PROIECT VU-METRU

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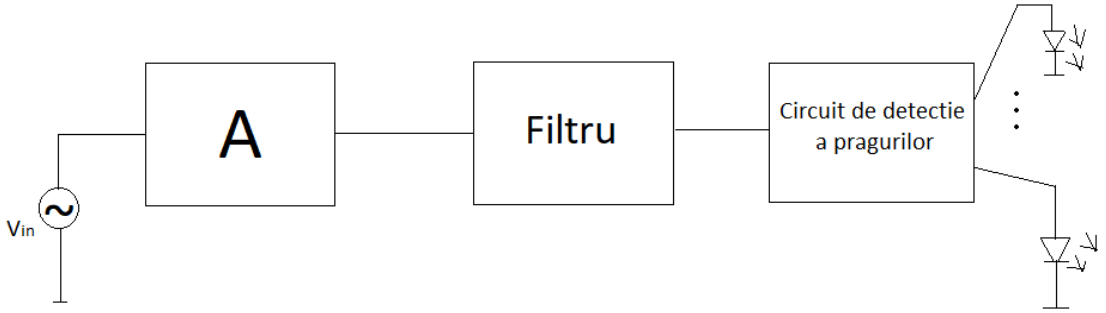
Grupa: 2127

Sa se proiecteze un circuit electronic care sa indice pe un afisaj cu LED-uri nivelul semnalului audio dintr-o banda de frecventa specificata (VU-metru). Circuitul este alimentat de la tensiunea ±VCC. LED-urile trebuie sa fie de culori diferite pentru fiecare domeniu specificat.

Date de proiectare

Amplitudinea semnalului de intrare [uV]	Banda de frecventa [Hz]		VCC	Semnalizari
	fmin	fmax		
880	200	8500	12	4

Schema bloc



Etape proiectare

1) Amplificatorul
2) Filtru
3) Circuit de detectie a paragurilor
4) Led-urile

1. Amplificatorul

Tensiunea de intrare este foarte mica de aceea semnalul trebuie amplificat.

DIMENSIONARE COMPONENTE (Prima amplificare)

AO are RN(reactie negativa) => $v_D = 0$

$$\left.\begin{array}{l} v_D = v^+ - v^- \\ v^- = \frac{R1}{R1+R2} * V_{out1} \\ v^+ = v_I \end{array}\right\} \dot{=}> v_I - \frac{R1}{R1+R2} * V_{out1} = 0 => v_I = \frac{R1}{R1+R2} * V_{out1}$$

$$A_v = \frac{Vout1}{vI} = 1 + \frac{R2}{R1}$$

Semnalul este amplificat datorita celor 2 rezistente!

Aleg V_{out1} = 50 mV

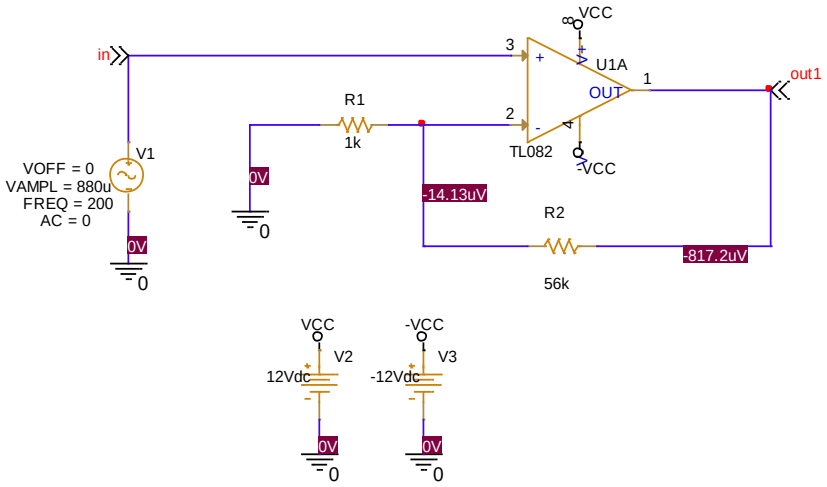
$$\Rightarrow A_v = \frac{Vout1}{vI} = \frac{50m}{0{,}88m} = 56{,}8 \approx 57$$

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

$$\Rightarrow 57 = 1 + \frac{R2}{R1} \Rightarrow \frac{R2}{R1} = 56 \Rightarrow R2 = 56R1$$

Daca $R1$ = 1 kΩ => $R2$ = 56 kΩ

SHEMA ELECTRICA

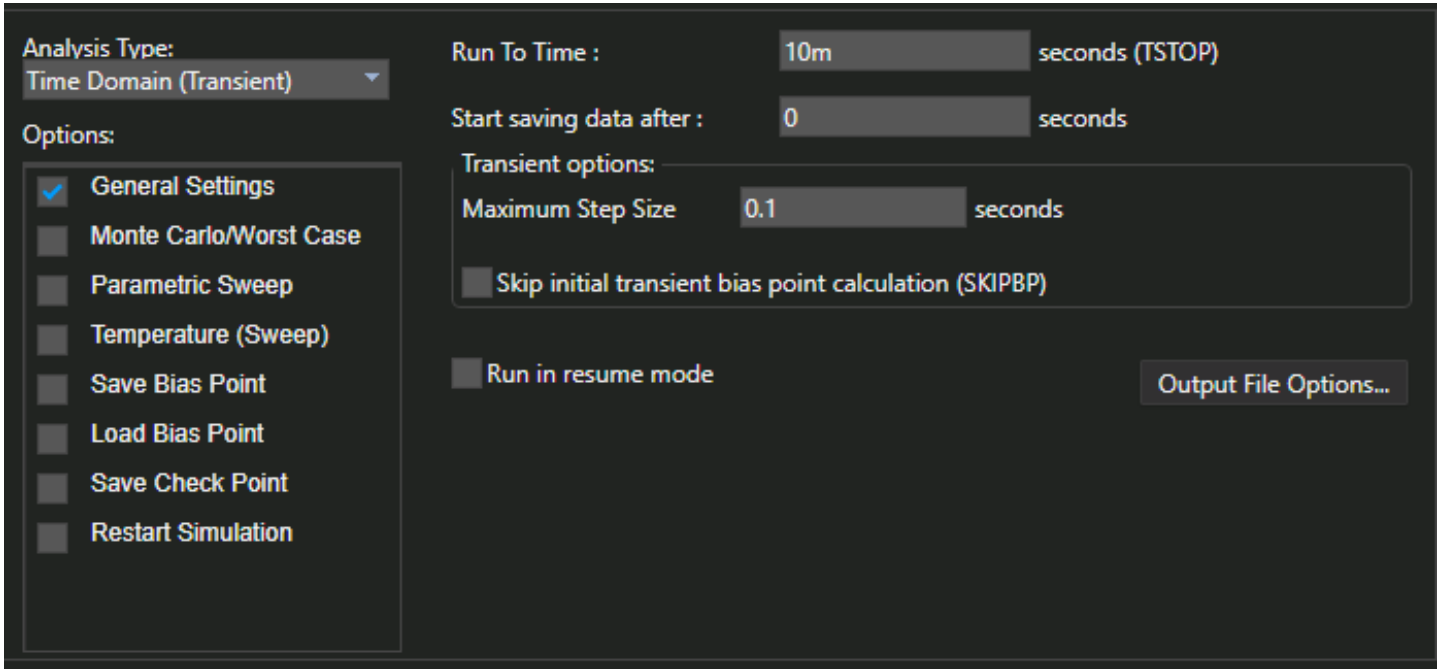


Amplificator neinversor cu reactie negativa pentru prima etapa de amplificare

Voff = 0 (nu exista componenta continua)

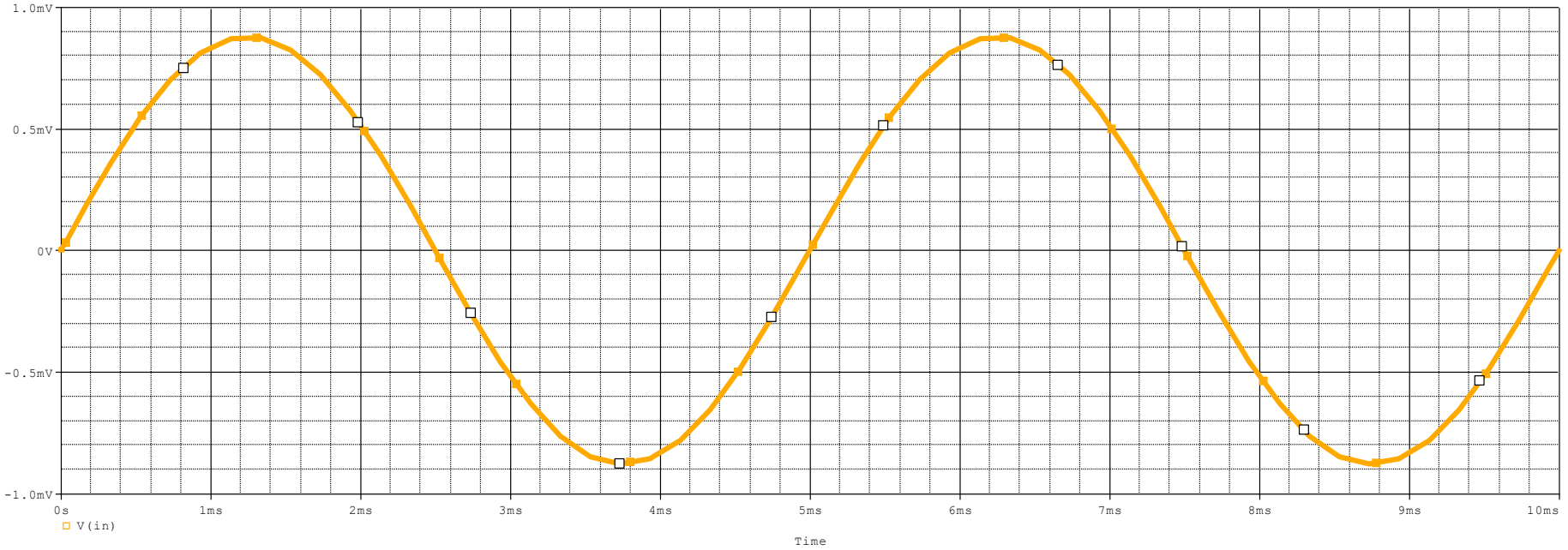
VAMPL = 880u (amplitudinea semnalului de intrare)

FREQ = 200 (frecventa minima din banda de frecvente)



Profil de simulare (analiza in timp pentru a putea vizualiza formele de unda ale semnalului de intrare/iesire)

