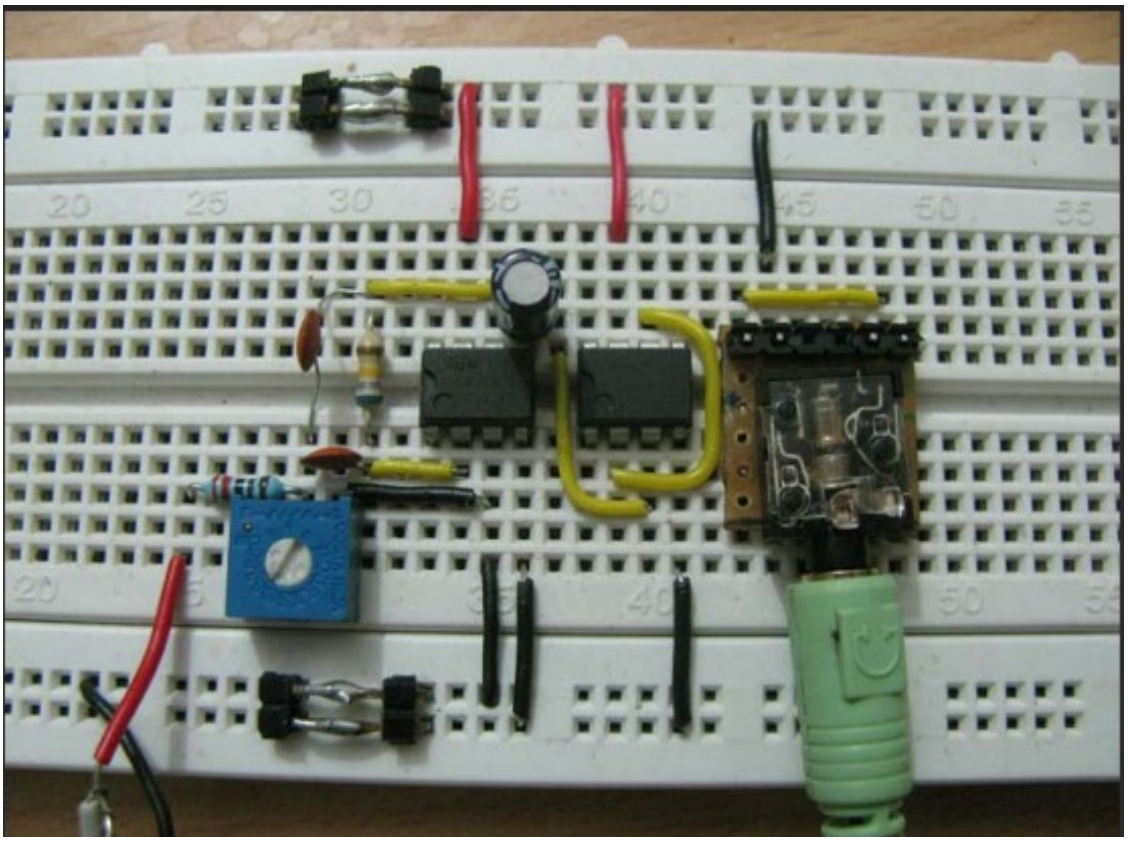
Filtru TB Audio



Mathe Leszay
Erik Robert

UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA

Tema

Filtru TB Audio, format din:
1.Biquad TS (500Hz)
2.Biquad TJ (4.5KHz)
-Cebasev,riplu de 3db
-Filtru LC în scară, format dintr-un filtru
 TS de ordin 2 și un filtru TJ de ordin 2,
implementat cu General Impedance Converter(GIC)

Cuprins

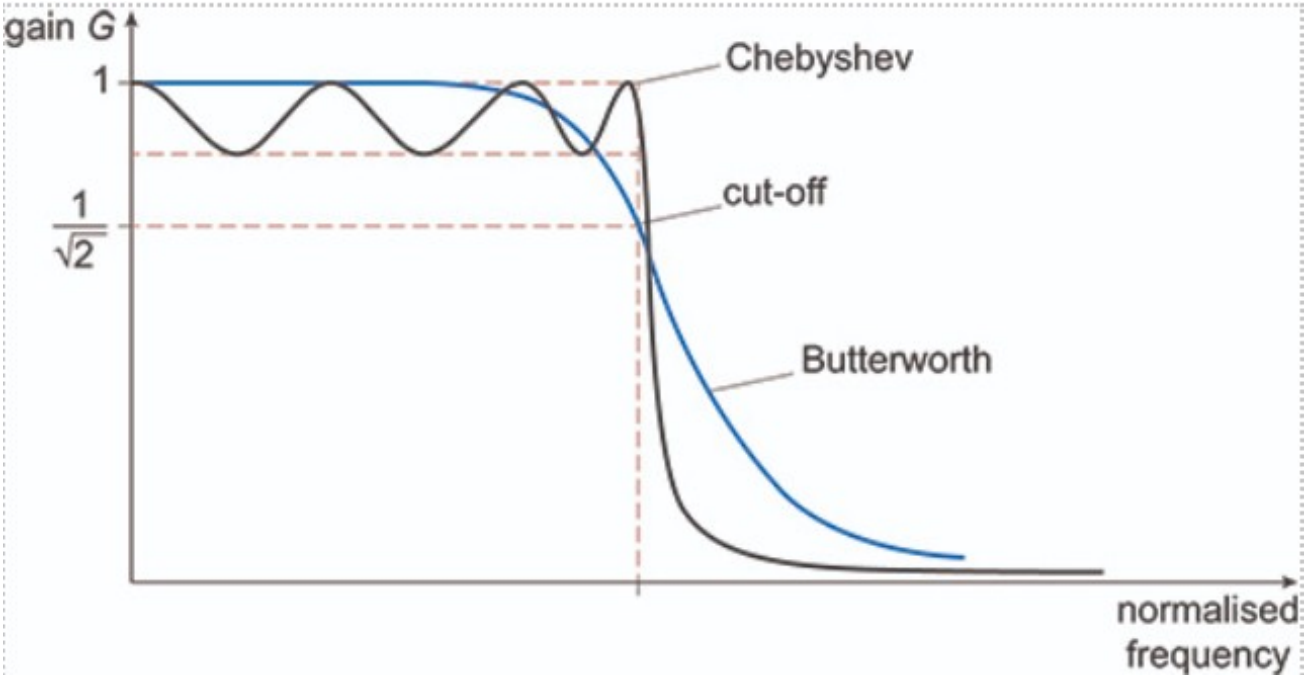
Proprietatil Filtrului Cebasev

Filtrele Cebîșev au proprietatea de a minimiza eroarea dintre filtrul characteristic ideal si cel actual cu un range inspus de acesta de frecventa(banda de trecere si banda de taiere) care cauzeaza permiterea oscilatiilor in banda de trecere.

-asta inseamna pentru filtrele Cebisev au proprietatea de a minimiza erorile cum ar fi Voff care apare intrun mod real si face ca filtrul sa se comporte mai mult ca intrun mod ideal cu un range inmpus de frecventa(banda de trecere si banda de taiere).Si acesta cauzeaza o permisie a oscilatiilor sau riplurilor in banda de trecere ca in exemplul de mai jos.Pe Butterworth putem lua ca pe un filtru normal RC ca sa vedeti ce face filtrul Chebyshev.

Pro:

-din cauza caderii mai rapide a taierii in frecventa acesta face ca zgomotul sa fie taiat semnificativ

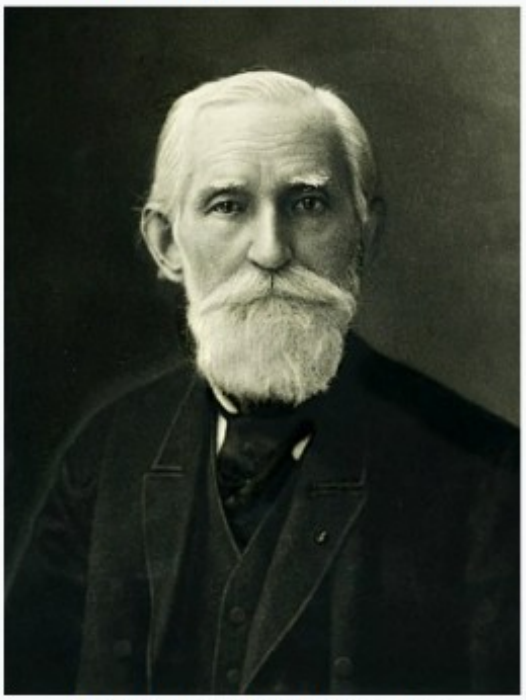


Chebisevul foloseste niste formule polinomiale pentru a reusi asta
Acest tip de filtru este numit dupa Pafnuty Chebyshev pentru ca caracteristicile matematicii vin de la polinomialele Chebyshev.

Tipul I se numeste Filtre Chebisev iar tipul II se numeste Filtre Chebisev inversoare.

Luat de pe Wikipedia Chebyshev_filter

Pafnuty Chebyshev

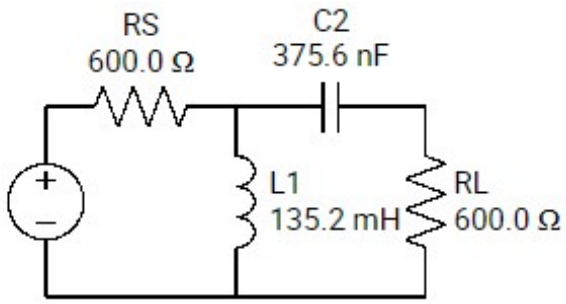


Pafnuty Lvovich Chebyshev

Born	16 May 1821[1] Akatovo, Kaluga Governorate, Russian Empire[1]
Died	8 December 1894 (aged 73)[1] St. Petersburg, Russian Empire[1][2]
Nationality	Russian
Other names	Chebysheff, Chebyshov, Tschebyscheff, Tschebycheff, Tchebycheff
Alma mater	Moscow University
Known for	Work on probability, statistics, mechanics, analytical geometry and number theory
Awards	Demidov Prize (1849)

Crearea Cicuitului TS

Filtru LC in scara, format dintr-un filtru TS de ordin 2 (500HZ)



facut cu markimicrowave.com filter design

La o foarte inalta frecventa Condensatorul este in conducere iar Bobina in blocaj.La DC si chiar la o mica frecventa Condensatorul este in blocaj iar bobina in conducere.Manipuland valorile celor doua putem face un filtru trece sus.

