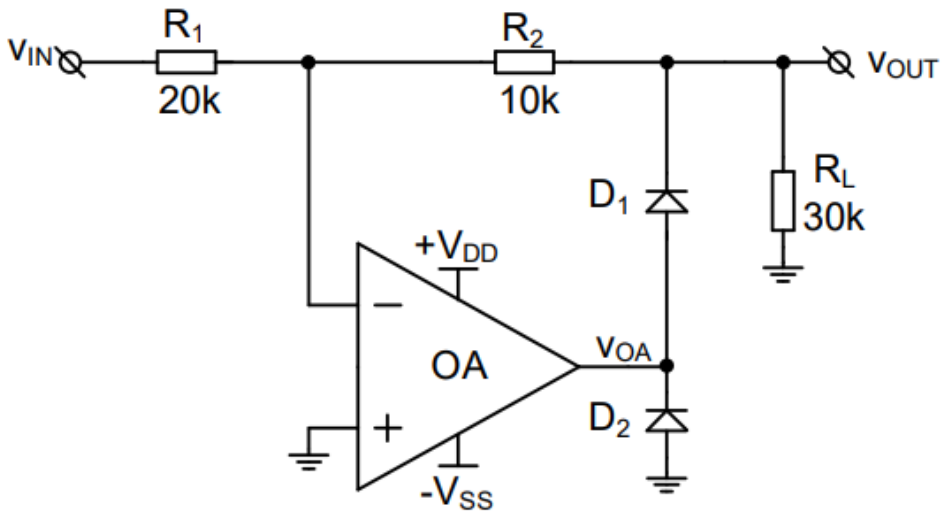

Etajul3PGA(ORIGINAL)
V(vout)
50mV
40mV
30mV
20mV
10mV
0mV
-10mV
-20mV
-30mV
-40mV
-50mV
-60mV
0.0ms
0.5ms
1.0ms
1.5ms
3.5ms
4.0ms
4.5ms
5.0ms
SPICE Error Log: C:\Users\bogdan\OneDrive\Desktop\Project scia\Etajul3PGA(ORIGINAL).log
Close
Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component
1 2.000e+3 5.020e-2 1.000e+0
2 4.000e+3 2.732e-6 5.442e-5
3 6.000e+3 2.656e-6 5.290e-5
4 8.000e+3 8.839e-7 1.761e-5
5 1.000e+4 2.532e-6 5.044e-5
6 1.200e+4 1.276e-6 2.543e-5
7 1.400e+4 2.202e-6 4.387e-5
8 1.600e+4 1.108e-6 2.208e-5
9 1.800e+4 2.284e-6 4.550e-5
10 2.000e+4 3.345e-6 6.662e-5
11 2.200e+4 7.438e-7 1.482e-5
12 2.400e+4 1.761e-6 3.507e-5
13 2.600e+4 1.218e-6 2.427e-5
14 2.800e+4 2.239e-6 4.460e-5
15 3.000e+4 2.053e-6 4.089e-5
Partial Harmonic Distortion: 0.015454%
Total Harmonic Distortion: 0.060246%
Date: Sat Jan 13 19:40:00 2024
Total elapsed time: 0.291 seconds.
tnom = 27
temp = 27
method = modified trap
totiter = 2529
Etajul3PGA(ORIGINAL)
R5
10k
-7.419303uV
R0
39.75k
U1
LT6018
SINE(0 6.29m 2k)
AC 1