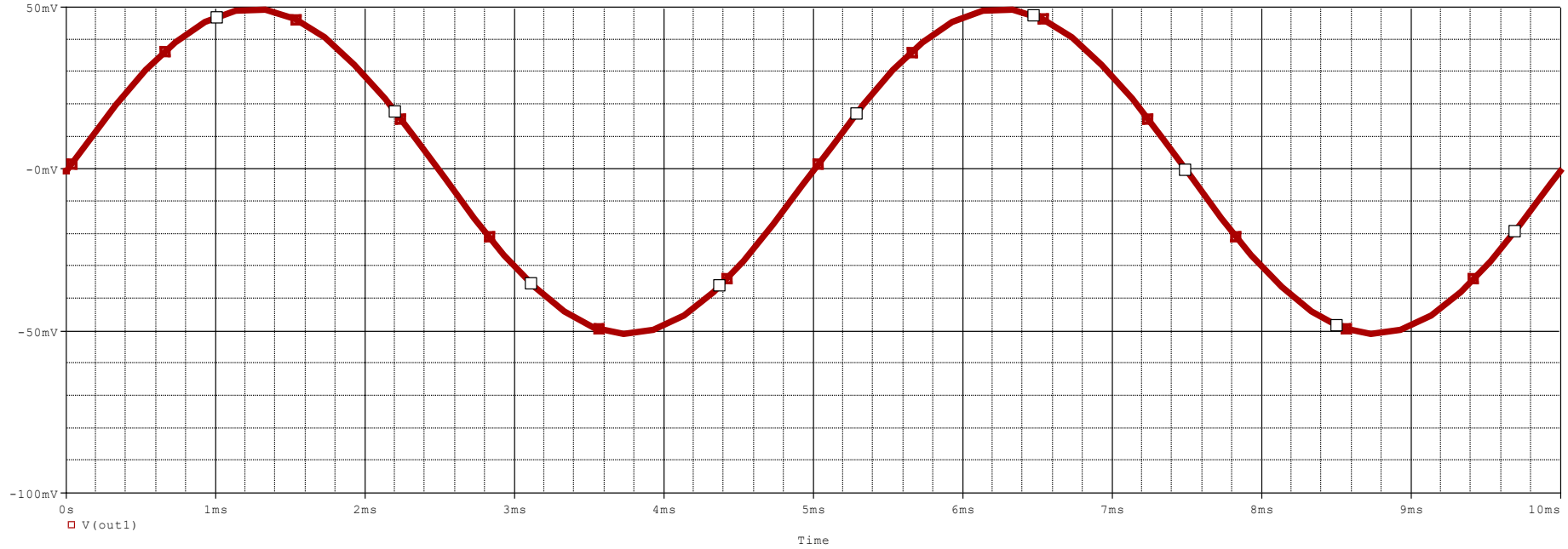
Semnalul de intrare



Trace Color	Trace Name	Y1	Y2	Y1 - Y2
	X Values	6.1712m	0.000	6.1712m
CURSOR 1,2	V(in)	871.551u	0.000	871.551u

Valoarea amplitudinii semnalului de intrare

Semnalul de iesire dupa prima amplificare



Trace Color	Trace Name	Y1	Y2	Y1 - Y2
	X Values	6.3356m	0.000	6.3356m
CURSOR 1,2	V(out1)	49.061m	-817.233u	49.879m

Diferenta dintre valoarea aleasa si cea obtinuta este foarte mica

Valoarea amplitudinii semnalului de iesire dupa prima amplificare

Deoarece tensiunea de intrare este foarte mica mai avem nevoie 2 de amplificari!

DIMENSIONARE COMPONENTE (A doua amplificare)

Dimensionam rezistentele R3 si R3.

AO are RN => $v_D = 0$

$v_D = v^+ - v^-$

$v^- = \frac{R3}{R3+R4} * V_{out2}$

$v^+ = V_{out1}$

$\Big\} \Rightarrow \cdot V_{out1} - \frac{R3}{R3+R4} * V_{out2} = 0 \Rightarrow V_{out1} = \frac{R3}{R3+R4} * V_{out2}$

$A_v = \frac{Vout2}{Vout2} = 1 + \frac{R4}{R3}$

Amplificarea este data de cele 2 rezistente!

Aleg Vout2 = 5V

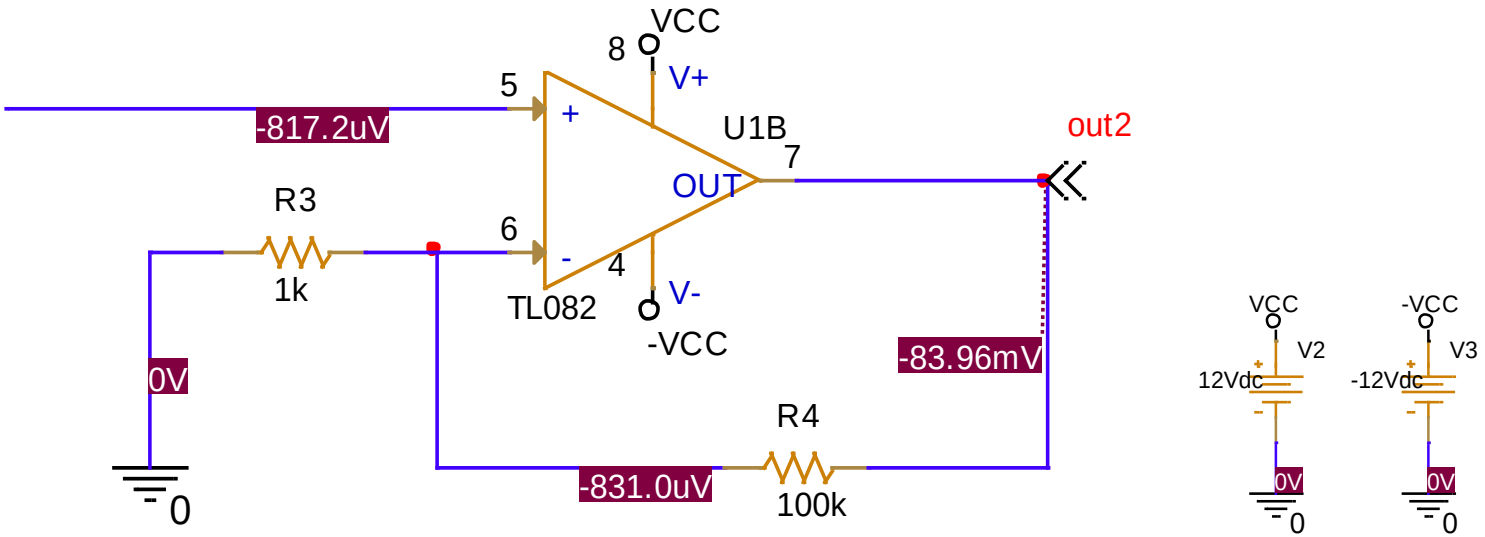
$A_v = \frac{Vout2}{Vout1} = \frac{5}{50*10^{-3}} = 100$

$A_v = 1 + \frac{R4}{R3}$

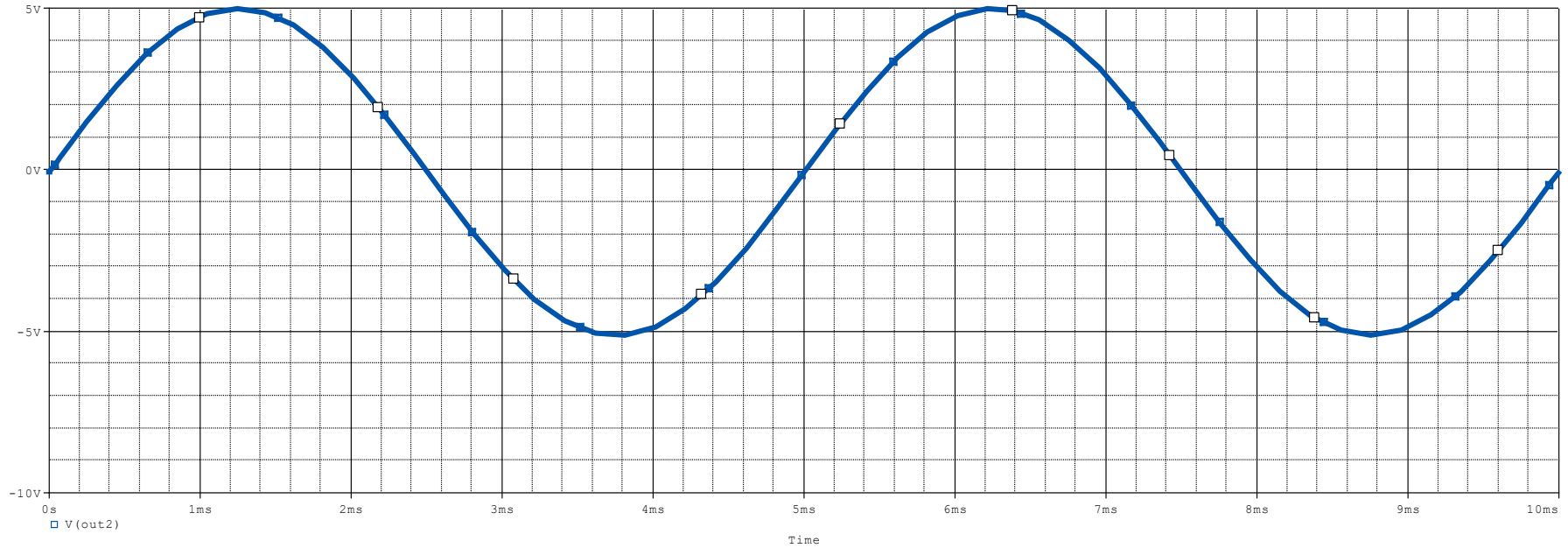
$\Big\} \Rightarrow 100 = 1 + \frac{R4}{R3} \Rightarrow 1 + \frac{R4}{R3} = 1 \Rightarrow R4 = 100 * R3$

Daca $R3 = 1$ kΩ => $R4$ = 99 kΩ

Am pus o rezistenta de 100 kΩ in loc de cea de 99k.



Semnalul de iesire dupa a doua amplificare



Trace Color	Trace Name	Y1	Y2	Y1 - Y2
	X Values	6.2230m	0.000	6.2230m
CURSOR 1,2	V(out2)	4.9714	-83.956m	5.0554

Valoarea amplitudinii semnalului de iesire dupa a doua amplificare

DIMENSIONARE COMPONENTE (A treia amplificare)

Dimensionam rezistentele R18 si R19.

AO are RN => $v_D = 0$

$v_D = v^+ - v^-$

$v^- = \frac{R18}{R18+R19} * V_{out3}$

$v^+ = V_{out2}$

$\Rightarrow \quad V_{out2} - \frac{R18}{R18+R19} * V_{out3} = 0 \Rightarrow V_{out2} = \frac{R18}{R18+R19} * V_{out3}$

$A_v = \frac{Vout3}{Vout2} = 1 + \frac{R19}{R18}$

Amplificarea este data de cele 2 rezistente!