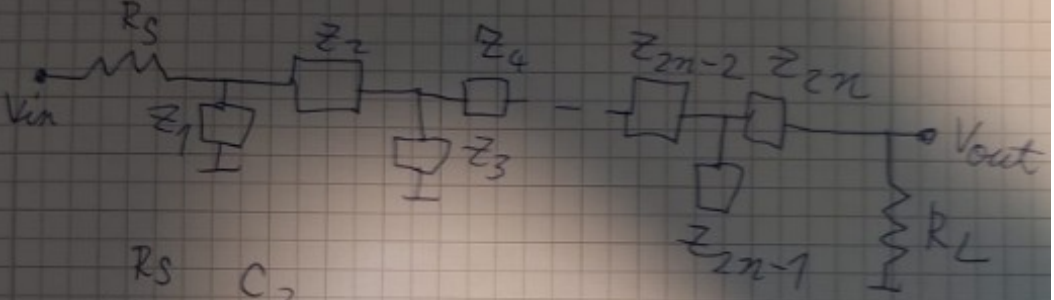
Filtru LC în scară - TS - ordin 2

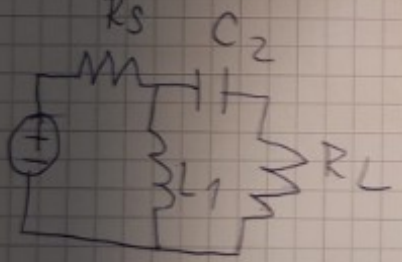
$GR_3 = 500$ Hz

3db ripple chebyshev

$R_S = R_L = 600\ \Omega$ - pentru filtru audio indicat $600\ \Omega$

ordin 2 - par

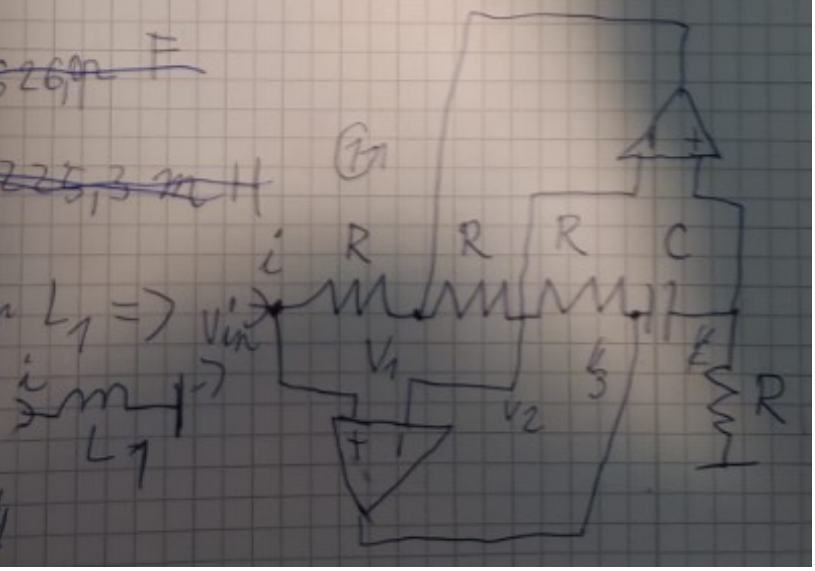




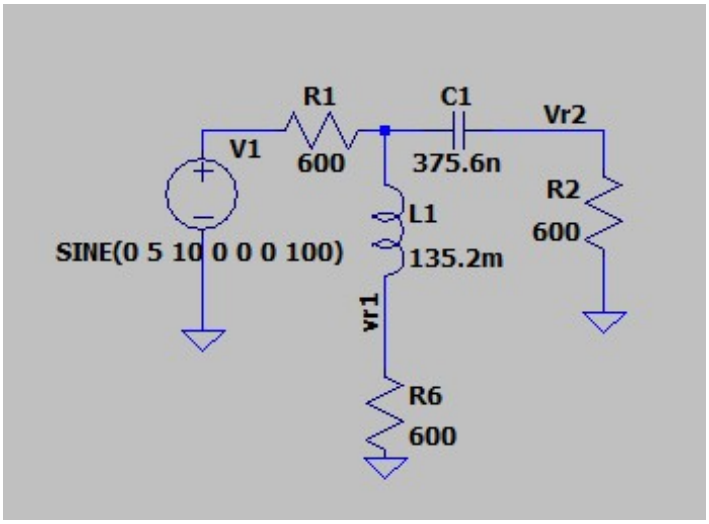
~~$C_2 = 626\mu F$~~

~~$L_1 = 225{,}3\ mH$~~

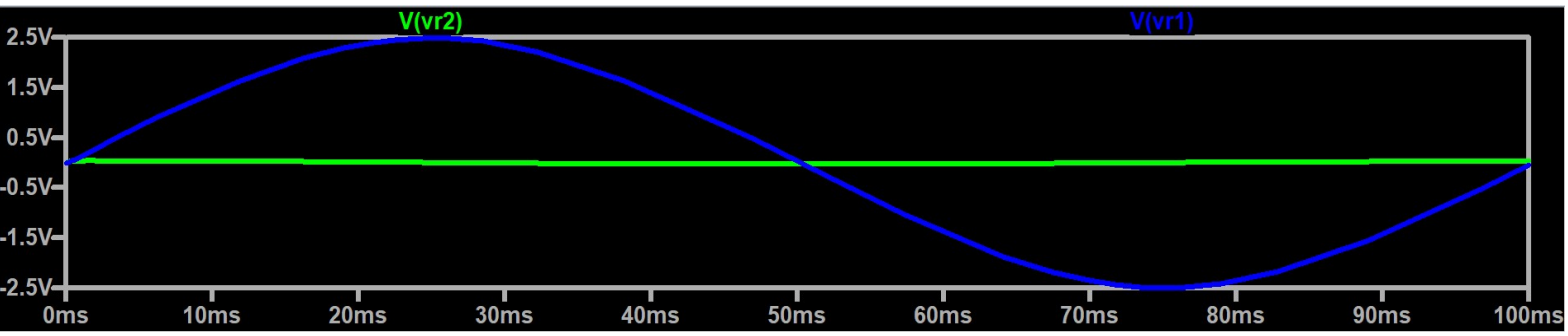
înlocuim L_1 =>



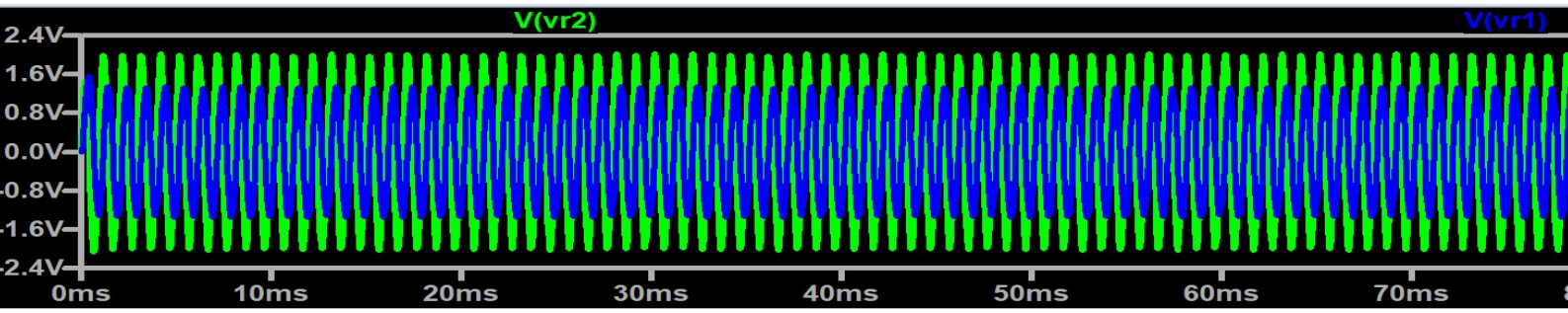
Explicarea functionalitatii Condensatorului si a Bobinei



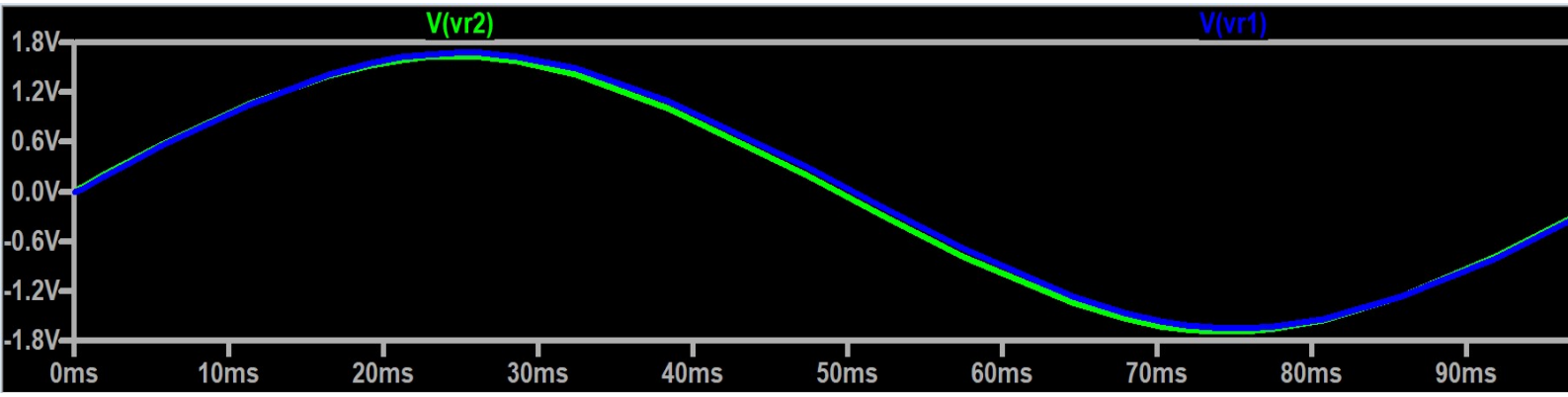
Invatat din cursul de la facultate numit CCP

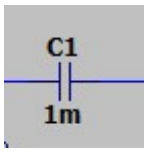


Se poate observa ca la 10Hz Tensiune pe R2 nu exista.Dar pe R6 exista

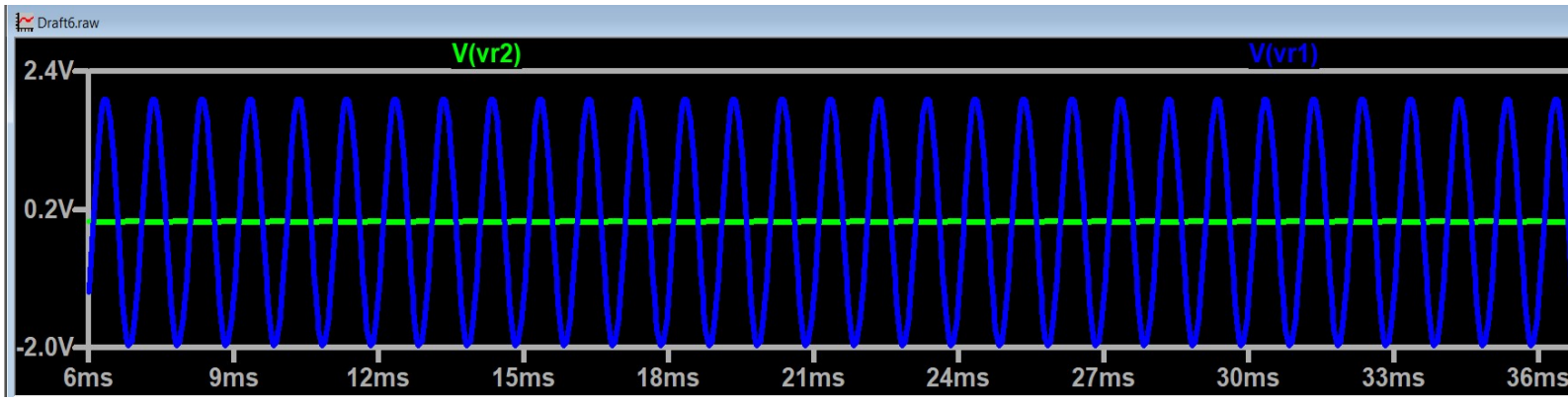


Se poate observa ca la 1kHz avem tensiune R2 in ce timp pe R6 scade





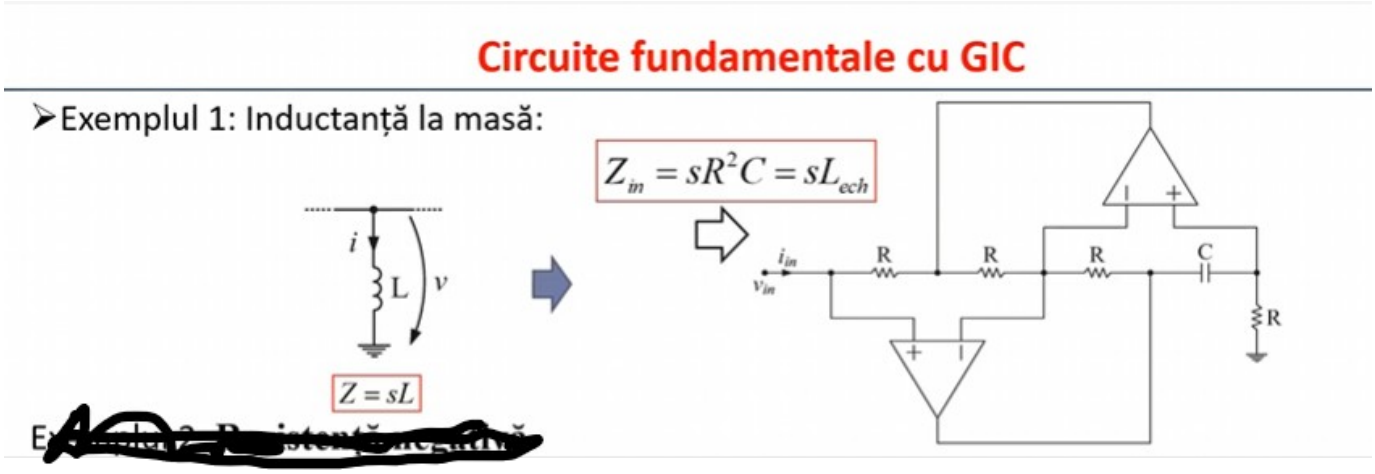
Daca ne intoarcem la 10Hz si C1 il crestem putem vedea ca acum poate trece aceasta frecventa.Prin urmare prin cresterea scadea frecventa de taiere si prin scaderea condesnatorului aceste ridica frecventa de taiere



Ce am spus este adevarat la frecventa de 1k si C=1n,nu lasa sa treaca semnalul

Bobina se incarca si stocheaza aceasta energie in campul magnetic.
Câmpurile magnetice generate de inductoare pot interfera cu alte componente din circuit.
Reactanța inductivă depinde de frecvență și poate distorsiona răspunsul filtrului trece-bandă, care ar trebui să aibă o lățime de bandă cât mai constantă și să atenueze semnalele din afara acestei benzi.

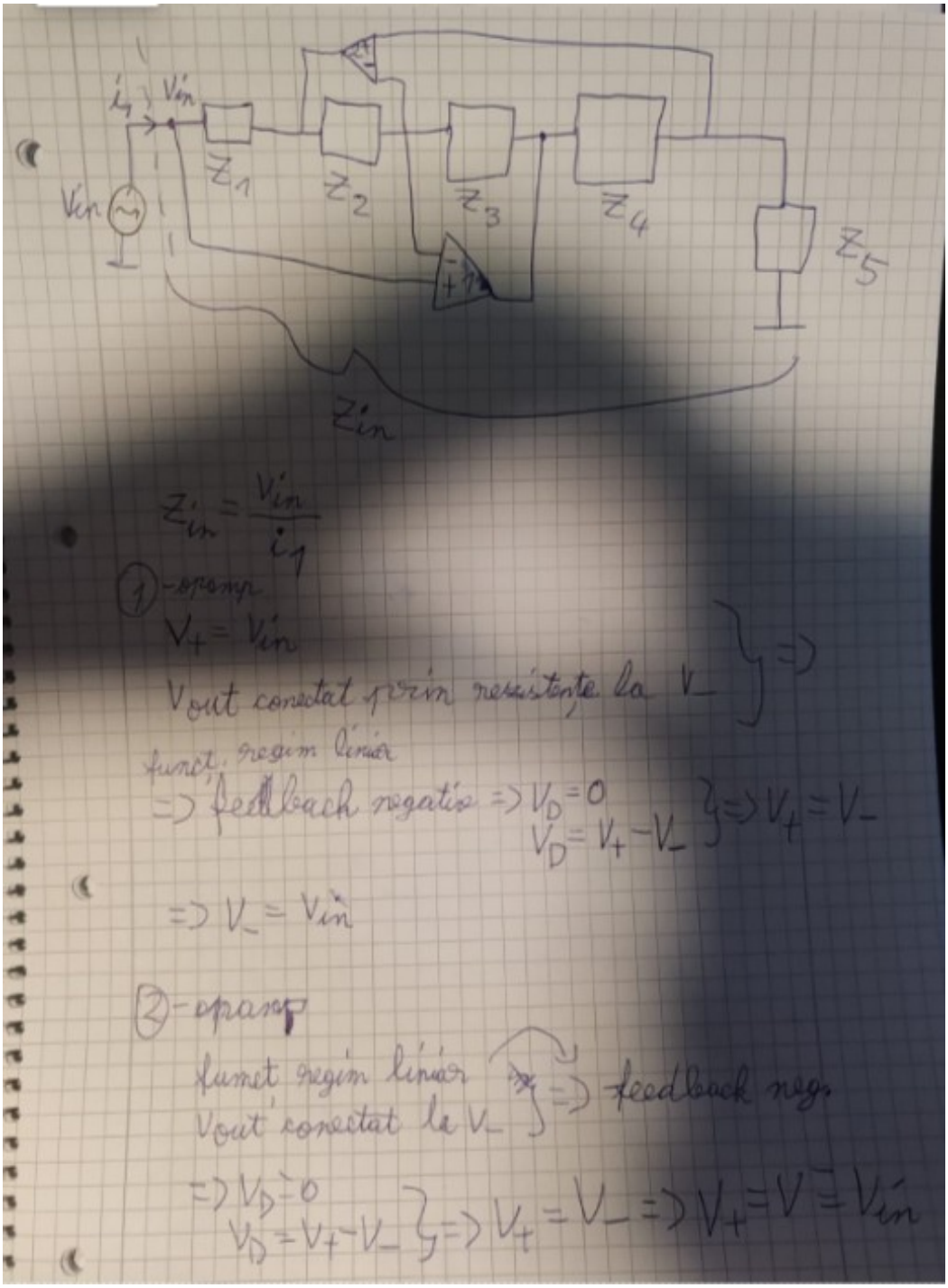
Pentru a schimba aceasta bobina folosim un GIC (General Impedance Converter)