→Switch min


Etajul3PGA(ORIGINAL)
V(vout)
12mV
9mV
6mV
3mV
0mV
-3mV
-6mV
-9mV
-12mV
-15mV
0.0ms
0.5ms
1.0ms
1.5ms
3.5ms
4.0ms
4.5ms
5.0ms
SPICE Error Log: C:\Users\bogdan\OneDrive\Desktop\Project scia\Etajul3PGA(ORIGINAL).log
Gmin = 2.70769e-13
Gmin = 0
Gmin stepping succeeded in finding the operating point.
N-Period=1
Fourier components of V(vout)
DC component:-0.00243284
Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component
1 | 2.000e+3 | 1.248e-2 | 1.000e+0
2 | 4.000e+3 | 3.891e-6 | 3.118e-4
3 | 6.000e+3 | 6.744e-7 | 5.403e-5
4 | 8.000e+3 | 1.065e-6 | 8.534e-5
5 | 1.000e+4 | 1.476e-6 | 1.182e-4
6 | 1.200e+4 | 1.064e-6 | 8.524e-5
7 | 1.400e+4 | 4.244e-7 | 3.400e-5
8 | 1.600e+4 | 3.499e-7 | 2.803e-5
9 | 1.800e+4 | 1.521e-6 | 1.219e-4
10 | 2.000e+4 | 6.810e-7 | 5.456e-5
11 | 2.200e+4 | 1.099e-6 | 8.800e-5
12 | 2.400e+4 | 8.565e-7 | 6.862e-5
13 | 2.600e+4 | 9.254e-7 | 7.414e-5
14 | 2.800e+4 | 4.166e-7 | 3.338e-5
15 | 3.000e+4 | 1.543e-6 | 1.236e-4
Partial Harmonic Distortion: 0.042748%
Total Harmonic Distortion: 0.109438%
Etajul3PGA(ORIGINAL)
R5
10k
-1.84546616µV
R0
39.75k
U1
LT6018
Vout
Vin
SINE(0 6.29m 2k)
AC 1

4. Etaj 4 - Rectifier

Full-Wave Rectifiers Implemented with OAs and Diodes
single-OA implementation: Analysis