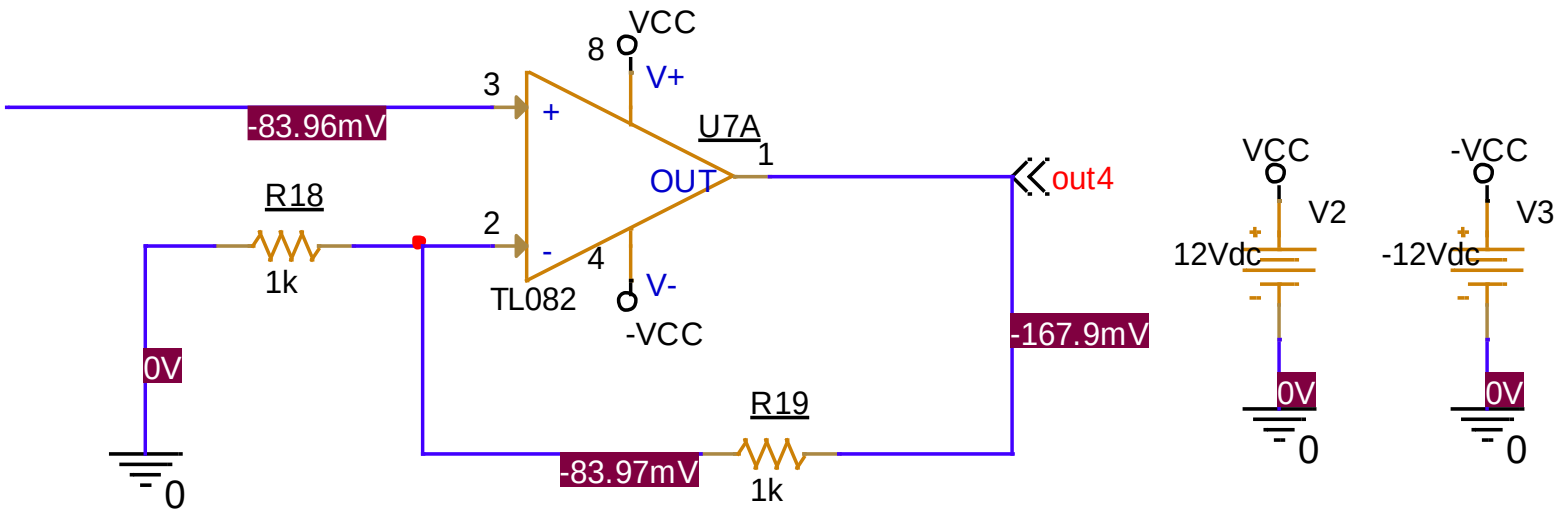
Aleg Vout3 = 10V

$A_v = \frac{Vout3}{Vout2} = \frac{10}{5} = 2$

$A_v = 1 + \frac{R19}{R18}$

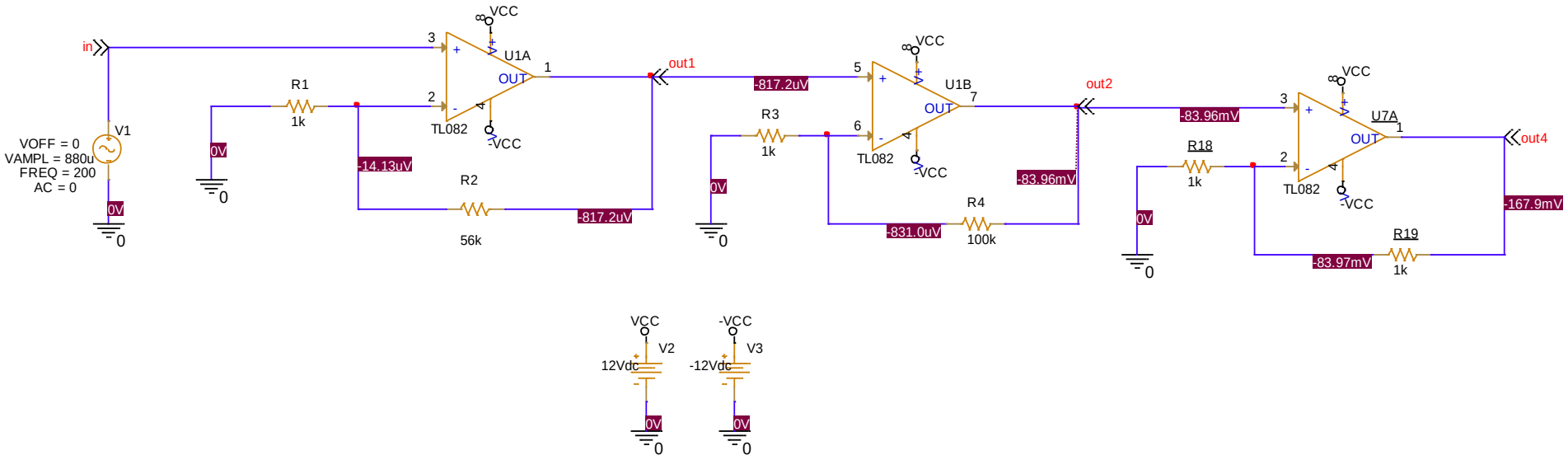
$\Rightarrow 2 = 1 + \frac{R19}{R18} \Rightarrow \frac{R19}{R18} = 1 \Rightarrow R19 = 1 * R18$

Daca $R18 = 1\ k\Omega$ => $R19 = 1\ k\Omega$



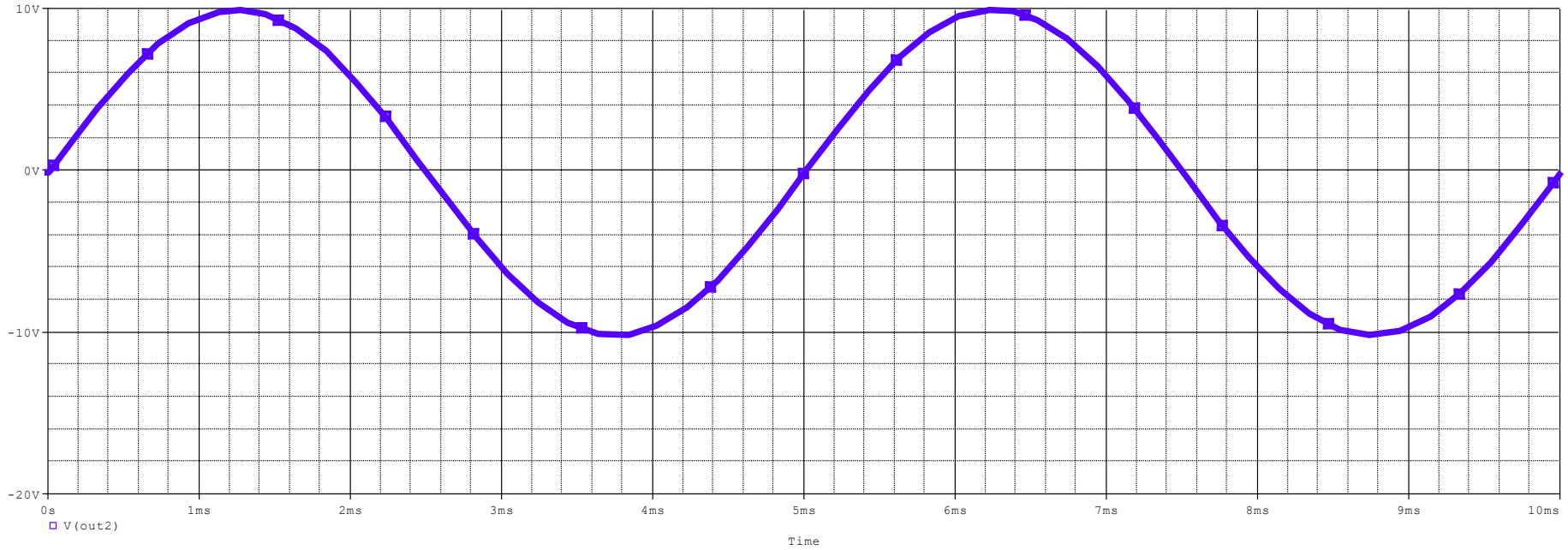
Amplificator neinversor cu reactie negativa pentru a treia etapa de amplificare

SHEMA ELECTRICA



Intregul circuit de amplificare format din 3 AO neinversoare cu RN

Semnalul de iesire dupa a treia amplificare



Trace Color	Trace Name	Y1	Y2	Y1 - Y2
	X Values	3.7973m	0.000	3.7973m
CURSOR 1,2	V(out2)	10.172	-167.022m	-10.005

Valoarea amplitudinii semnalului de iesire dupa a doua amplificare

- ✓ Tensiunea de intrare este de 12V => la iesire circuitul nu poate avea un semnal mai mare de 12V!
- ✓ Dupa dimensionare si proiectare la iesire vor fi 10V.

2. Filtru

Semnalul amplificat trebuie filtrat in functie de banda de frecvente => filtru trece banda

fmin = f_i = 200Hz

fmax = f_s = 8500Hz

⇨ Banda de frecvente = 8500 – 200 = 8300Hz

Dimensionez R_5 si R_6.

Fie C_1 = 50nF , iar C_2 = 220pF

$$f_{min} = \frac{1}{2\pi R_5 C_1} => R_5 = \frac{1}{2\pi C_1 f_{min}}$$

$$R_5 = \frac{1}{6{,}28*50*10^{-9}*200} = \frac{1}{6{,}28*0{,}5*10^2*10^{-9}*20*10} = \frac{10^6}{62{,}8}$$

$$R_5 = 0{,}015 * 10^6 => R_5 = 15\text{k}\Omega$$

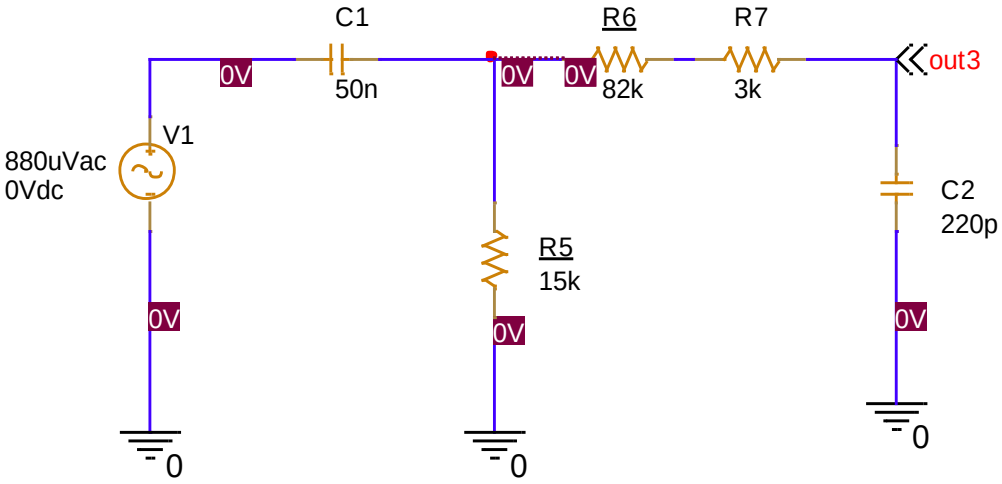
$$f_{max} = \frac{1}{2\pi R_6 C_2} => R_6 = \frac{1}{2\pi C_2 f_{max}}$$

$$R_6 = \frac{1}{6{,}28*220*10^{-12}*8500} = \frac{1}{6{,}28*0{,}22*10^3*10^{-12}*85*10^2} = \frac{10^7}{117{,}436}$$

$$R_6 = 0{,}085 * 10^6 => R_6 = 85\text{k}\Omega$$

Deoarece nu exista rezistenta de 85k voi folosi 2 rezistente in serie. Una de 82k si una de 3k.