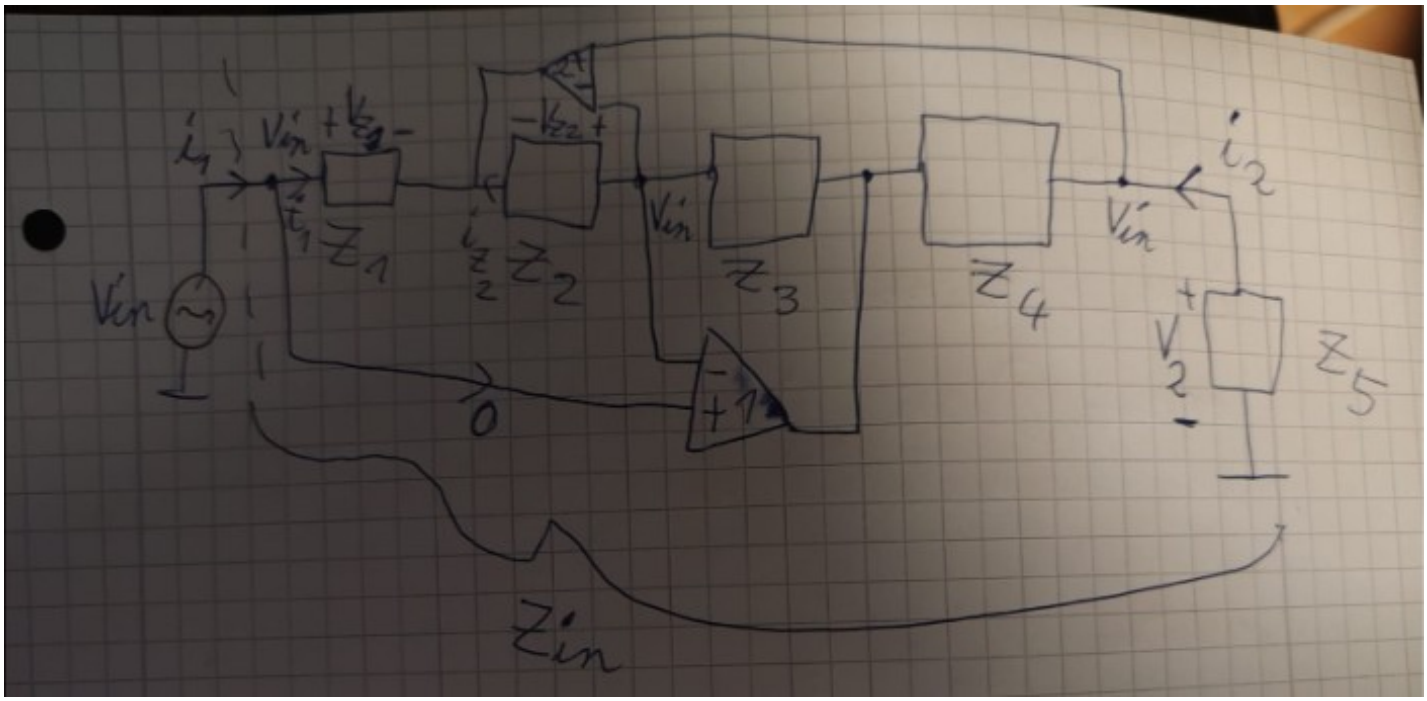


Luat din curs 9-10 Filtre Analogice de la materia SCIA

Explicarea Convertorului

Invatat cum se calculeaza de pe Youtube: Engineering Prof. General Impedance Converter Circuit Equation and Analysis





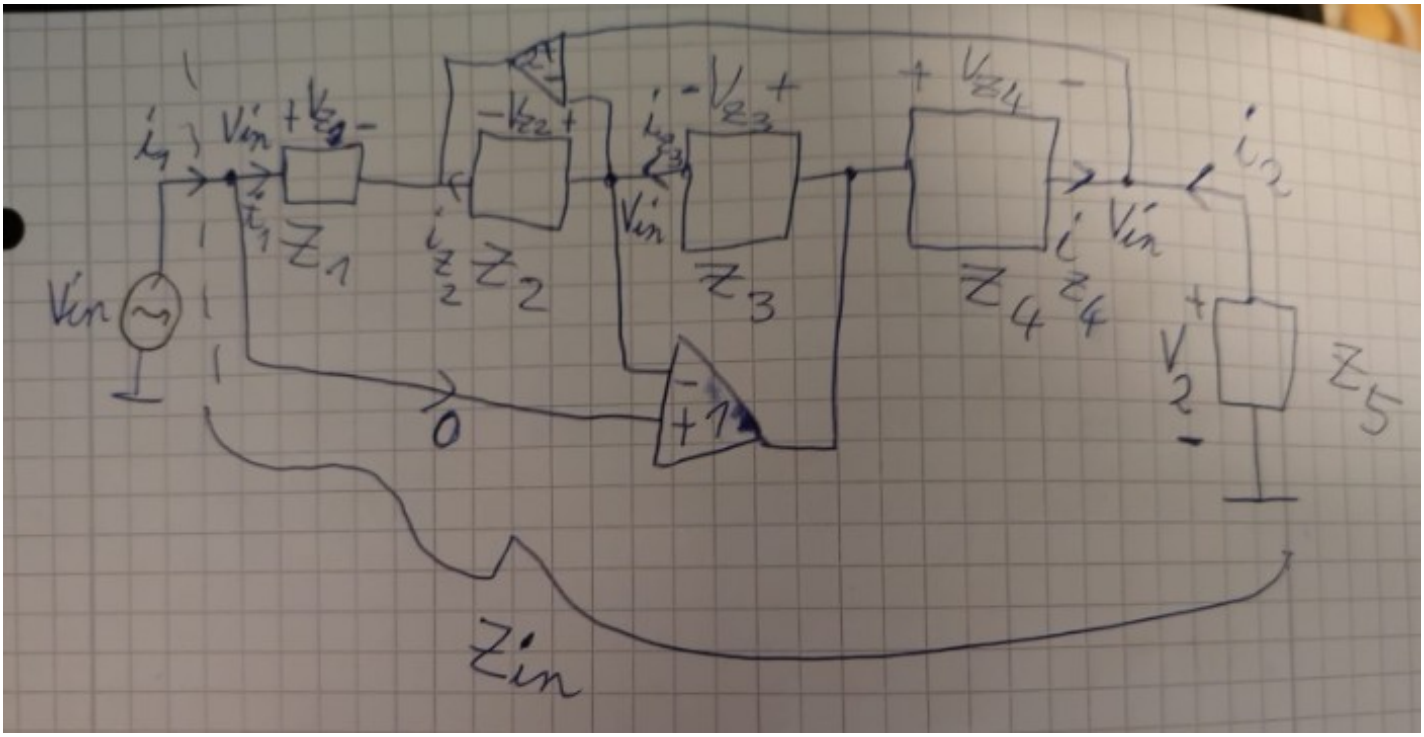
$V_2 = V_{in}$

i_1 trece numai prin Z_1 deoarece opamp (1) are impedanta infinită sau mai bine spus foarte mare la V^+ și V^-

pentru V_{z_1} și V_{z_2}

- ambii au un nod comun
- ambii au V_{in} la capete

$\Rightarrow V_{z_1} = V_{z_2} \Rightarrow i_{z_2} \cdot z_2 = i_1 \cdot Z_1$



$i_{z_2} = i_{z_3}$ - ~~trece mum~~ V - impedanță infinită deci nu trece i_{z_2}

pentru V_{z_3} și V_{z_4}

- ambii au un nod comun
- ambii au Vin la capete

$\Rightarrow$ ~~$V_{z_4} = V_{z_2}$~~ $V_{z_3} = V_{z_4} \Rightarrow i_{z_2} \cdot Z_3 = i_{z_4} \cdot Z_4$

$i_{z_4} = -i_2$ – V+ impedanță infinită deci nu trece i_{z_4}

$\Rightarrow i_{z_2} \cdot z_3 = -i_2 \cdot z_4 \Rightarrow i_{z_2} = -\frac{z_4}{z_3} \cdot i_2$

din ce am realizat mai înainte $\begin{cases} i_1 z_1 = i_{z_2} z_2 \\ i_{z_2} = -\frac{z_4}{z_3} \cdot i_2 \end{cases}$

$\Rightarrow i_1 \cdot z_1 = \left(-\frac{z_4}{z_3} \cdot i_2\right) z_2 \Rightarrow i_1 = \frac{-z_2 z_4}{z_1 z_3} \cdot i_2$ $\Rightarrow$

și mai luăm din schemă $V_2 = -i_2 \cdot z_5$

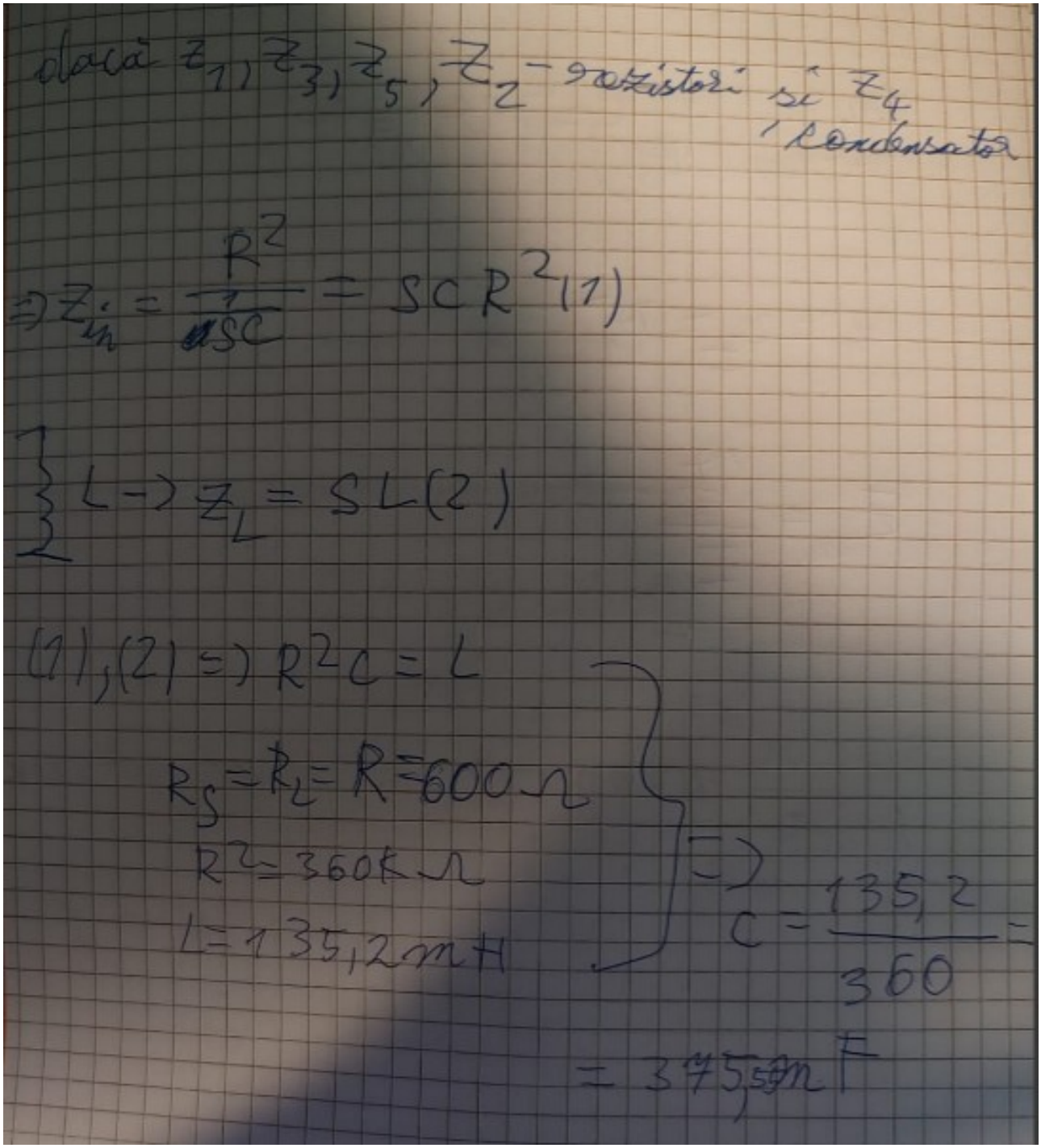
$\Rightarrow i_1 = \frac{-z_2 z_4}{z_1 \cdot z_3} \cdot \left(-\frac{V_2}{z_5}\right)$ $\Rightarrow$

și mai luăm din schemă $V_2 = V_{in}$ (deoarece sub nod e V_{in} și jos gnd)