Vin>0

Assume D_1, D_2 = OFF

$V_1^+ = 0$; $V_1^- > 0$ => $V_{OA1} \searrow V_{OL}$ => D_1 = ON; D_2 = OFF

AO1 has negative feedback thru D1

=> $V_1^- = V_1^+ = 0$

$V_1^- = V_2^-$ => no current through R_2 and R_3

$\Rightarrow \mathbf{V_{0ut} = -(R_5/R_4)V_{in}}$

Vin<0

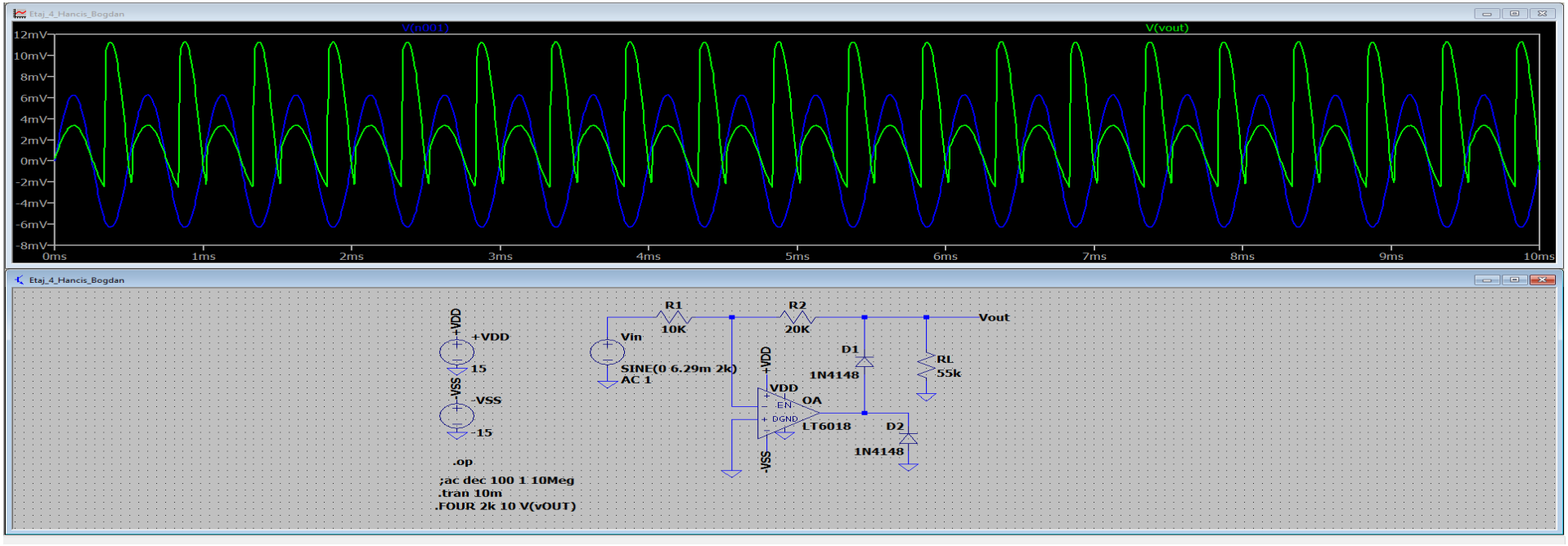
Assume D_1, D_2 = OFF

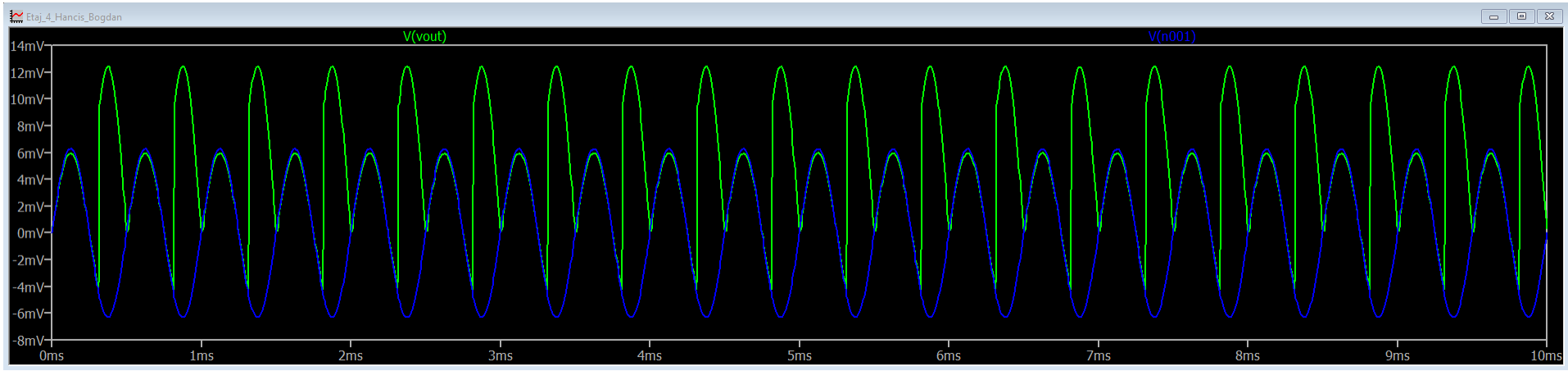
$V_1^+ = 0$; $V_1^- < 0$ => $V_{OA1} \nearrow V_{OH}$