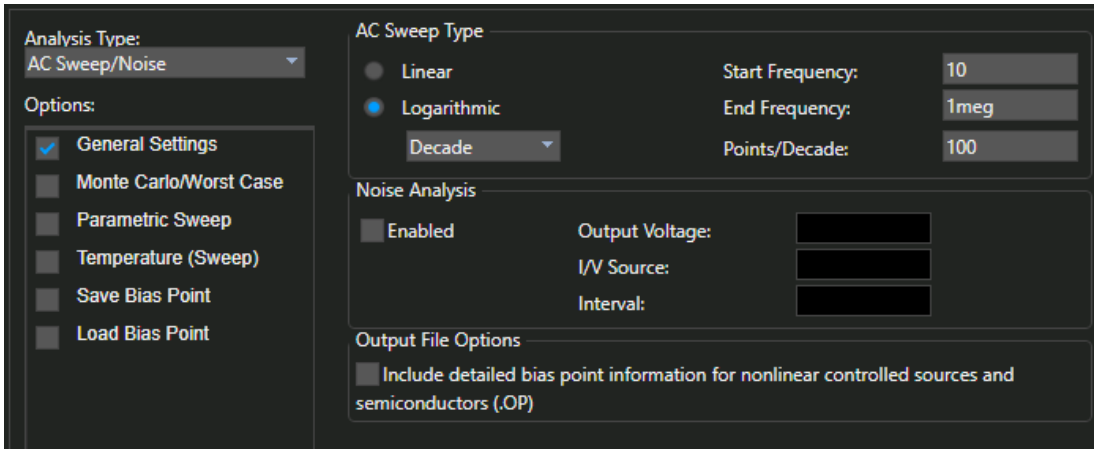
Schema electrica



Filtru trece banda

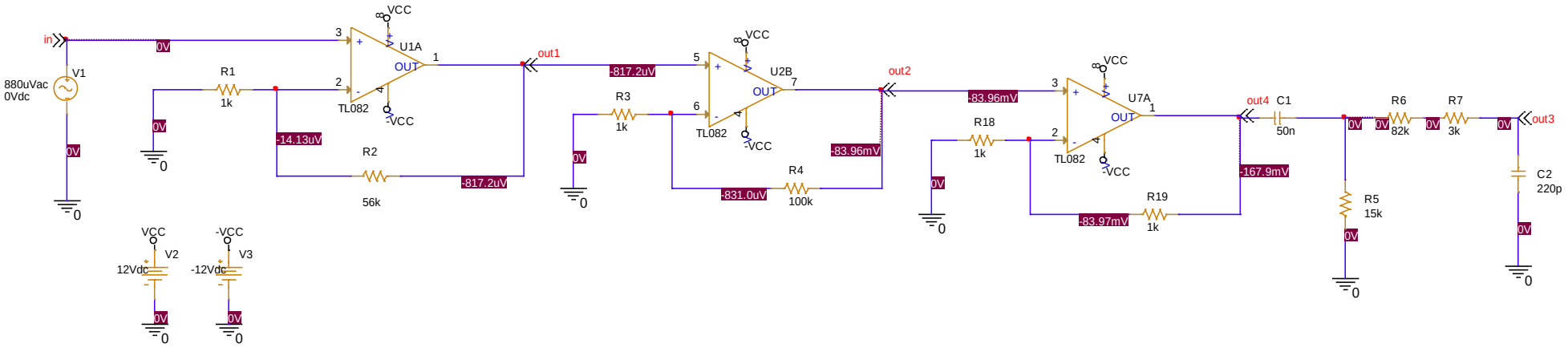
Measurement	Value
Bandwidth_Bandpass_3dB(V(out3))	8.31093k
Cutoff_Highpass_3dB(V(out3))	201.76446
Cutoff_Lowpass_3dB(V(out3))	8.51269k

Banda de frecvente a semnalului dupa amplificare si filtrare

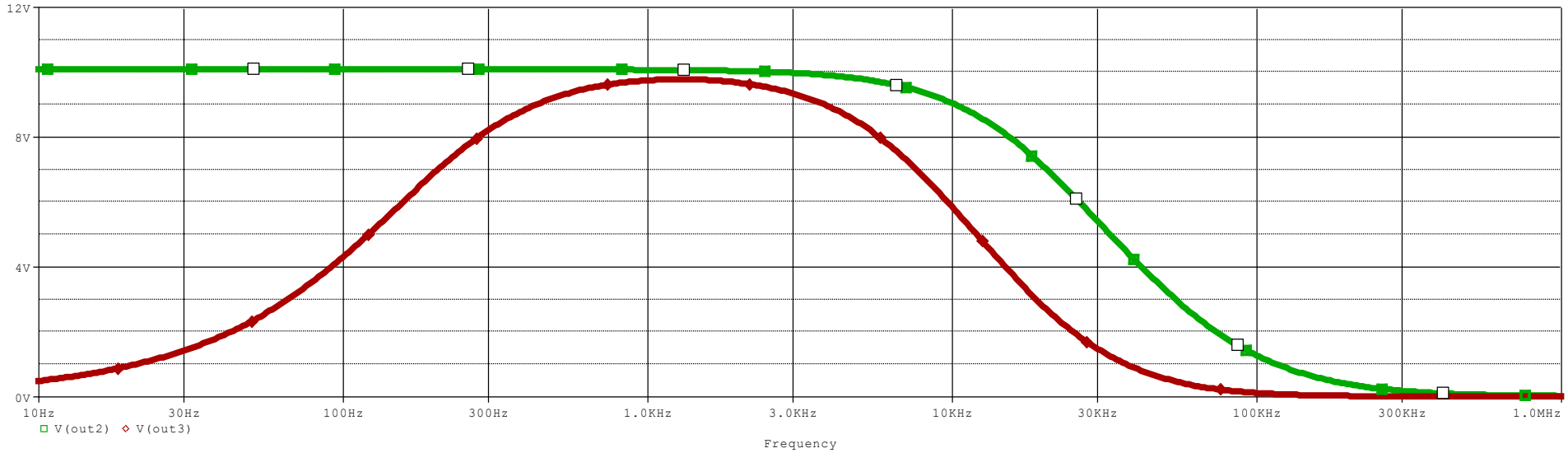


Profil de simulare AC Sweep (pentru a vizualiza banda de frecvente a semnalului)

Amplificator + filtru



Semnalul amplificat nefiltrat (verde) si semnalul amplificat filtrat (rosu)



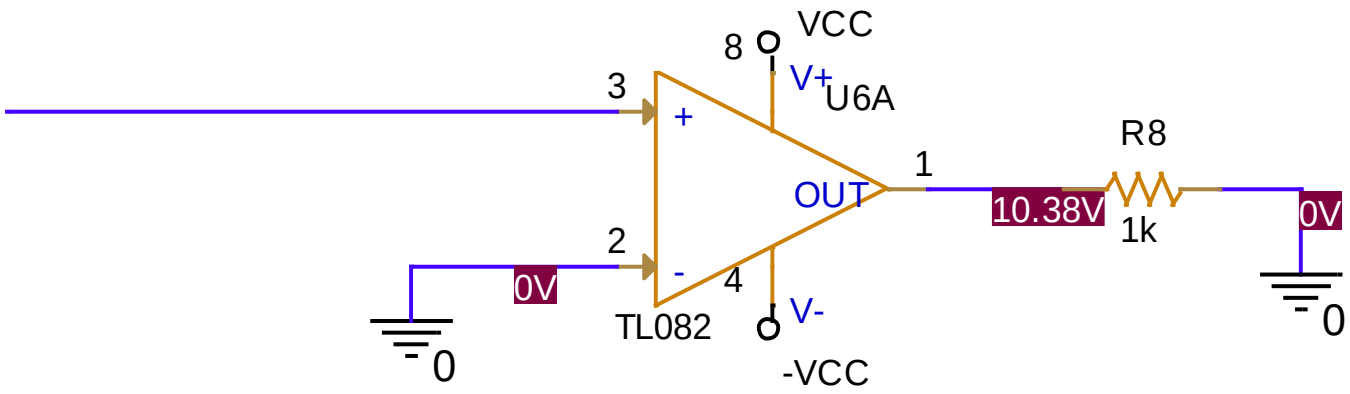
3. Circuit de detectie a pragurilor

I. 0V – 2.5V

$v_D = v^+ - v^-$

$v^- = 0$

$v^+ = V_{cc} = 12V$



Comparator neinversor pentru primul prag

II. 2.5V – 5V

$v^+ = V_{cc} = 12V$

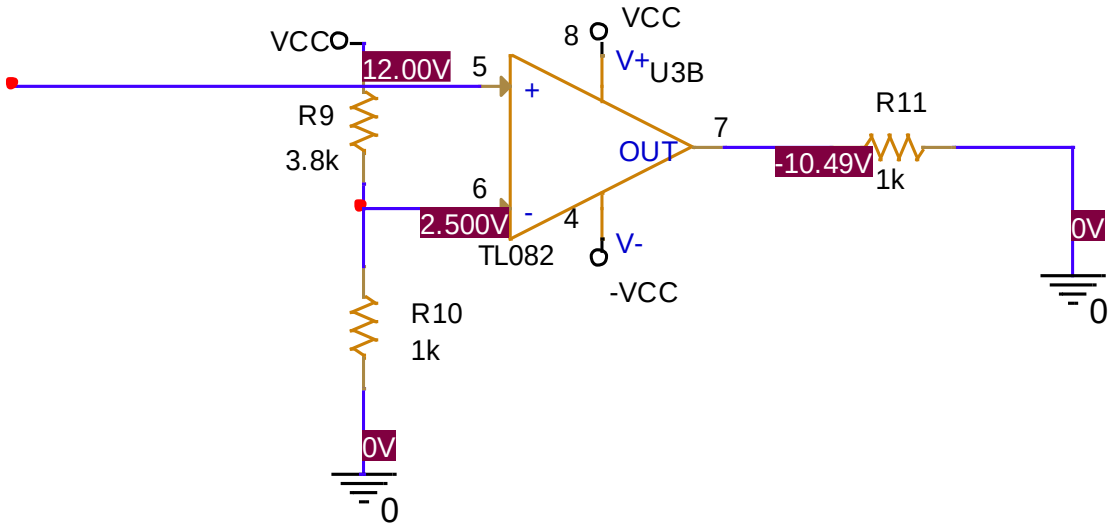
$v^- = 2.5V$

$v^- = \frac{R_{10}}{R_{10}+R_9} * V_{cc}$ } => $2.5 = \frac{R_{10}}{R_{10}+R_9} * 12$

$\frac{R_{10}}{R_{10}+R_9} * 4.8 = 1$ => $4.8*R_{10} = R_{10} + R_9$ => $3.8*R_{10} = R_9$

Daca R_{10} = 1 kΩ

⇨ $R_9 = 3.8\ k\Omega$



Comparator neinversor pentru al doilea prag

III. 5V – 7.5V

$$v^+ = V_{cc} = 12V$$

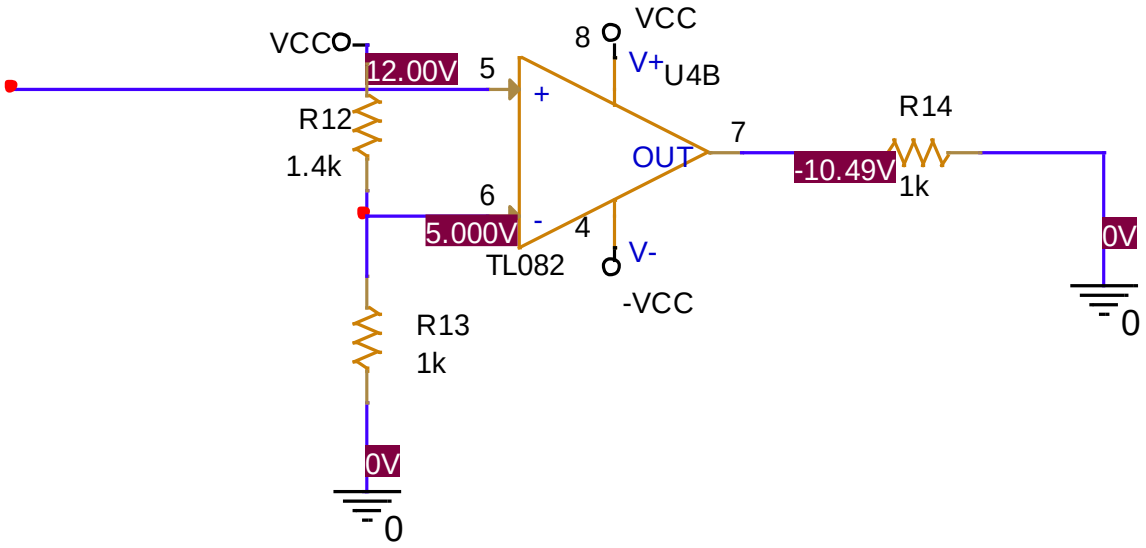
$$v^- = 5V$$

$$v^- = \frac{R_{13}}{R_{13}+R_{12}} * V_{cc} \quad \Rightarrow 5 = \frac{R_{13}}{R_{13}+R_{12}} * 12$$

$$\frac{R_{10}}{R_{10}+R_9} * 2.4 = 1 \Rightarrow 2.4*R_{13} = R_{13} + R_{12} \Rightarrow 1.4*R_{13} = R_{12}$$