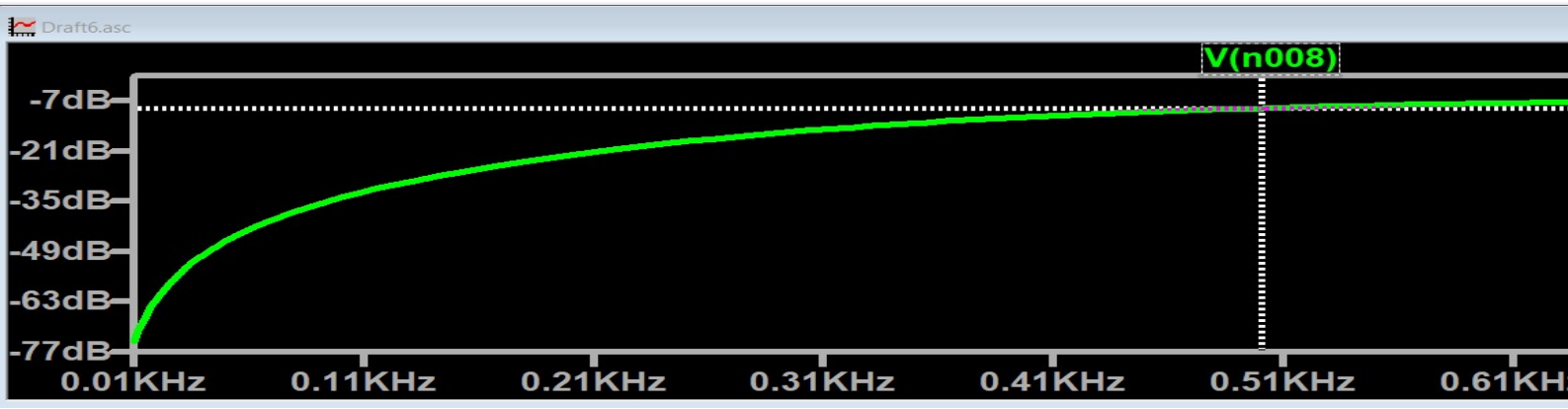
$\Rightarrow i_1 = \frac{z_2 \cdot z_4}{z_1 \cdot z_3 \cdot z_5} \cdot V_{in}$

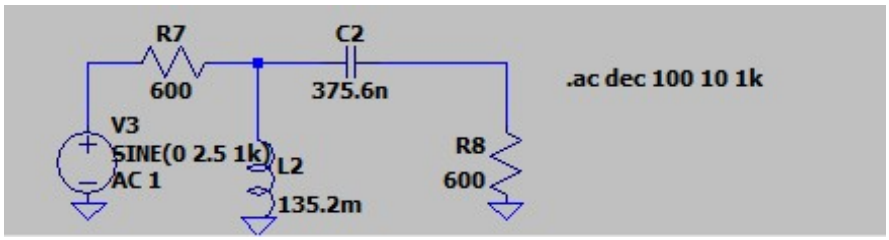
știm $z_{in} = \frac{V_{in}}{i_1}$

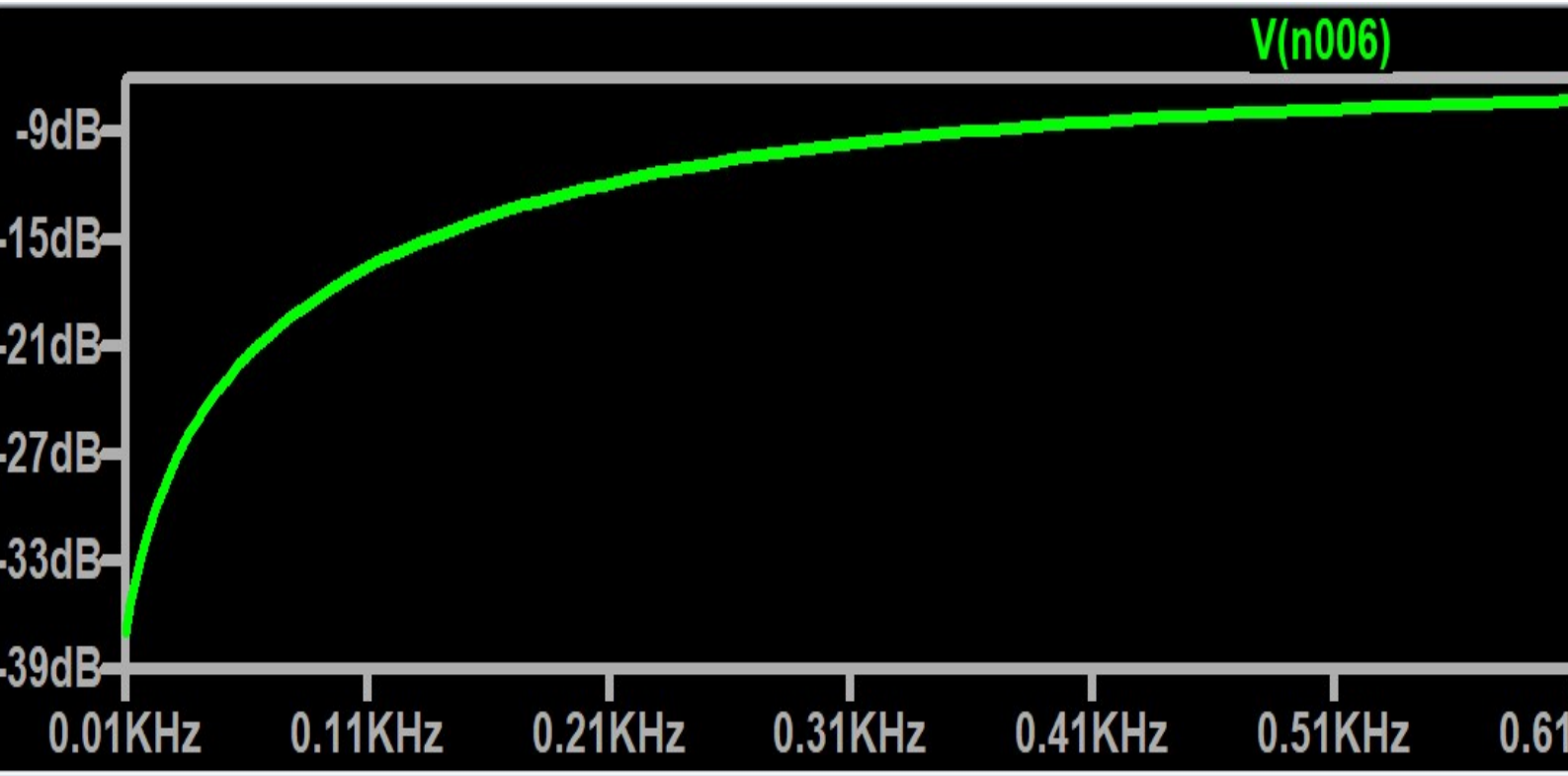
înlocuim i_1 în a 2 formulă $\Rightarrow z_{in} = \frac{z_1 z_3 z_5}{z_2 z_4}$

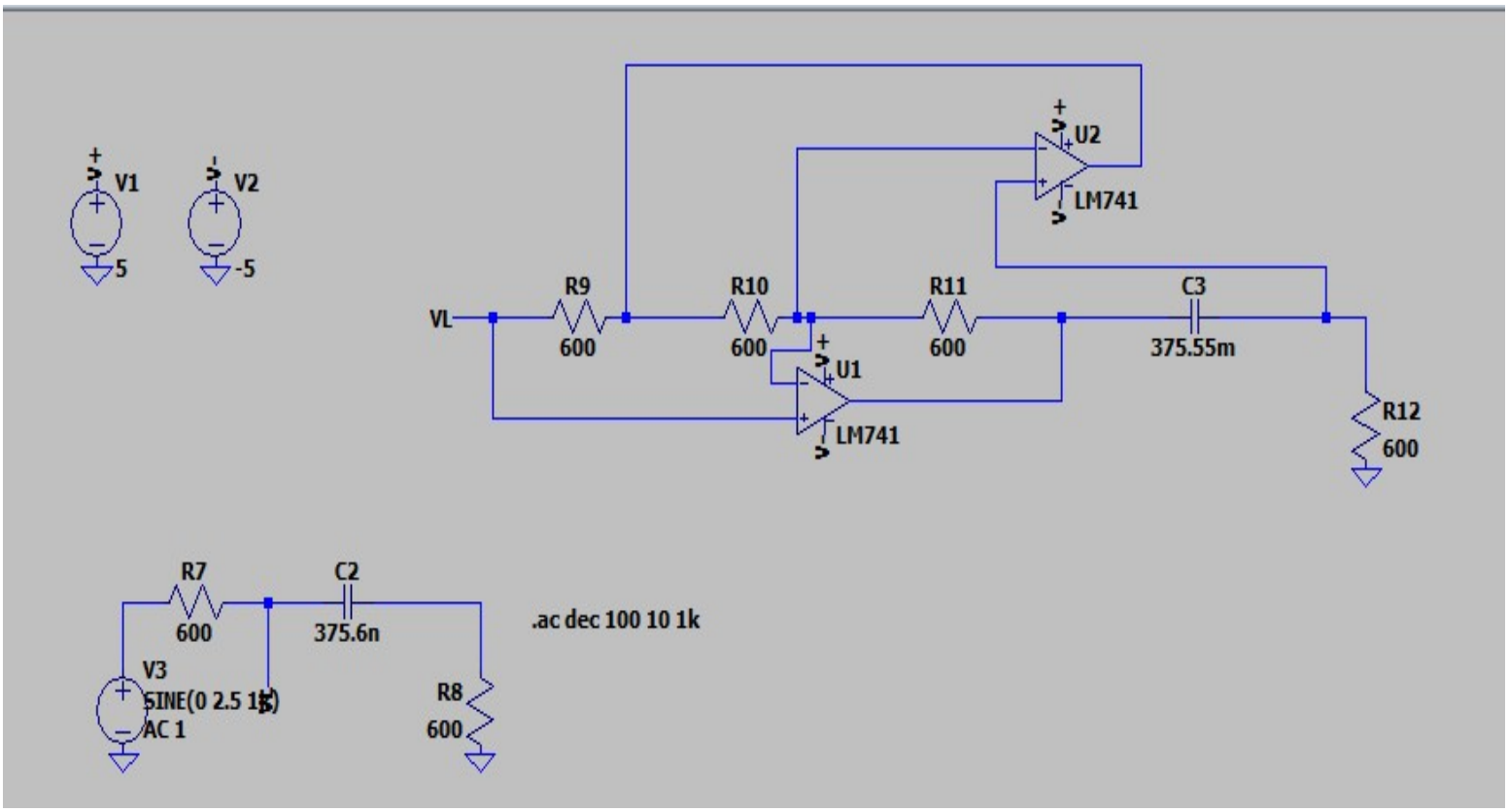

dacă Z_1, Z_3, Z_5, Z_2 - rezistori și Z_4 / condensator
$\Rightarrow Z_{in} = \frac{R^2}{\frac{1}{sC}} = sCR^2$ (1)
L -> $Z_L = sL$ (2)
(1), (2) => $R^2C = L$
$R_S = R_L = R = 600\Omega$
$R^2 = 360k\Omega$
$L = 135,2mH$
$\Rightarrow C = \frac{135,2}{360} =$
$= 375,5nF$