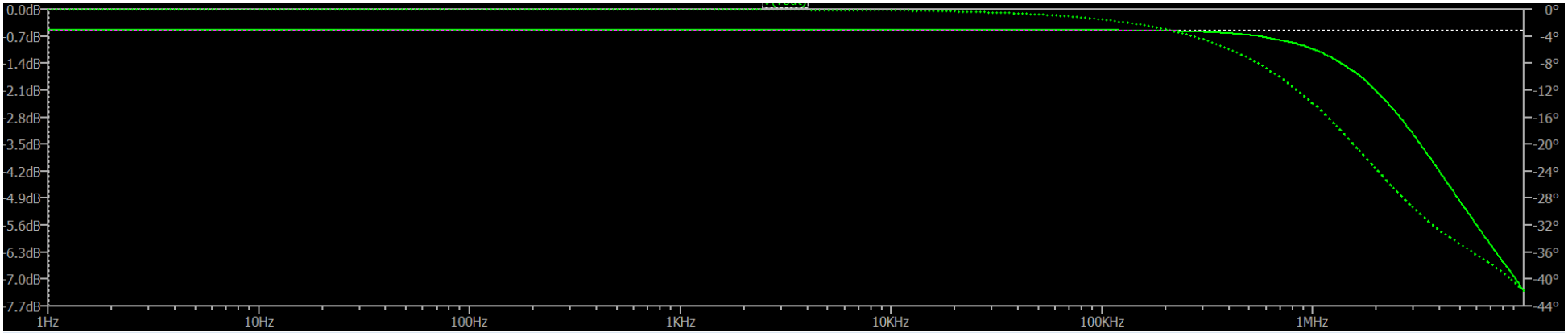
=> D_1 = OFF; D_2 = ON

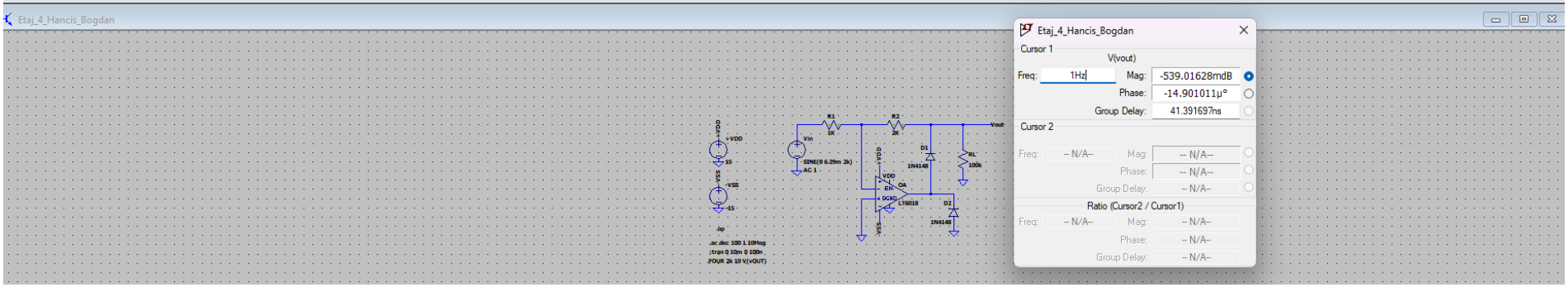
AO1 implements an Inverting Amplifier

=> $V_{01} = -R_2/R_1 Vin$



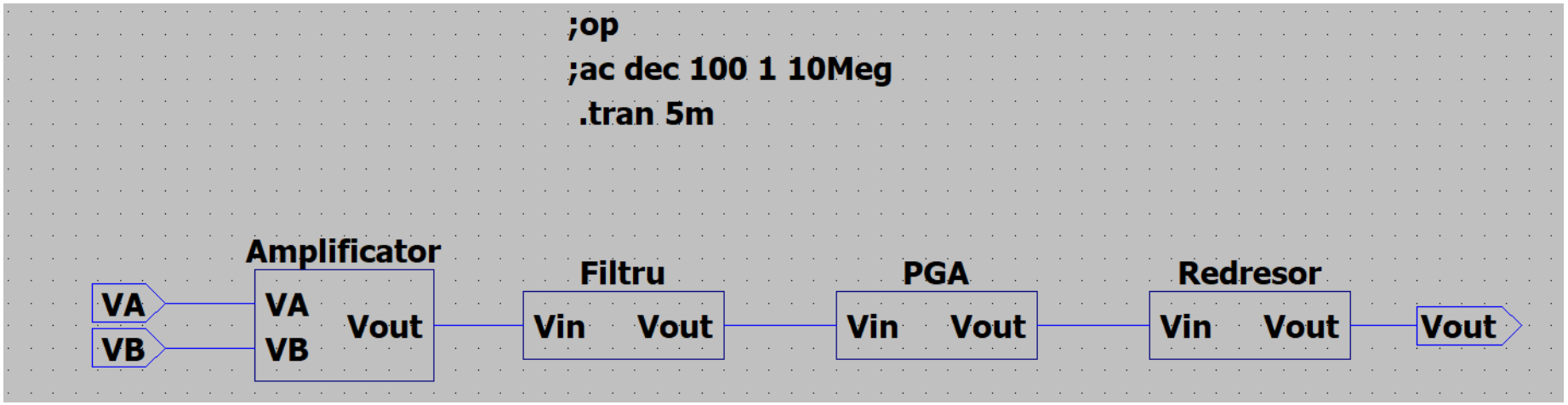

Etaj_4_Hancis_Bogdan
V(vout)
V(n001)
14mV
12mV
10mV
8mV
6mV
4mV
2mV
0mV
-2mV
-4mV
-6mV
-8mV
0ms
1ms
2ms
3ms
4ms
5ms
6ms
7ms
8ms
9ms
10ms

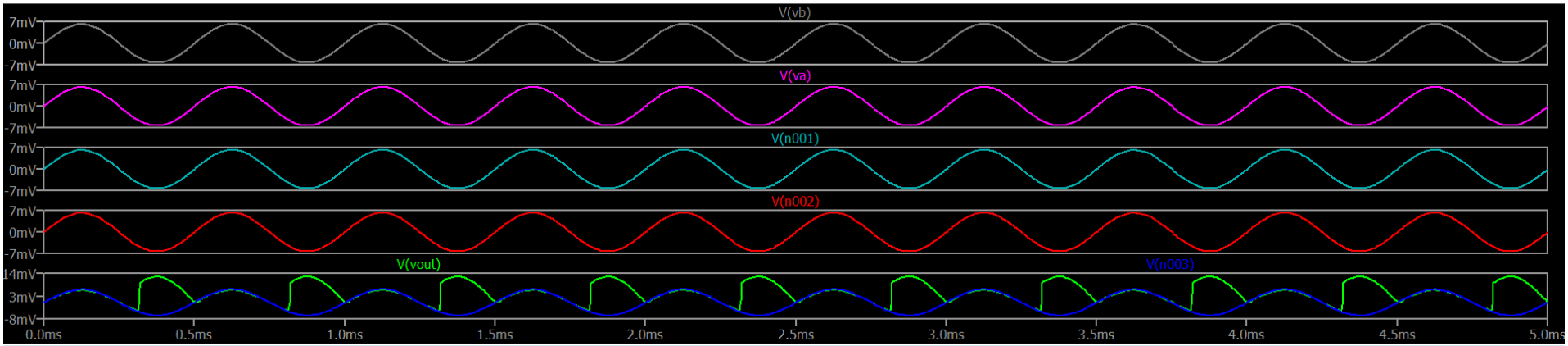

0.0dB
-0.7dB
-1.4dB
-2.1dB
-2.8dB
-3.5dB
-4.2dB
-4.9dB
-5.6dB
-6.3dB
-7.0dB
-7.7dB
0°
-4°
-8°
-12°
-16°
-20°
-24°
-28°
-32°
-36°
-40°
-44°
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz


Etaj_4_Hancis_Bogdan
Cursor 1
V(vout)
Freq: 1Hz
Mag: -539.01628mdB
Phase: -14.901011µ°
Group Delay: 41.391697ns
Cursor 2
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Ratio (Cursor2 / Cursor1)
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
VDD
VSS
Vin
Vout
R1
R2
D1
D2
RL
1N4148
LT6018
.op
.ac dec 100 1 10Meg
.tran 0 10m 0 100n
.FOUR 2k 10 V(vOUT)

5.Block diagram :

In this section , we will show a block diagram containing all circuits we used :





6. Bibliography :

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- 2022-23_SwAIC6_MNeag_InstrumentAmplifiers.pdf
- 2022-23_SwAIC7_MNeag_NonlinearCircuitsWithOpAmps.pdf
- 2022-23_SwAIC9_MNeag_SignalGenerators.pdf