Daca R_{13} = 1 kΩ

⇨ R_{12} = 1.4 kΩ



Comparator neinversor pentru al treilea prag

IV. 7.5V – 10V

$v^+ = V_{cc}$ = 12V

$$v^- = 7.5V$$

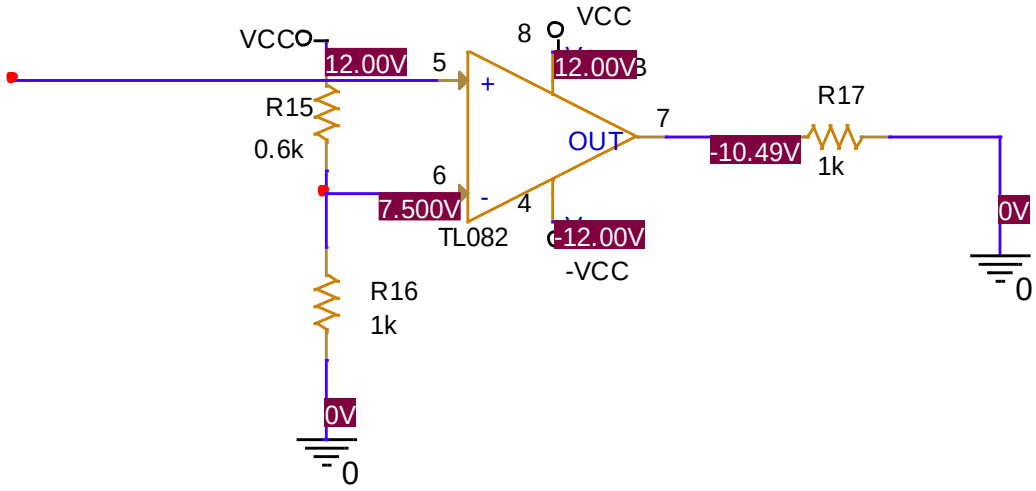
$$v^- = \frac{R_{16}}{R_{16}+R_{15}} * V_{cc}$$

$$\Rightarrow 7.5 = \frac{R_{16}}{R_{16}+R_{15}} * 12$$

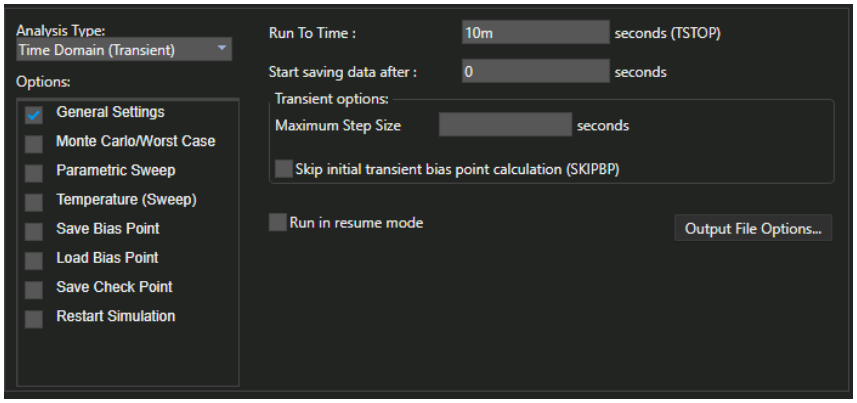
$$\frac{R_{16}}{R_{16}+R_{15}} * 1.6 = 1 \Rightarrow 1.6*R_{16} = R_{16} + R_{15} \Rightarrow 0.6*R_{16} = R_{15}$$