Raspunsul in frecventa

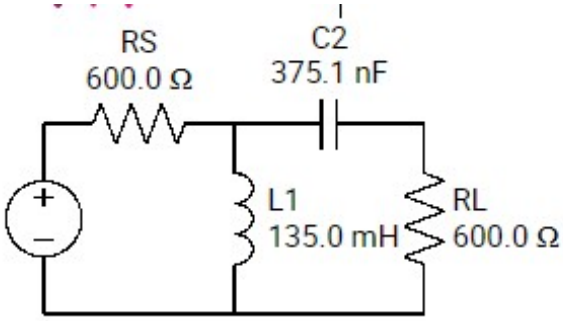


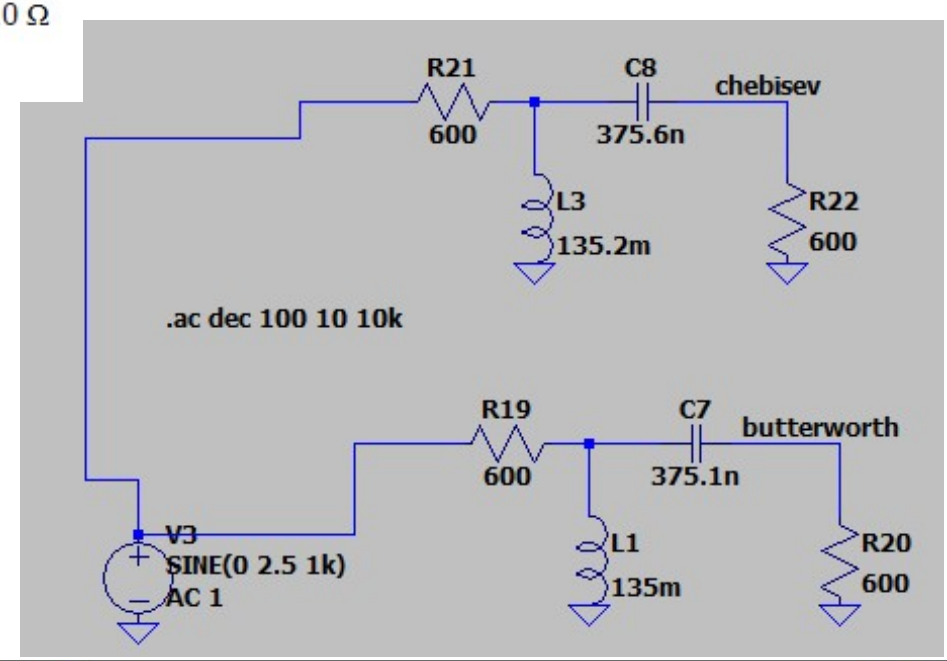


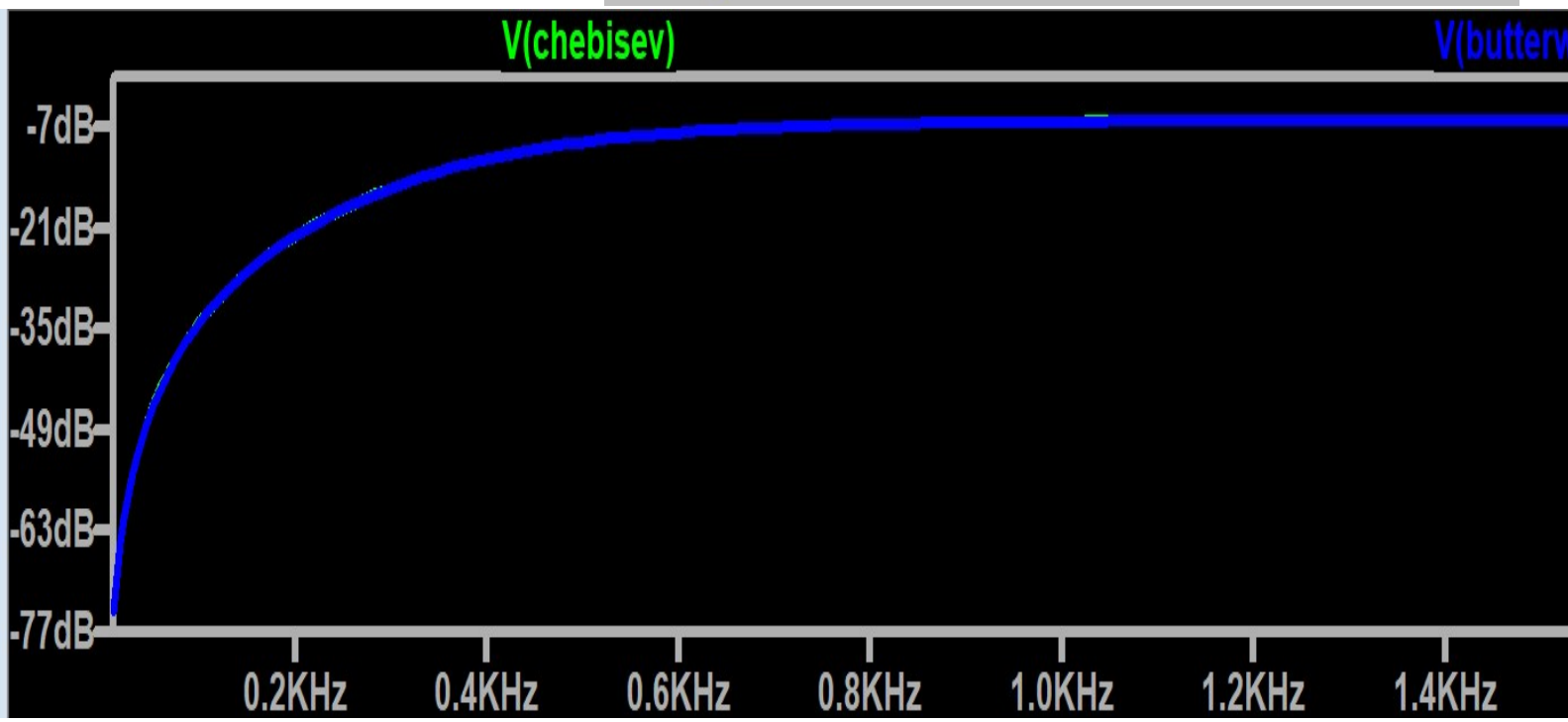

V(n006)
-9dB
-15dB
-21dB
-27dB
-33dB
-39dB
0.01KHz
0.11KHz
0.21KHz
0.31KHz
0.41KHz
0.51KHz
0.61


V1
5
V2
-5
U2
LM741
VL
R9
600
R10
600
R11
600
C3
375.55m
U1
LM741
R12
600
R7
600
C2
375.6n
V3
SINE(0 2.5 1k)
AC 1
R8
600
.ac dec 100 10 1k

Chebisev vs Butterworth



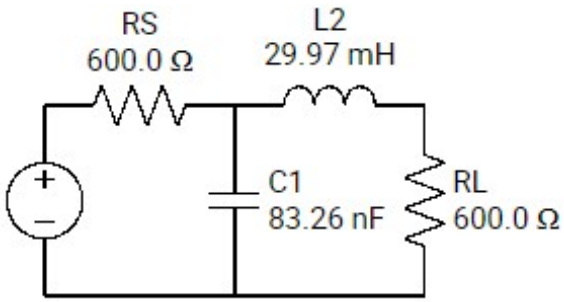




Is cam la fel doarece este numai ordin 2,la ordine mai mari se observa diferenta mai bine

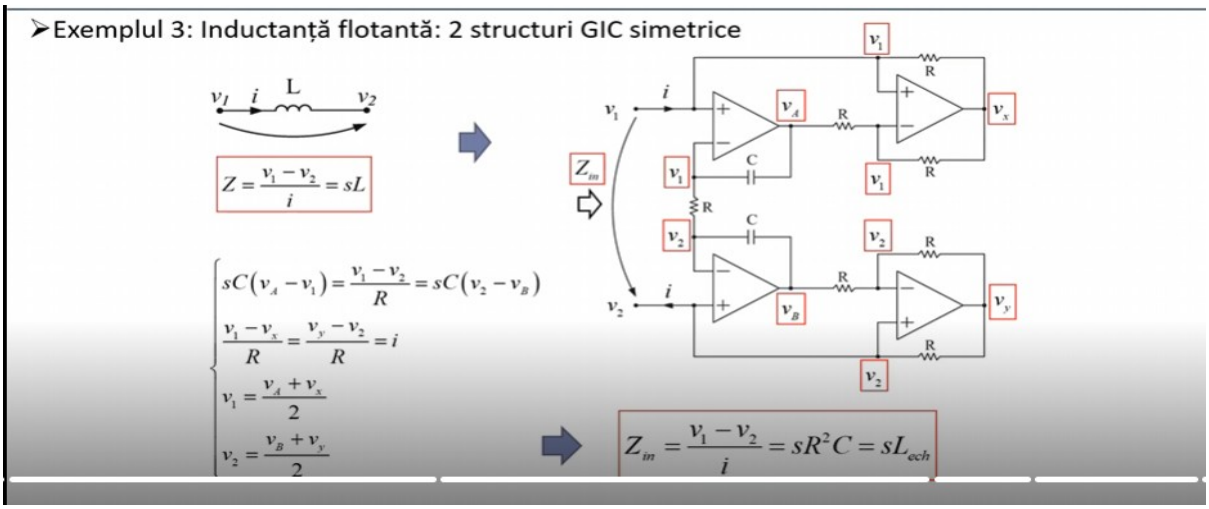
Crearea Cicuitului TJ

Filtru LC in scara, format dintr-un filtru TJ de ordin 2 (4.5kHZ)



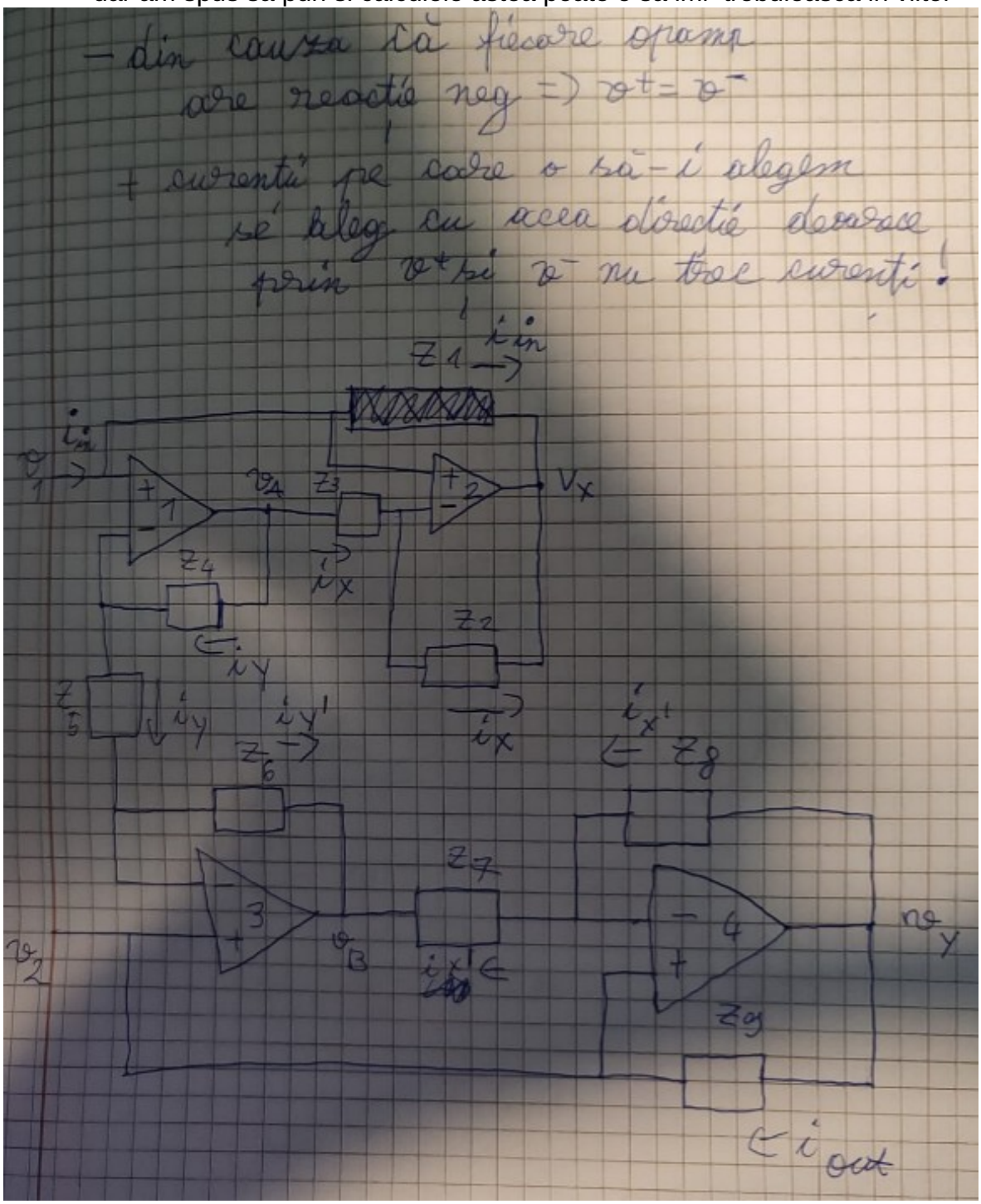
Acelasi lucru explicat de mai sus dar acesta functioneaza invers din cauza pozitionarii inverse a condensatorlui si bobinei

Luat din curs 9-10 Filtre Analogice de la materia SCIA

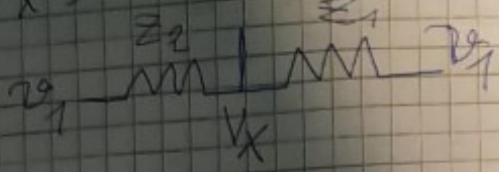


Explicarea circuitului GIC

Am facut eu ceva calcule, pe net nu am gasit, calculele incep de la poza a 3a dar am spus sa pun si calculele astea poate o sa imi trebuieasca in viitor



$v_x \Rightarrow$



$v_1 - v_x = Z_1 \cdot I_{in} = Z_2 \cdot I_{in}$

~~$\Rightarrow$ Z toate is egale intre ele~~

$v_1 - v_x = Z_1 \cdot I_{in} = Z_2 \cdot i_x$

$$i_x = \frac{Z_1}{Z_2} \cdot I_{in} \quad (3)$$

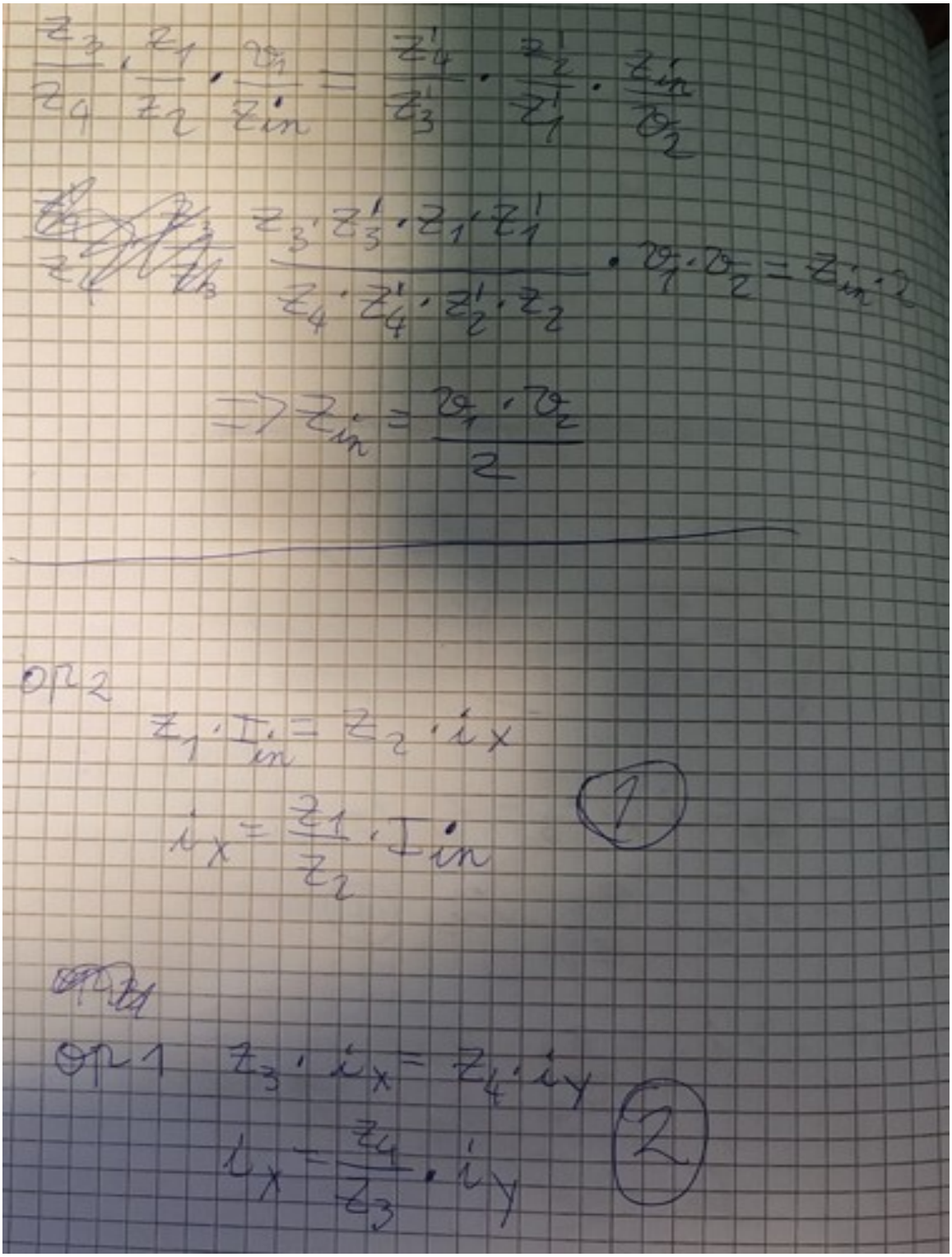
$v_A - v_{in1} = i_x \cdot Z_3 = Z_4 \cdot i_2$

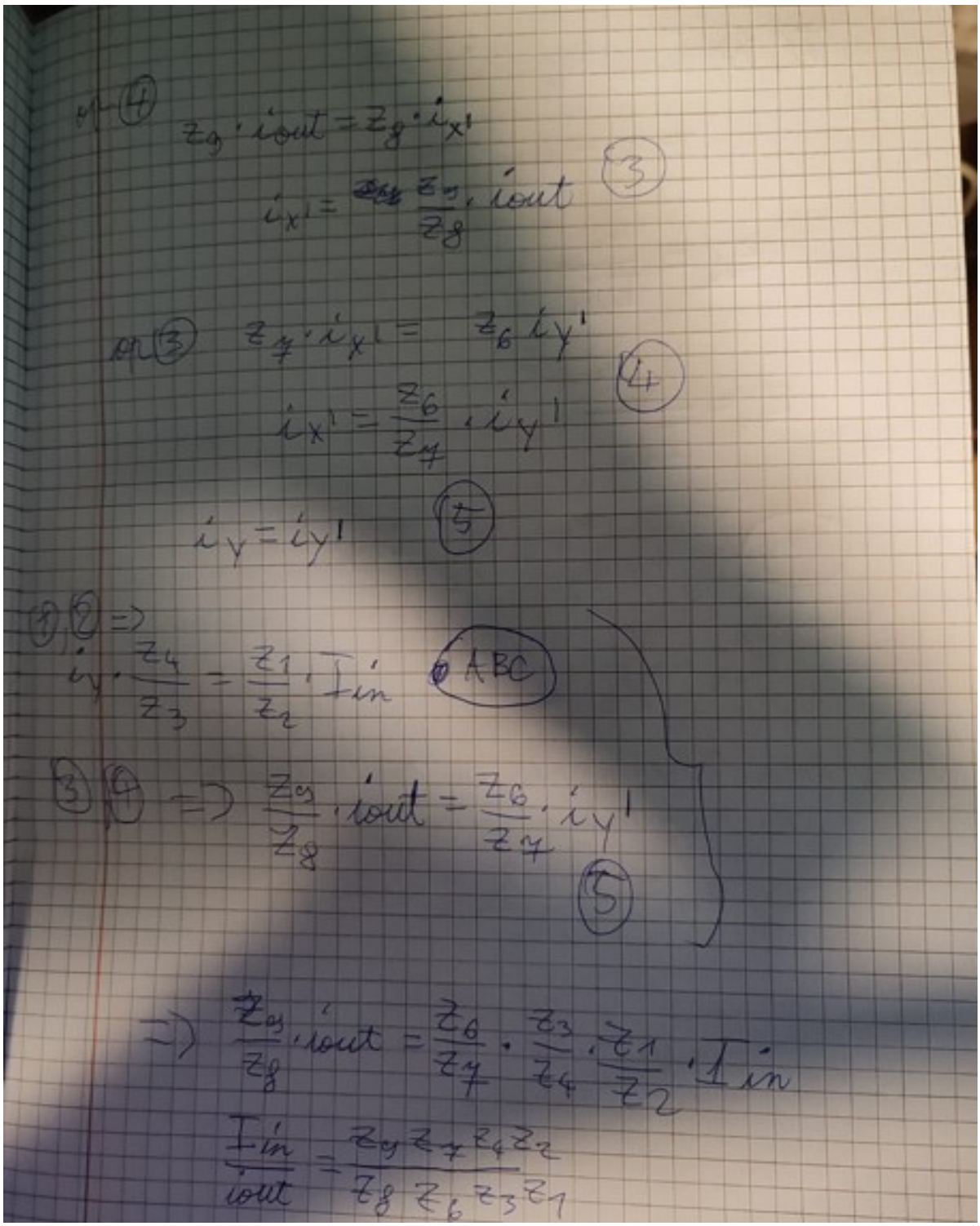
$$\Rightarrow i_2 = \frac{Z_3}{Z_4} \cdot i_x \quad (4)$$

$$3,4 \Rightarrow i_2 = \frac{Z_3}{Z_4} \cdot \frac{Z_1}{Z_2} \cdot I_{in} \quad (5)$$

$$I_{in} = \frac{V_{in}}{Z_{in}} \qquad i_2 = -i_2'$$

$$i_2 = \frac{Z_3}{Z_4} \cdot \frac{Z_1}{Z_2} \cdot \frac{V_{in1}}{Z_{in}} \qquad i_2' = \frac{Z_3'}{Z_4'} \cdot \frac{Z_1'}{Z_2'} \cdot \frac{v_2}{Z_{in}}$$


$\frac{Z_3}{Z_4} \cdot \frac{Z_1}{Z_2} \cdot \frac{v_1}{Z_{in}} = \frac{Z_4'}{Z_3'} \cdot \frac{Z_2'}{Z_1'} \cdot \frac{Z_{in}}{v_2}$
$\frac{Z_3 \cdot Z_3' \cdot Z_1 \cdot Z_1'}{Z_4 \cdot Z_4' \cdot Z_2' \cdot Z_2} \cdot v_1 \cdot v_2 = Z_{in} \cdot i$
$\Rightarrow Z_{in} = \frac{v_1 \cdot v_2}{2}$
OP 2
$Z_1 \cdot I_{in} = Z_2 \cdot i_x$
$i_x = \frac{Z_1}{Z_2} \cdot I_{in}$
(1)
OP 1
$Z_3 \cdot i_x = Z_4 \cdot i_y$
$i_x = \frac{Z_4}{Z_3} \cdot i_y$
(2)


(1) $Z_9 \cdot i_{out} = Z_8 \cdot i_{x'}$
$i_{x'} = \frac{Z_9}{Z_8} \cdot i_{out}$ (3)
(3) $Z_7 \cdot i_{x'} = Z_6 \cdot i_{y'}$
$i_{x'} = \frac{Z_6}{Z_7} \cdot i_{y'}$ (4)
$i_y = i_{y'}$ (5)
(1), (2) =>
$i_y \cdot \frac{Z_4}{Z_3} = \frac{Z_1}{Z_2} \cdot I_{in}$ (6) ABC
(3), (4) => $\frac{Z_9}{Z_8} \cdot i_{out} = \frac{Z_6}{Z_7} \cdot i_{y'}$ (5)
=> $\frac{Z_9}{Z_8} \cdot i_{out} = \frac{Z_6}{Z_7} \cdot \frac{Z_3}{Z_4} \cdot \frac{Z_1}{Z_2} \cdot I_{in}$
$\frac{I_{in}}{i_{out}} = \frac{Z_9 Z_7 Z_4 Z_2}{Z_8 Z_6 Z_3 Z_1}$

v_1 sau $v_{in}' = i_y \cdot Z_5$

$v_2 = -i_y \cdot Z_5$

$$Z_{in}' = \frac{v_1}{I_{in}}$$

$$Z_{in}' = \frac{i_y \cdot Z_5}{I_{in}}$$

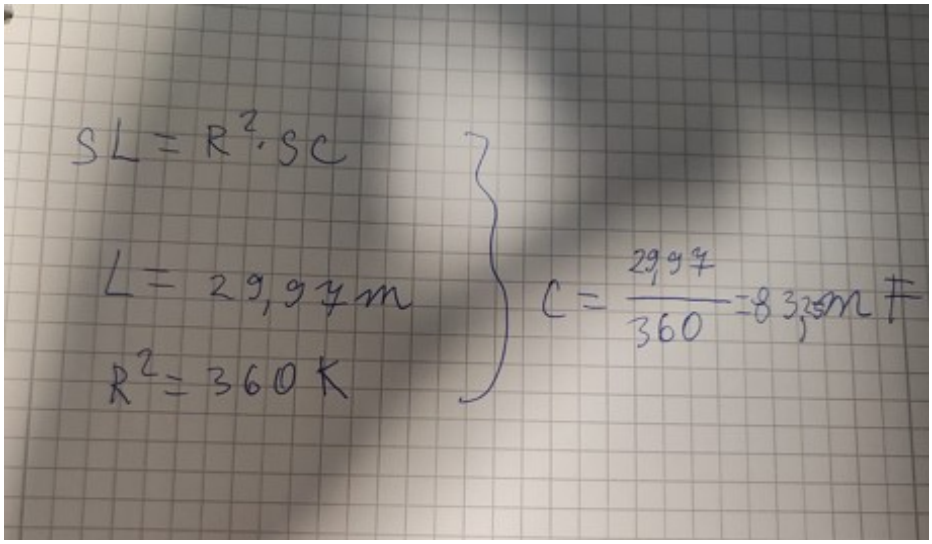
(ABC) \ $i_y \cdot \frac{Z_4}{Z_3} = \frac{Z_1}{Z_2} \cdot I_{in}$

$$Z_{in}' = \frac{Z_1}{Z_2} \cdot \frac{Z_3}{Z_4} \cdot Z_5$$

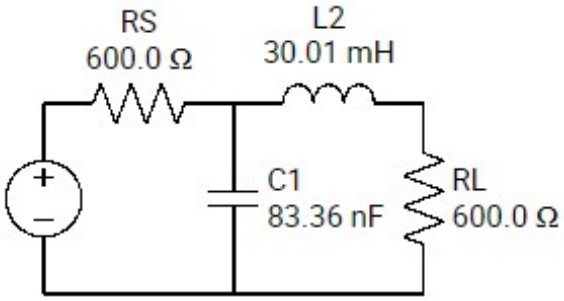
dacă înlocuim Z_4 cu condensator și restul cu rezistențe

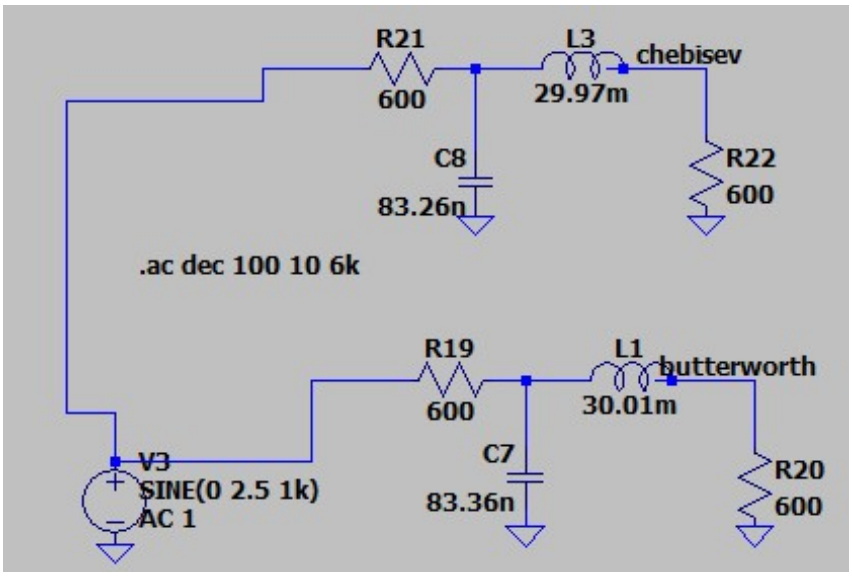
$$\Rightarrow Z_{in} = \frac{R \cdot R \cdot R}{R \cdot \frac{1}{sC}} = R^2 \cdot sC$$

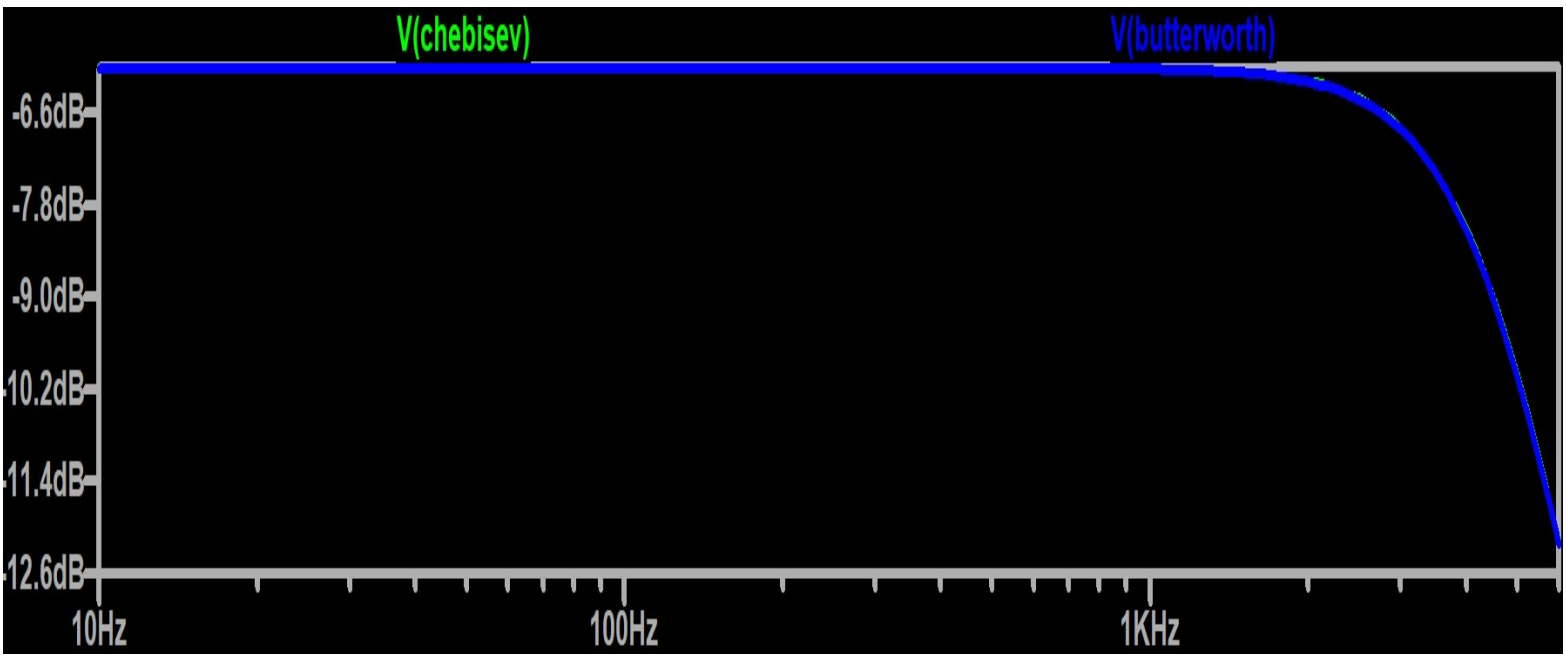
~~se poate~~ și pe partea cealaltă tot așa valori o să avem deoarece e simetric.