Daca R_{15} = 1 kΩ

⇨ R_{16} = 0.6 kΩ

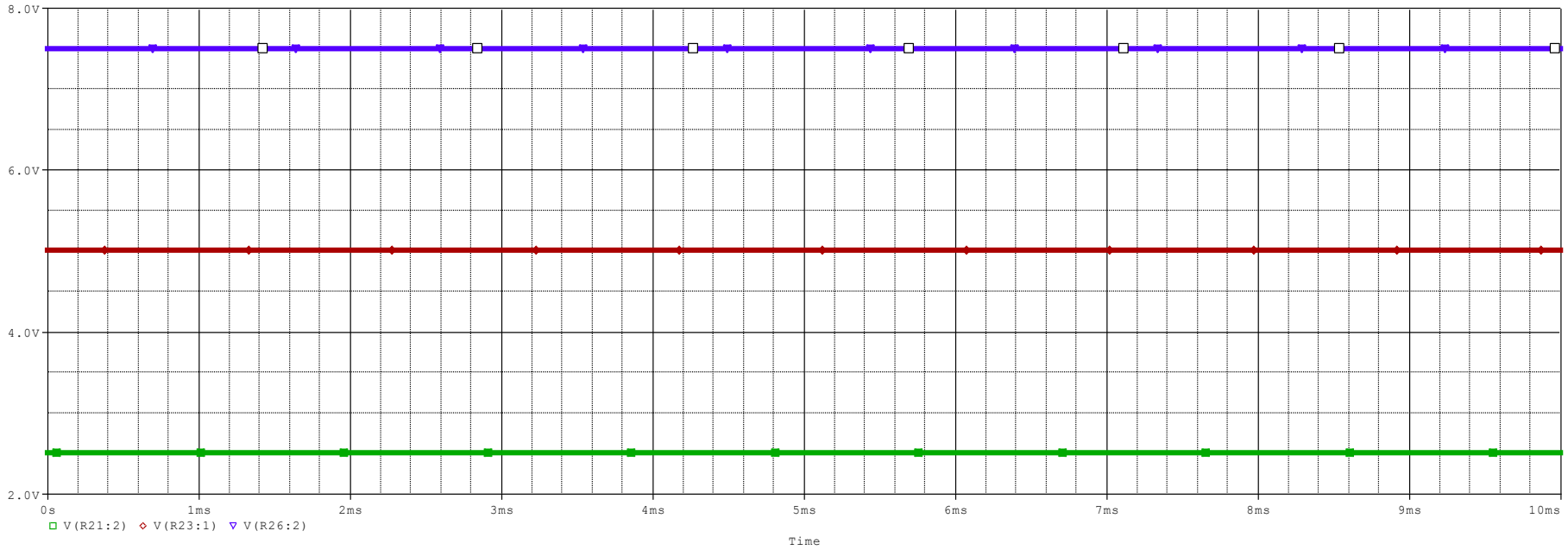


Comparator neinversor pentru al patrulea prag

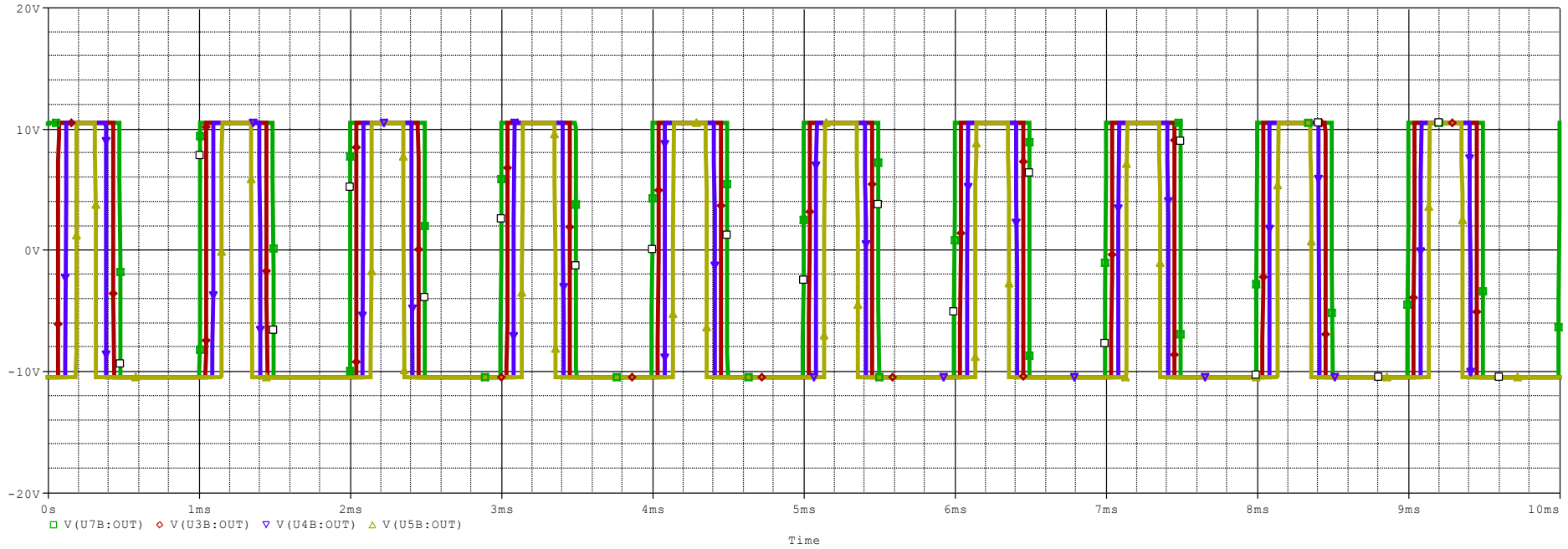


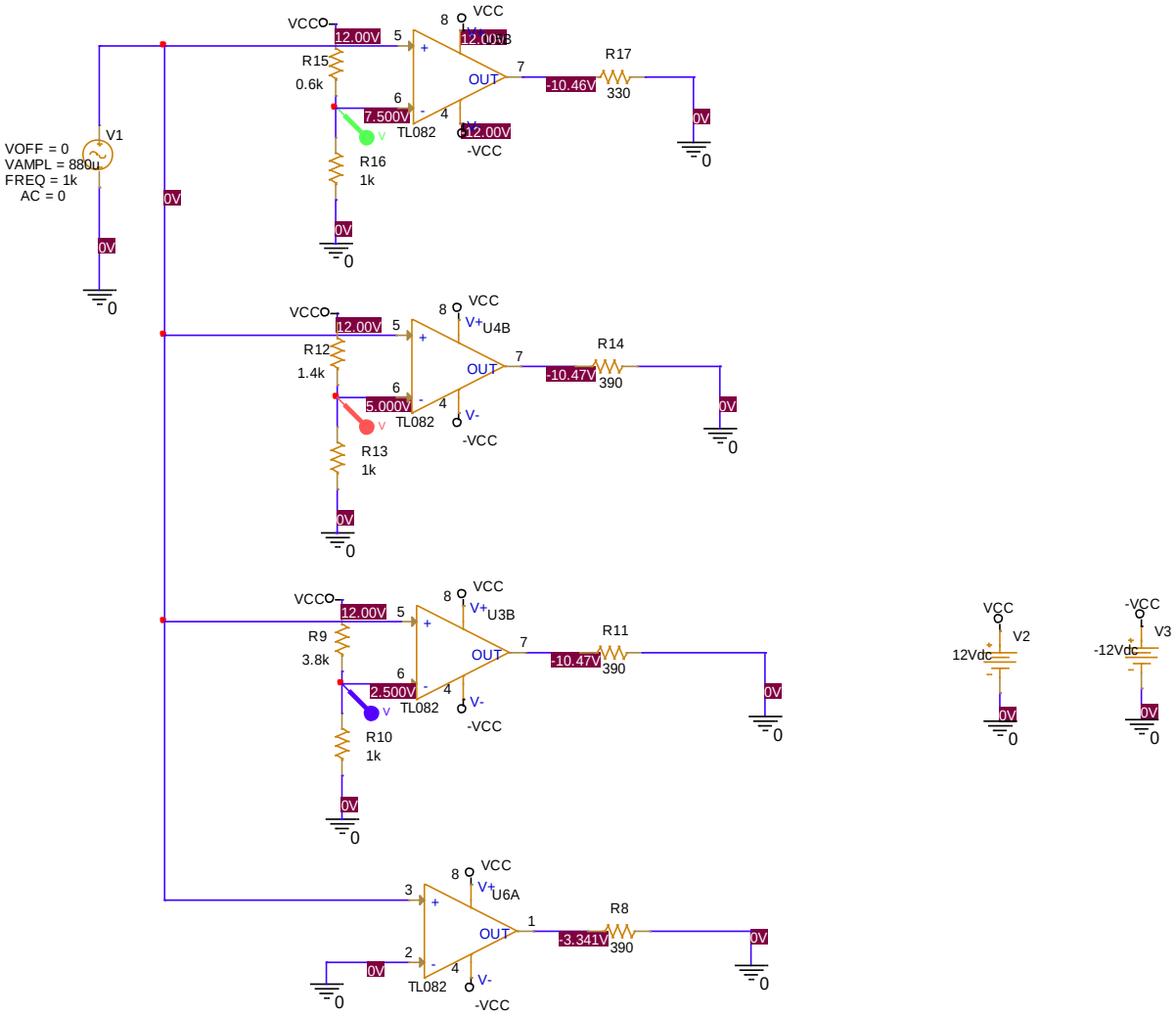
Profil de simulare

Semnalele de iesire ale pragurilor



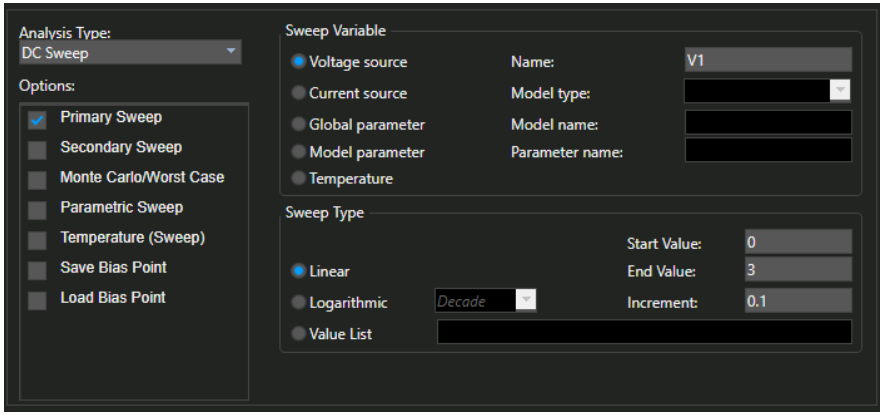
Semnalul de iesire dupa fiecare prag

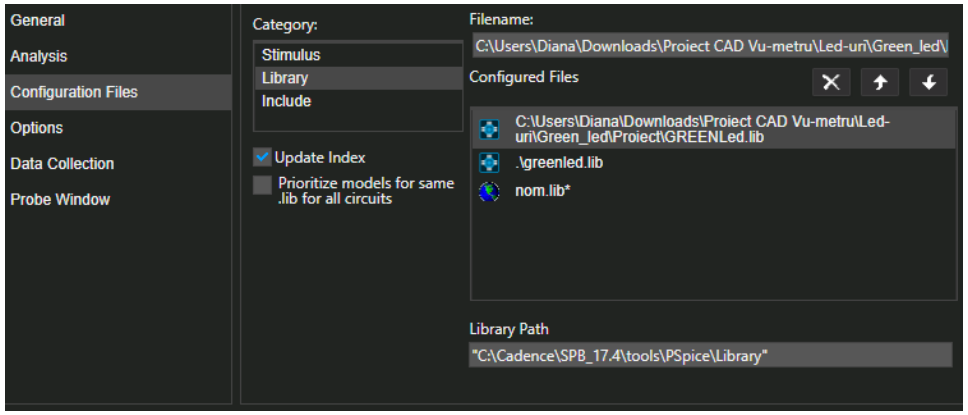




Circuitul de detectie a pragurilor

4. Led-uri





Profil de simularea (la toate led-urile la fel doar fisierul.lib este specific fiecarui led)

i. Led rosu

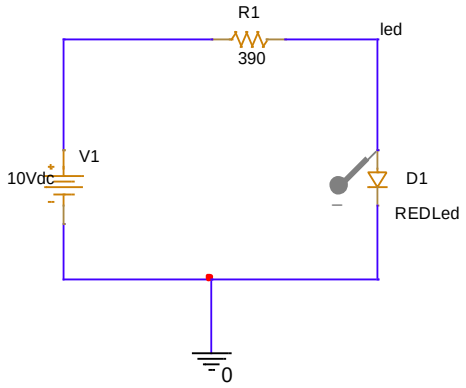
V_{dc} = 9V

$I_{LED} = 20\ mA$

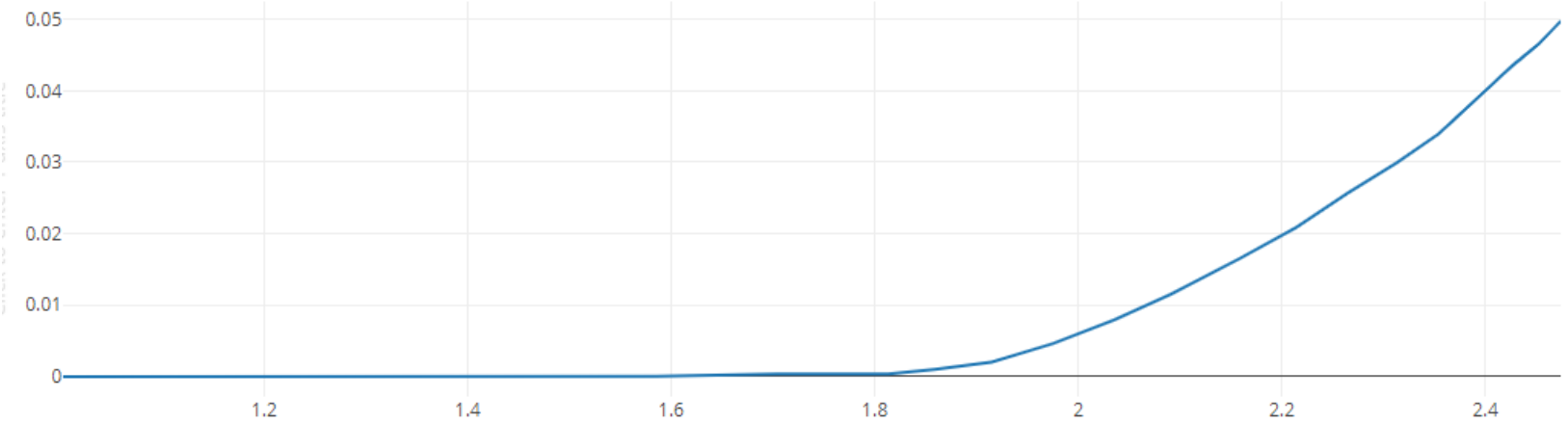
$$R = \frac{V_R}{I_{LED}} = \frac{V_1 - V_p}{I_{LED}} = \frac{10V - 2V}{20mA} = 400\Omega$$

Pentru ca nu exista rezistenta cu valoarea de 400 voi pune una de 390 Ω.

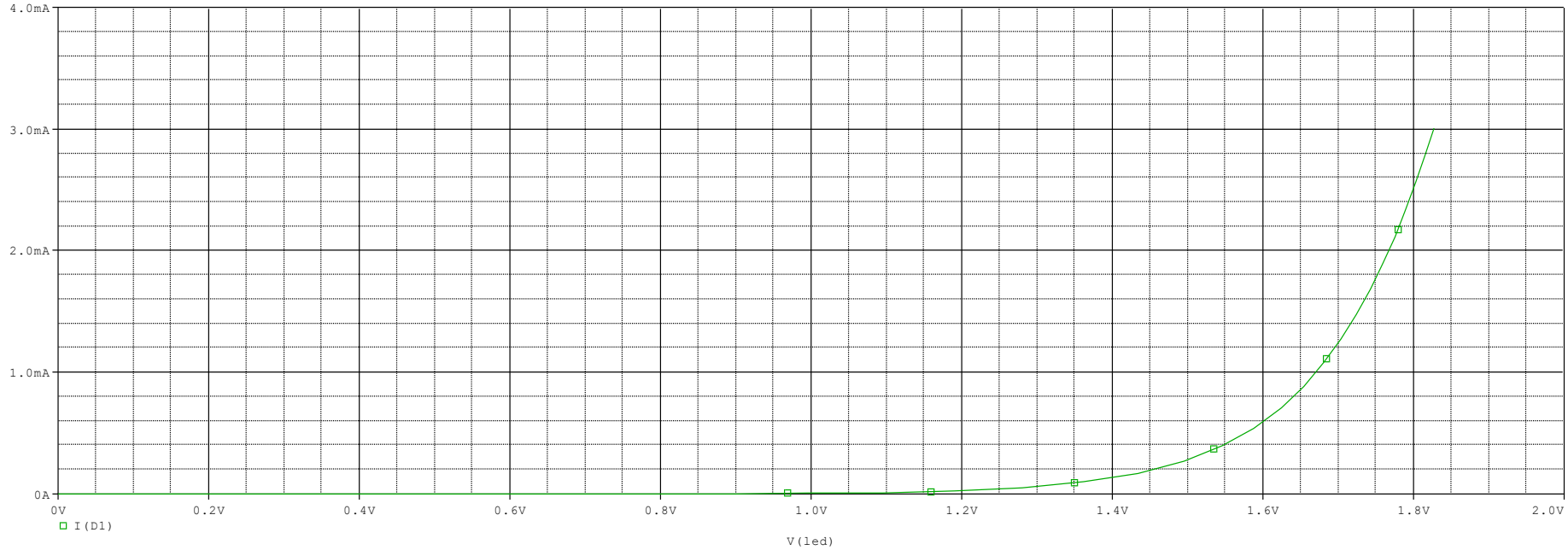
```
.MODEL REDLed D
+ IS=2.5920E-9
+ N=5
+ RS=7.0169
```