SL = R². SC
L = 29,97m
R² = 360 K
C = 29,97 / 360 = 83,25m

Chebisev vs Butterworth

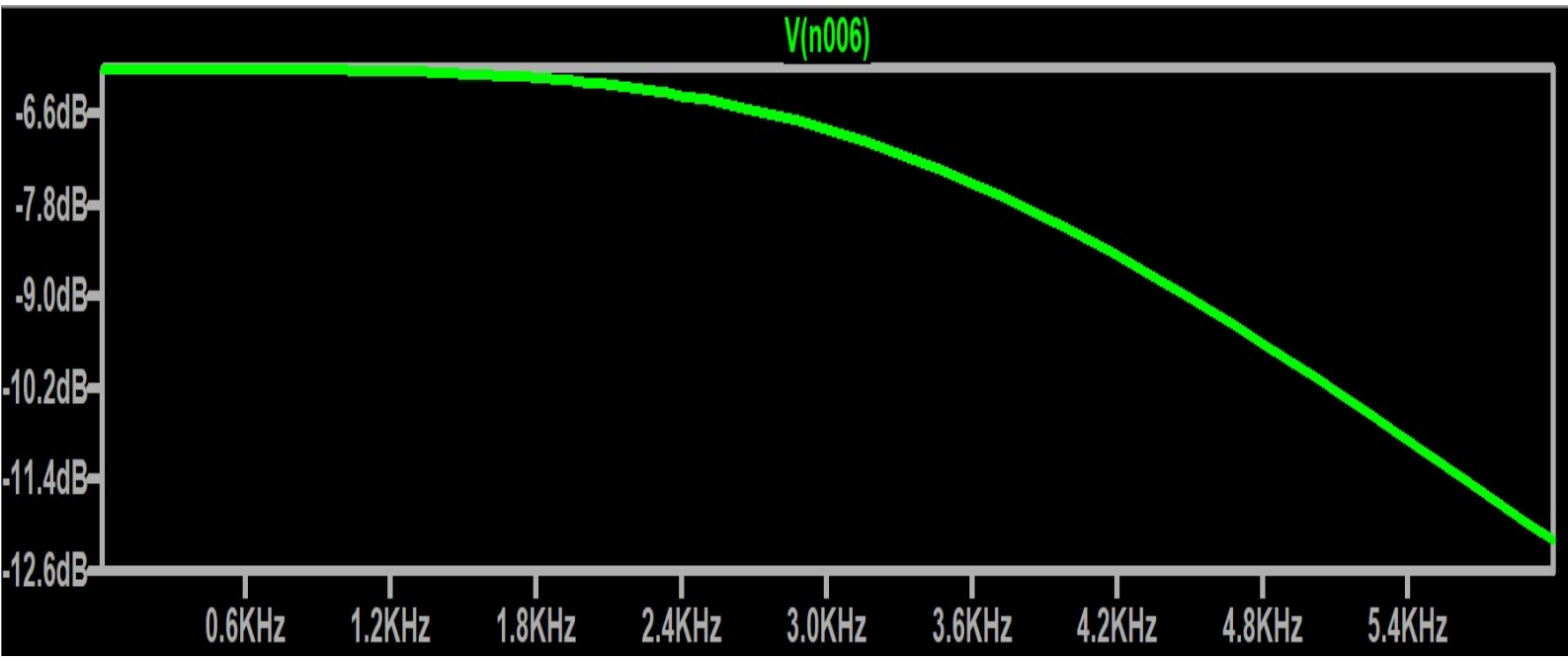


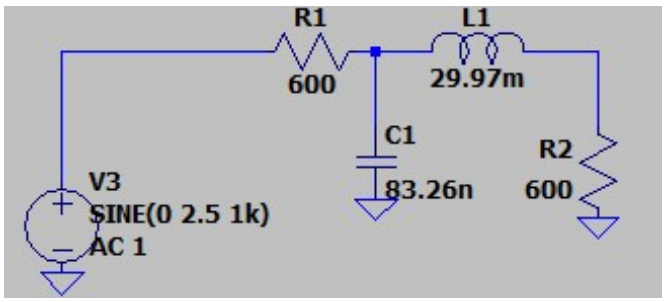


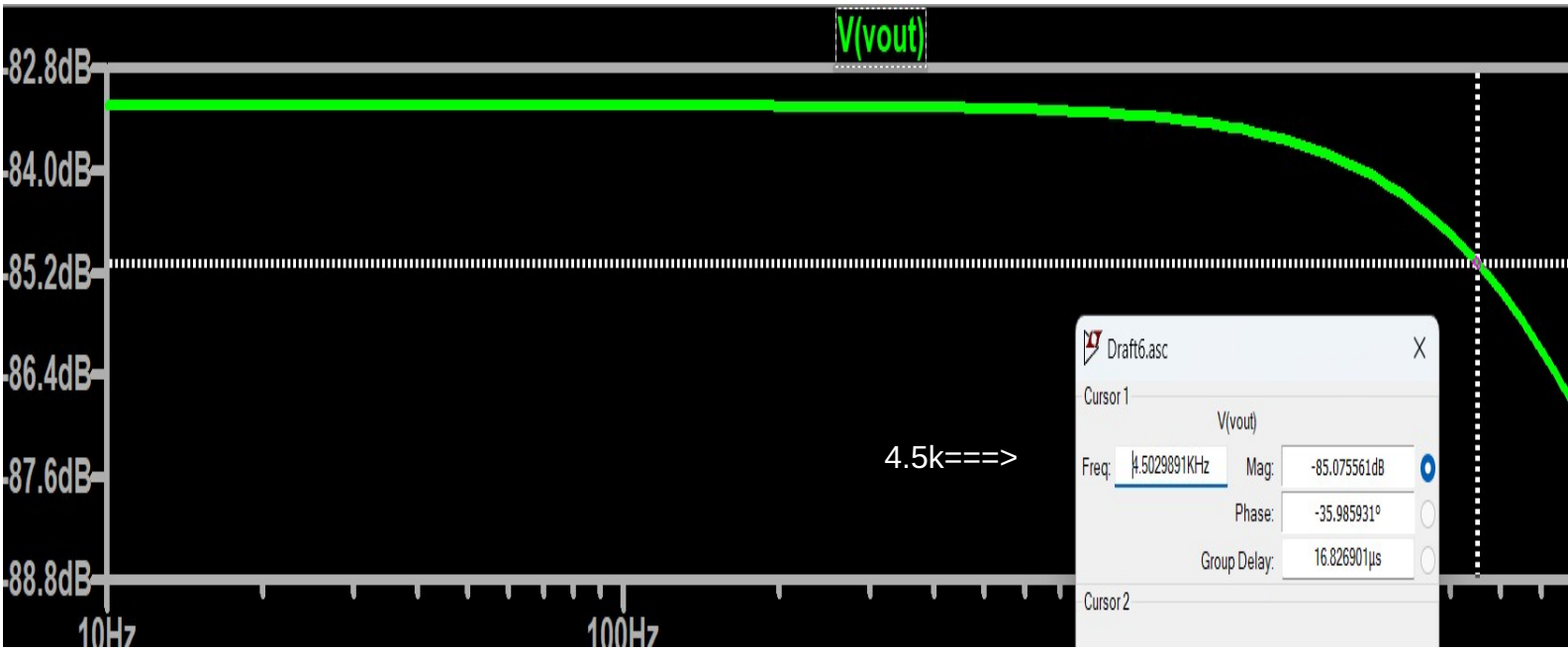


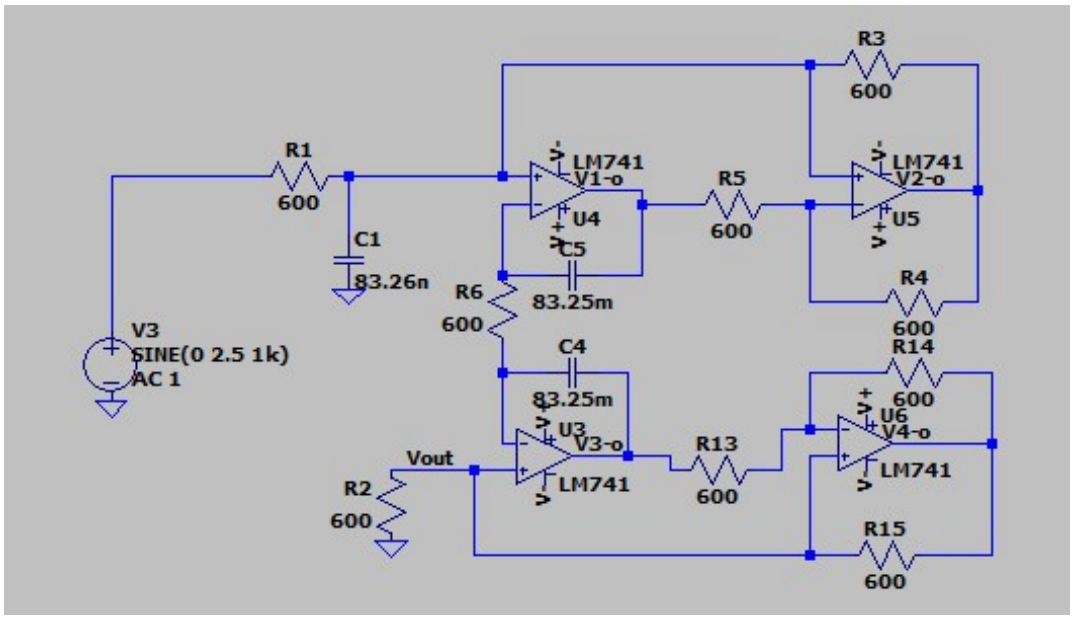
Acelasi lucru ce l-am discutat si la TS

Raspunsul in frecventa





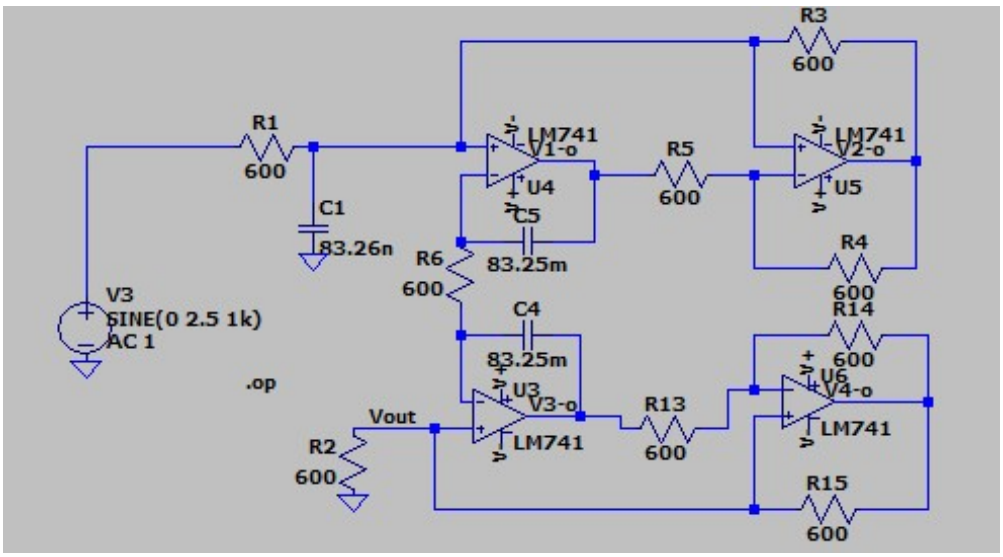

V(vout)
-82.8dB
-84.0dB
-85.2dB
-86.4dB
-87.6dB
-88.8dB
10Hz
100Hz
4.5k===>
Draft6.asc
Cursor 1
V(vout)
Freq: 4.5029891KHz
Mag: -85.075561dB
Phase: -35.985931°
Group Delay: 16.826901µs
Cursor 2


R3
600
R1
600
LM741
V1-o
U4
R5
600
LM741
V2-o
U5
C1
83.26n
C5
83.25m
R6
600
R4
600
V3
SINE(0 2.5 1k)
AC 1
C4
83.25m
R14
600
U6
V4-o
LM741
U3
V3-o
LM741
Vout
R2
600
R13
600
R15
600

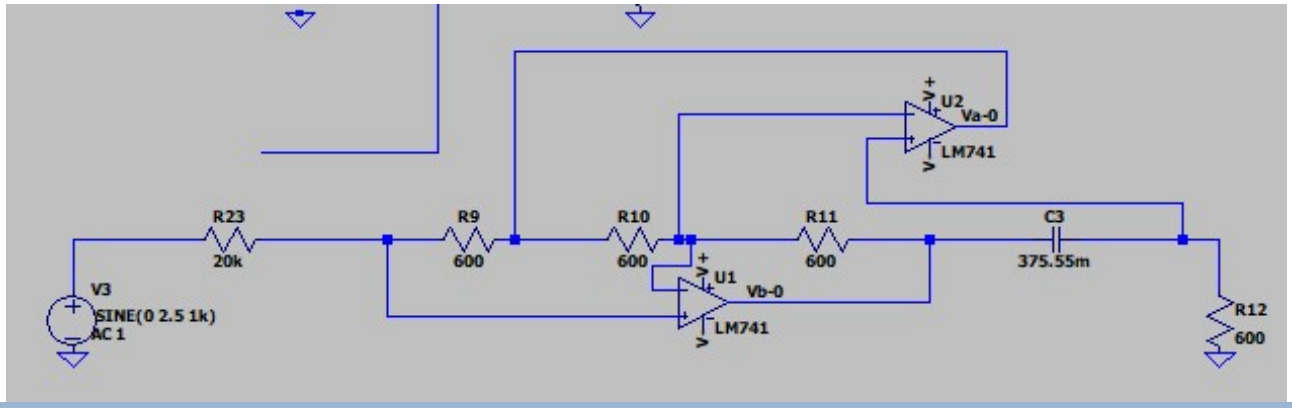
```
        --- Operating Point ---

V(n009):        -3.47069e-05   voltage
V(vin):         0              voltage
V(n010):        -7.82155e-21   voltage
V(n014):        0.000965296    voltage
V(v-):          -5             voltage
V(v+):          5              voltage
V(n016):        0.00208753     voltage
V(n015):        -3.47207e-05   voltage
V(n013):        -3.4693e-05    voltage
V(n001):        -1.83588       voltage
V(n005):        0              voltage
V(vout):        -1.83588       voltage
V(n011):        -1.86494       voltage
V(v3-o):        3.74401        voltage
V(n007):        -1.86494       voltage
V(v1-o):        3.74401        voltage
V(n008):        0.0338723      voltage
V(v2-o):        -3.67391       voltage
V(n012):        0.0338723      voltage
V(v4-o):        -3.67391       voltage
V(n003):        0              voltage
V(n002):        0              voltage
V(n004):        0              voltage
V(n006):        0              voltage
V(n019):        0              voltage
V(n017):        0              voltage
```