Caracteristica cu plotdigitizer



Caracteristica in Orcad



ii. Led verde

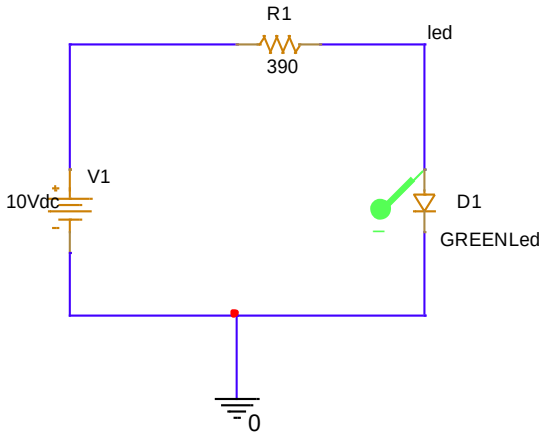
V_{dc} = 9V

$$I_{LED} = 20\,mA$$

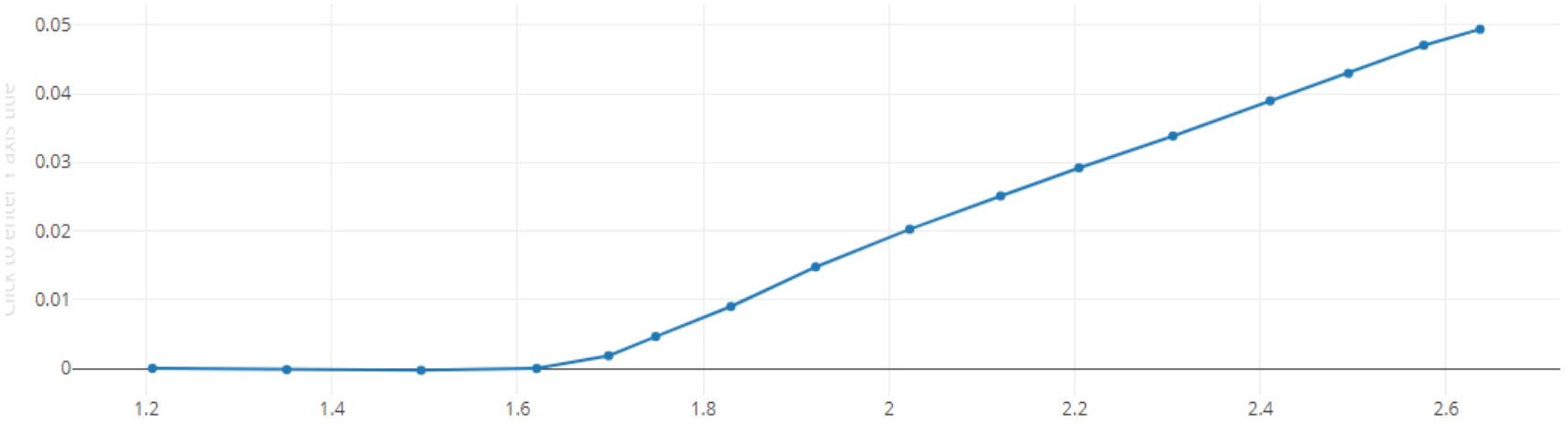
$$R = \frac{V_R}{I_{LED}} = \frac{V_1 - V_p}{I_{LED}} = \frac{10V - 2.1V}{20mA} = 395\Omega$$

Pentru ca nu exista rezistenta cu valoarea de 395 voi pune una de 390 Ω.

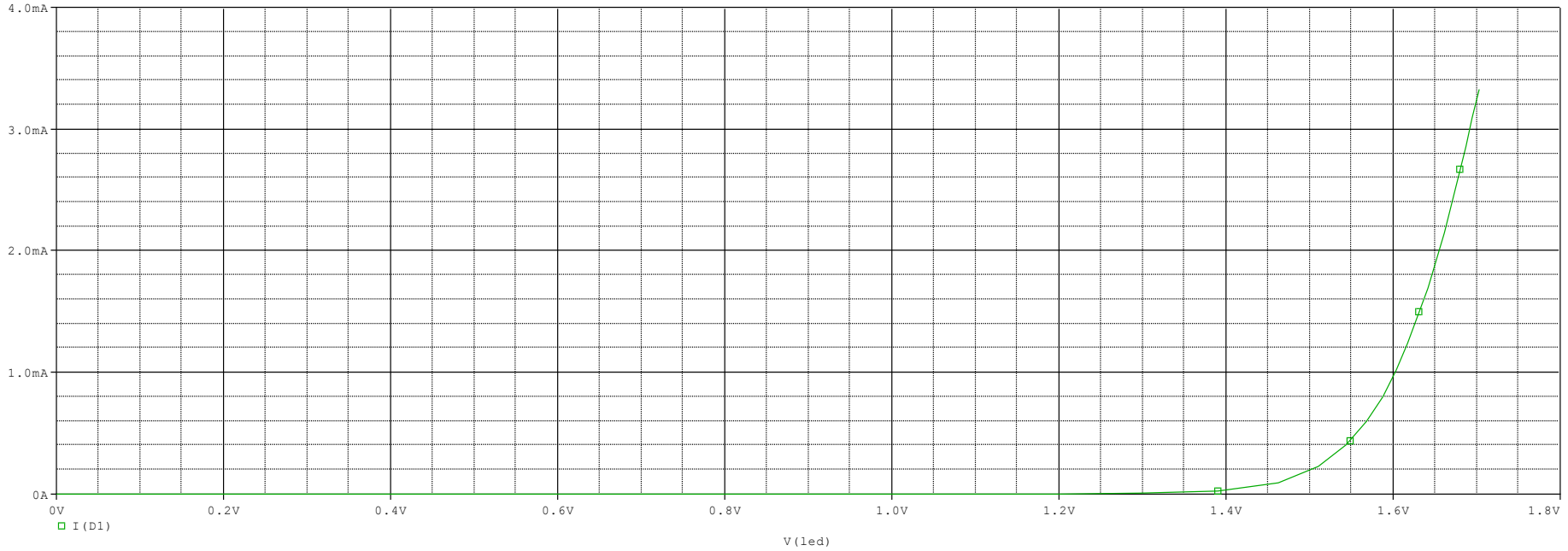
```
.MODEL GREENLed D
+ IS=155.15E-18
+ N=2.0804
+ RS=15.318
```



Caracteristica cu plotdigitizer



Caracteristica in Orcad



iii. Led albastru

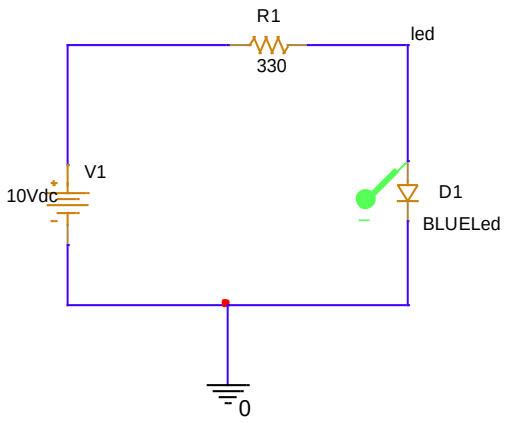
V_{dc} = 9V

$I_{LED} = 20\,mA$

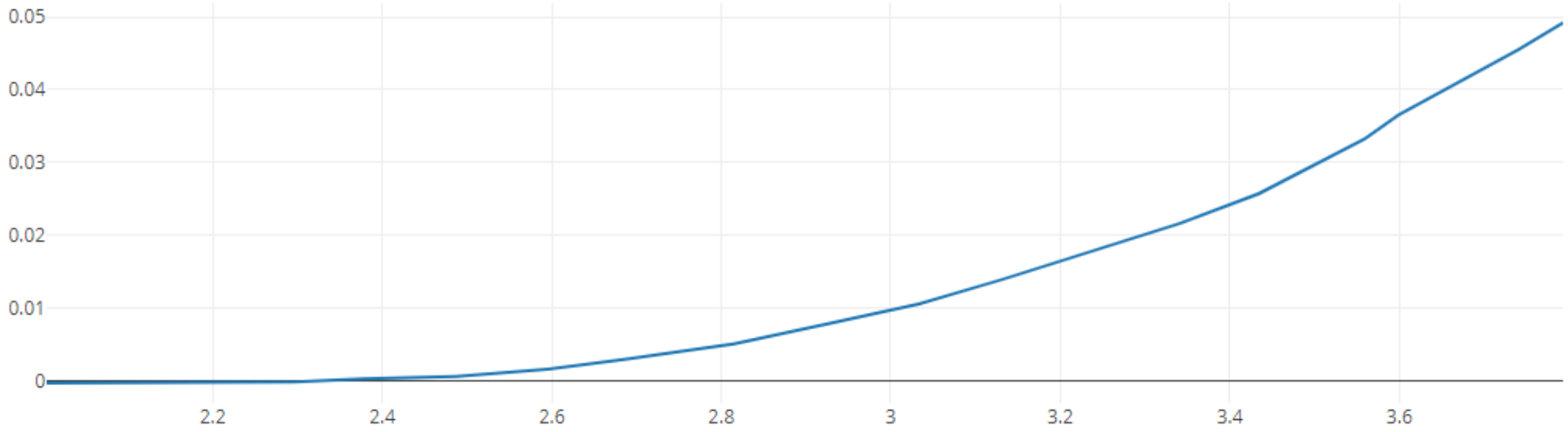
$$R = \frac{V_R}{I_{LED}} = \frac{V_1 - V_p}{I_{LED}} = \frac{10V - 3.3V}{20mA} = 335\Omega$$

Pentru ca nu exista rezistenta cu valoarea de 335 voi pune una de 330 Ω.

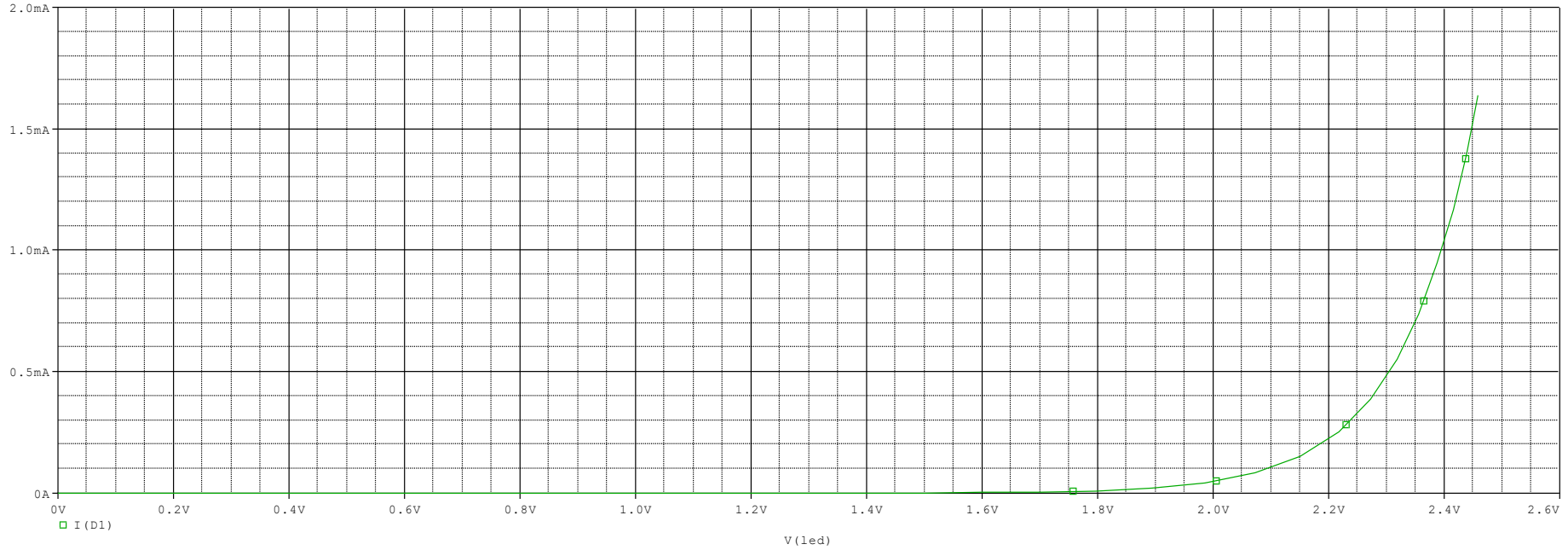
```
.MODEL BLUELed D
+ IS=9.0310E-12
+ N=5
+ RS=1.7176E-6
```