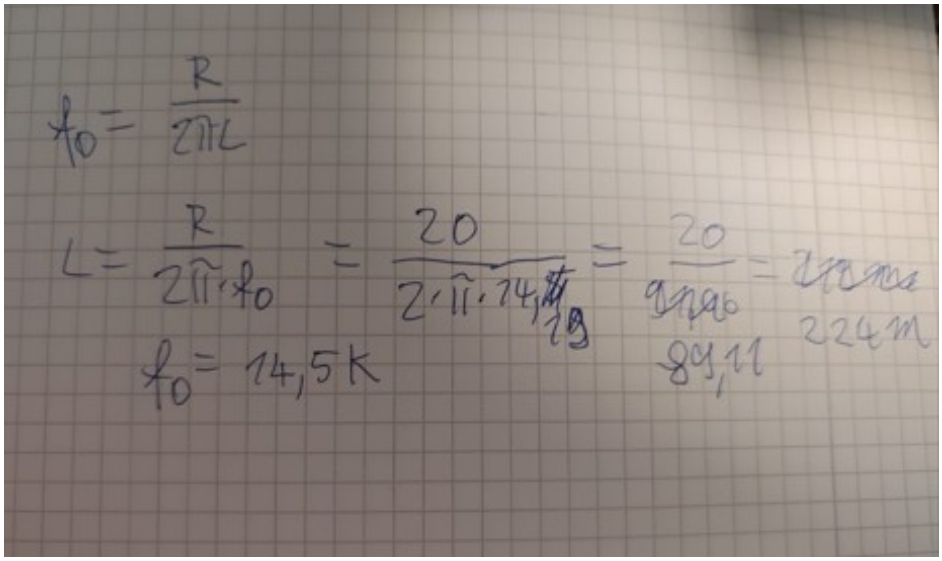
Nu sunt liniare,am incercat sa vad daca functioneaza ca o inductanta si functioneaza



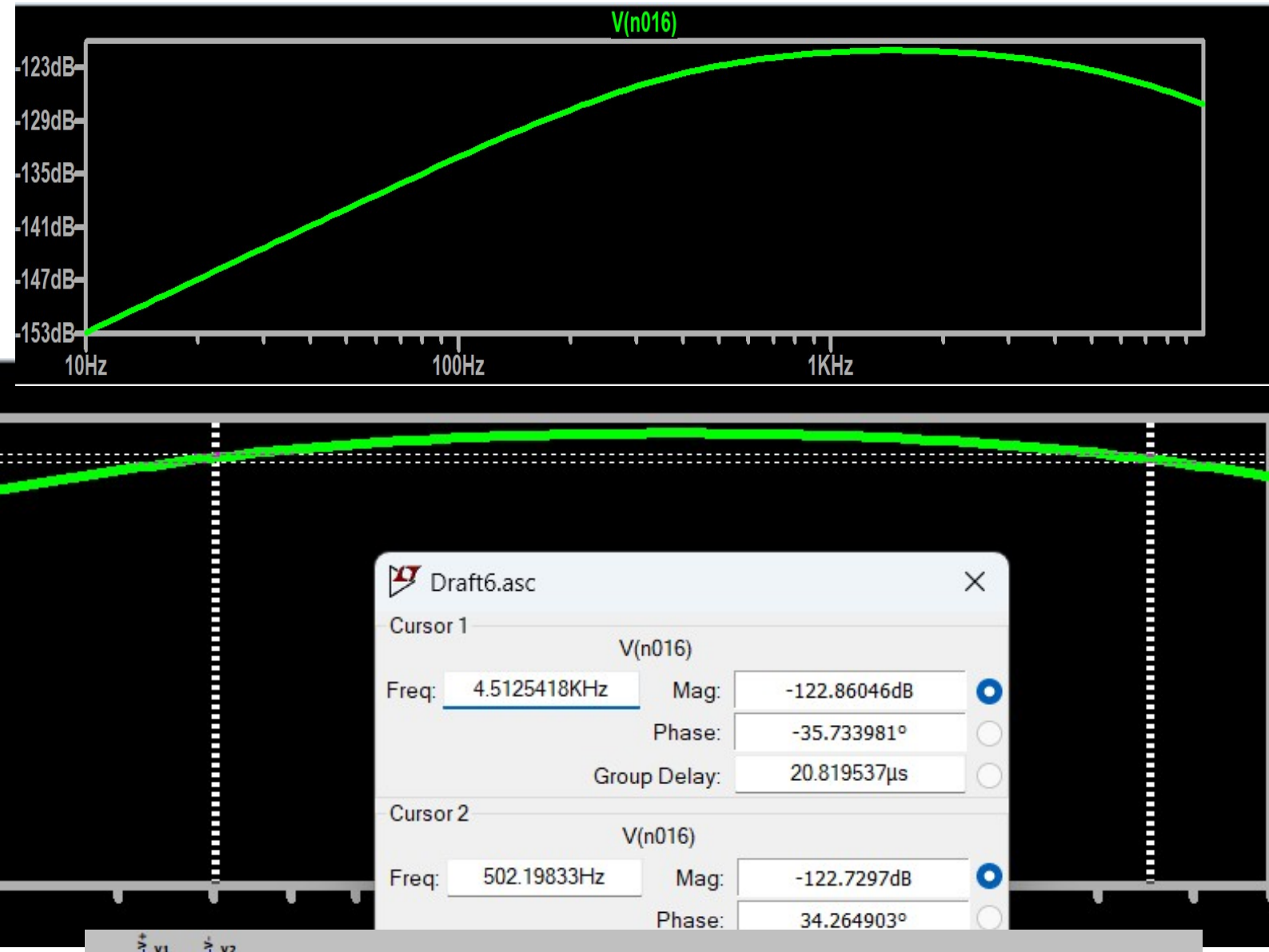
Am ceva probleme si la primul circ deoarece incepe de la -6db nu de la zero

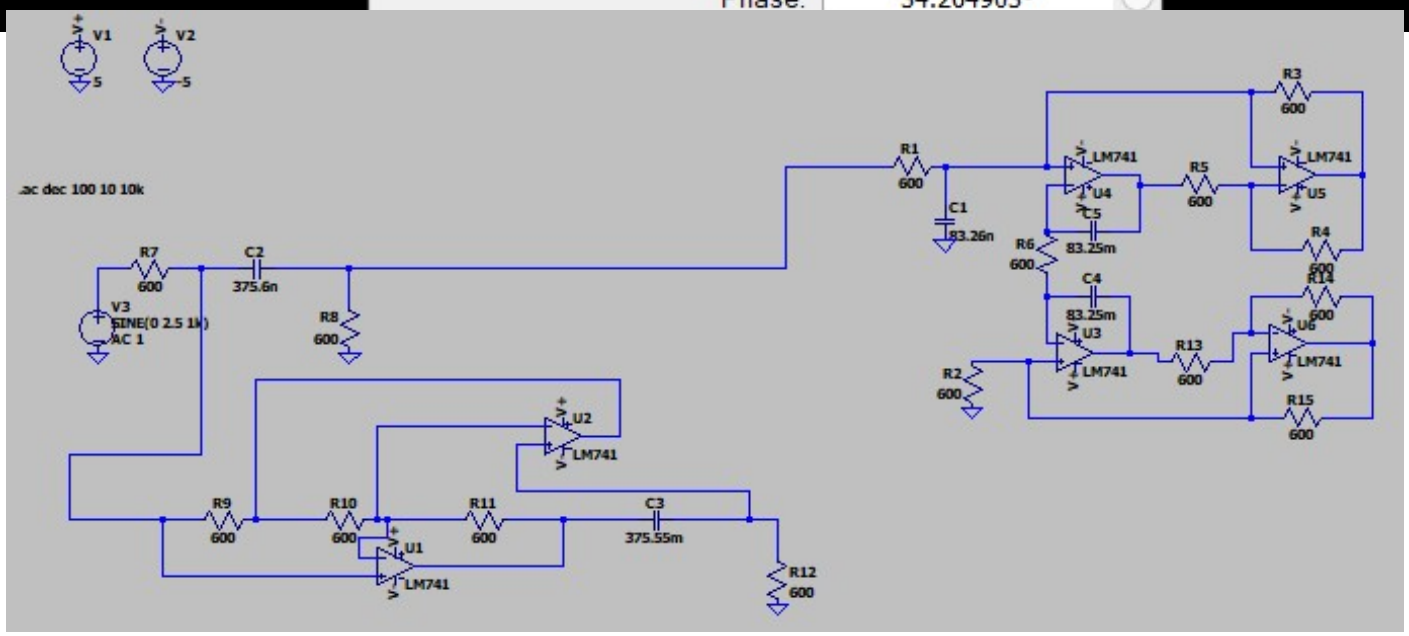


la B3db am 14.19K

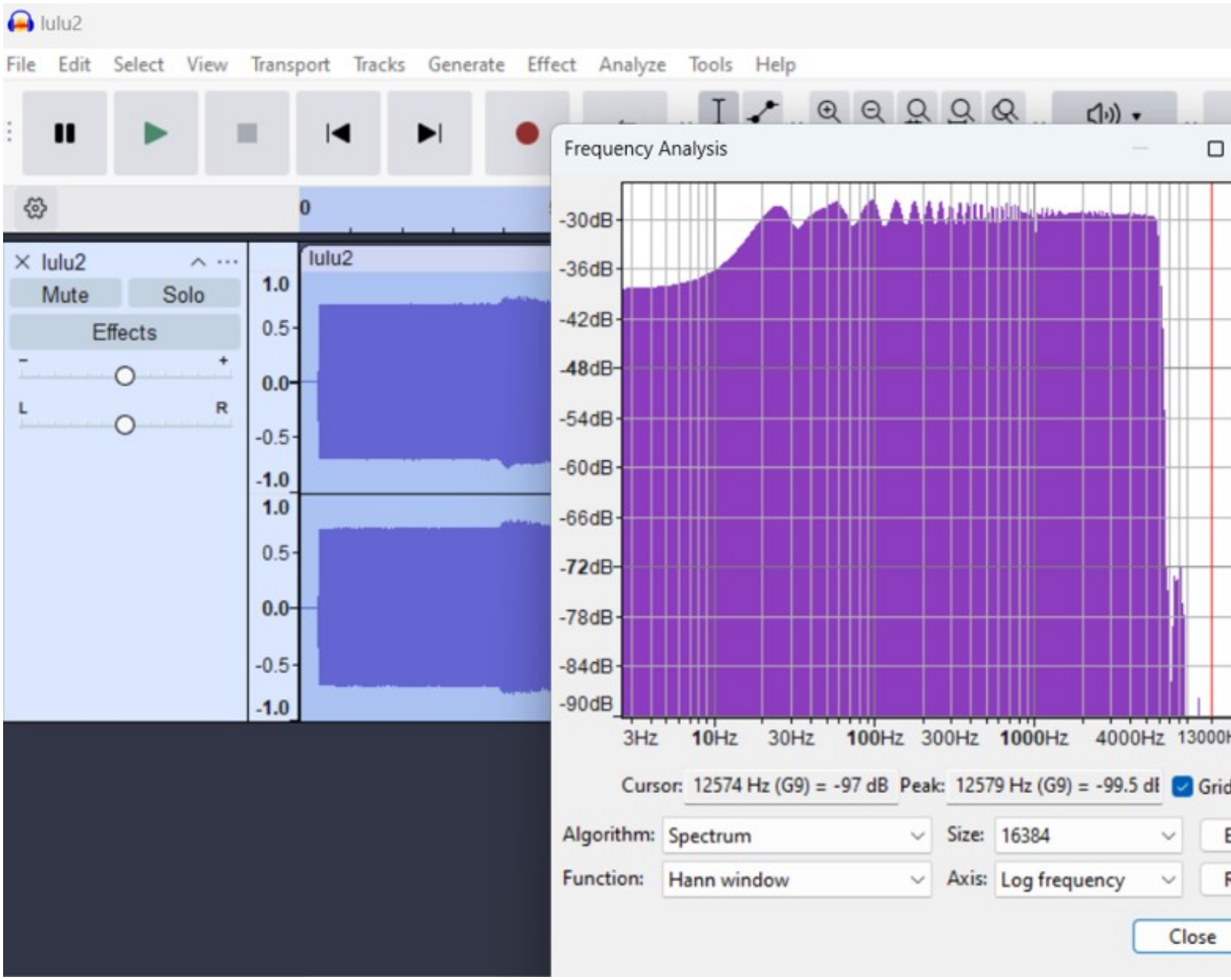

$f_0 = \frac{R}{2\pi L}$
$L = \frac{R}{2\pi \cdot f_0} = \frac{20}{2 \cdot \pi \cdot 14,5} = \frac{20}{89,11} = 224\,m$
$f_0 = 14,5\,K$

Circuitul Final





Testare cu fisier .war



In aplicatia Audacity putem vedea spectrul fisierului care este intre 25Hz-10kHz
Fisierul e un video de pe youtube pe care l-am downloadat "Sound test 10hz-10khz"

Nu merge

Fisier Muzica