Caracteristica cu plotdigitizer



Caracteristica in Orcad



iv. Led galben

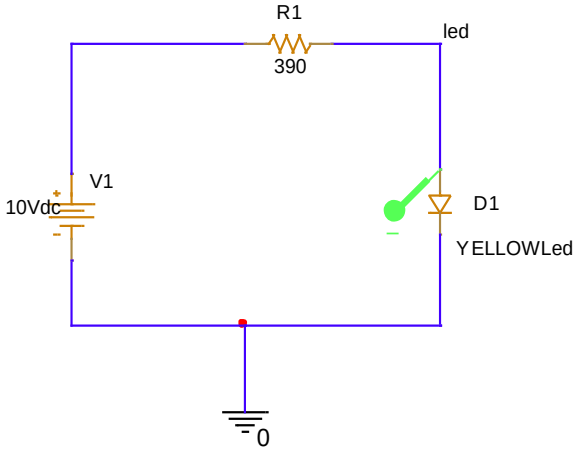
V_{dc} = 9V

$$I_{LED} = 20\,mA$$

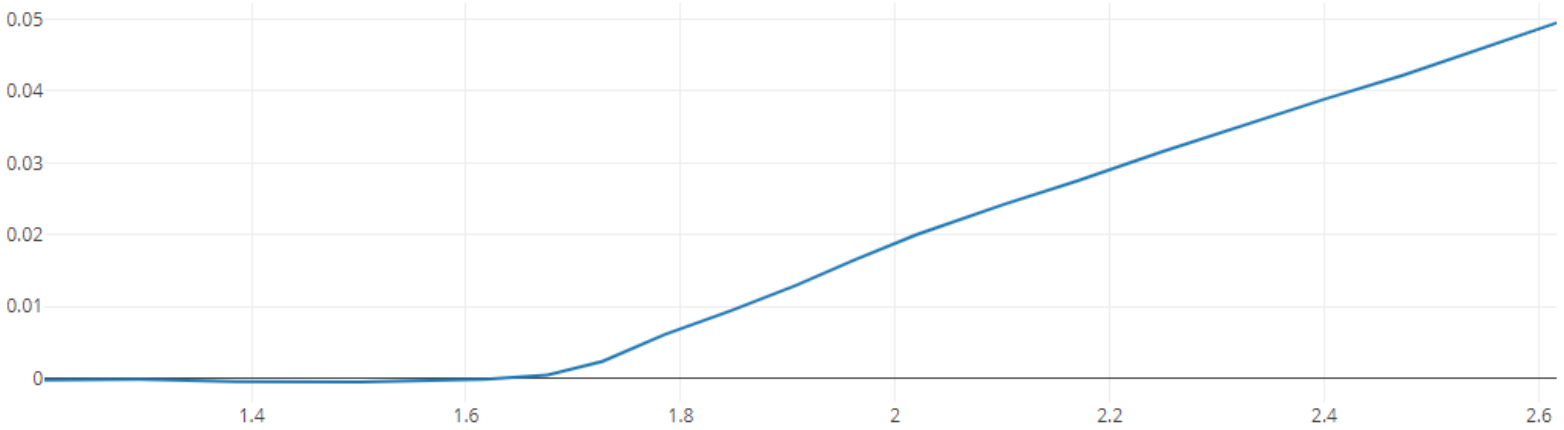
$$R = \frac{V_R}{I_{LED}} = \frac{V_1 - V_p}{I_{LED}} = \frac{10V - 2.1V}{20mA} = 395\Omega$$

Pentru ca nu exista rezistenta cu valoarea de 395 voi pune una de 390 Ω.

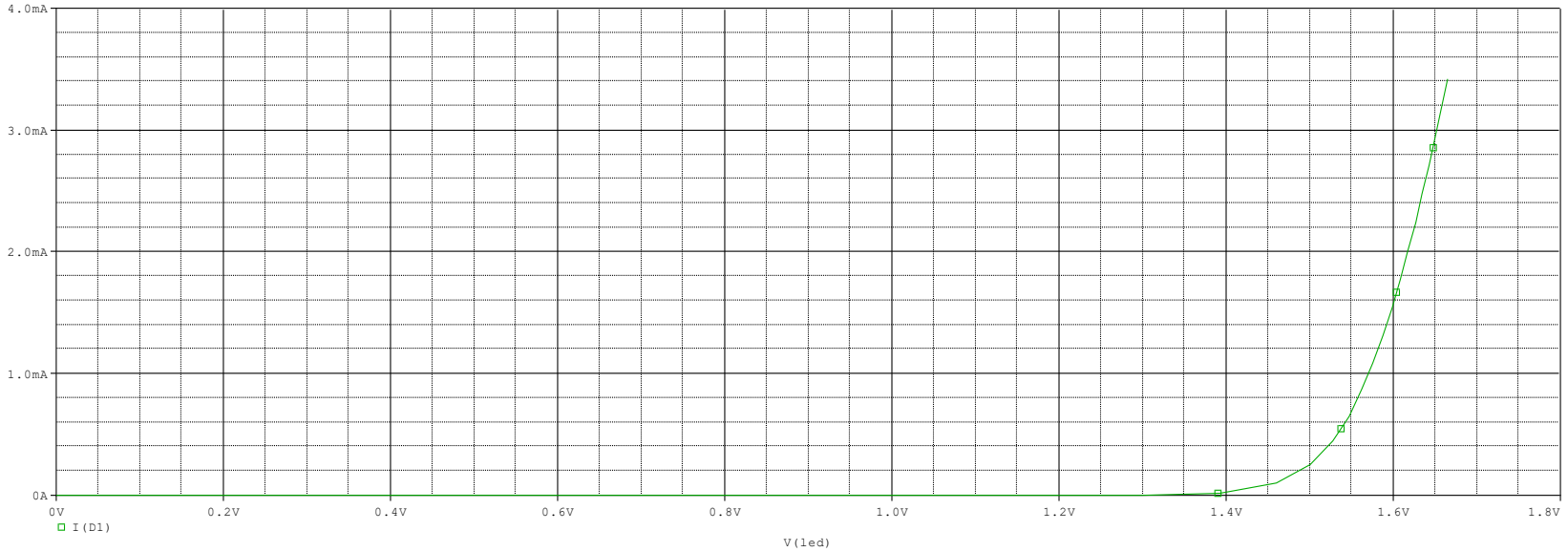
```
.MODEL YELLOWLed D
+ IS=47.888E-21
+ N=1.5978
+ RS=17.929
```



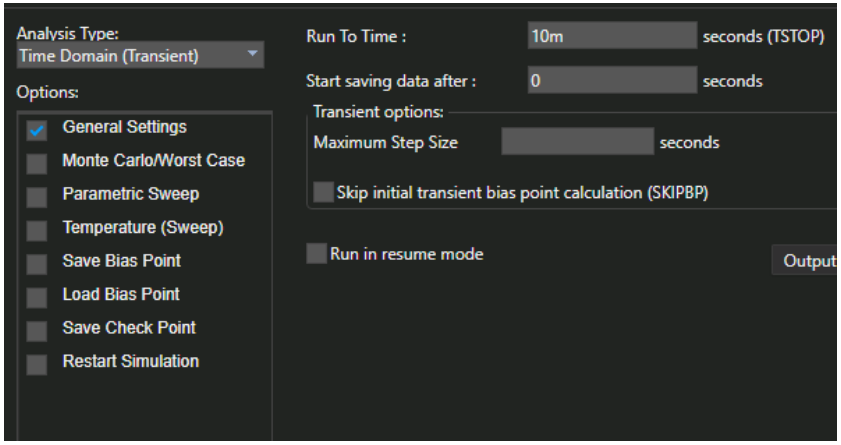
Caracteristica cu plotdigitizer



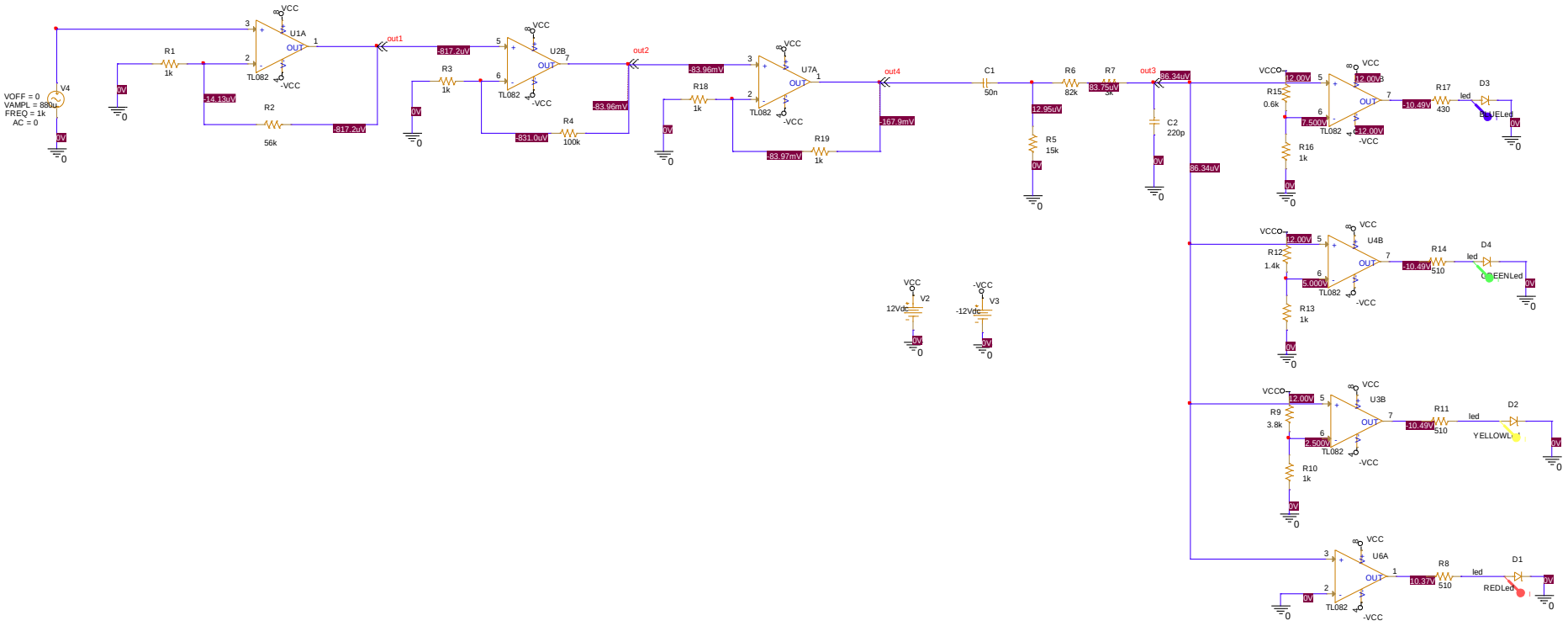
Caracteristica in Orcad

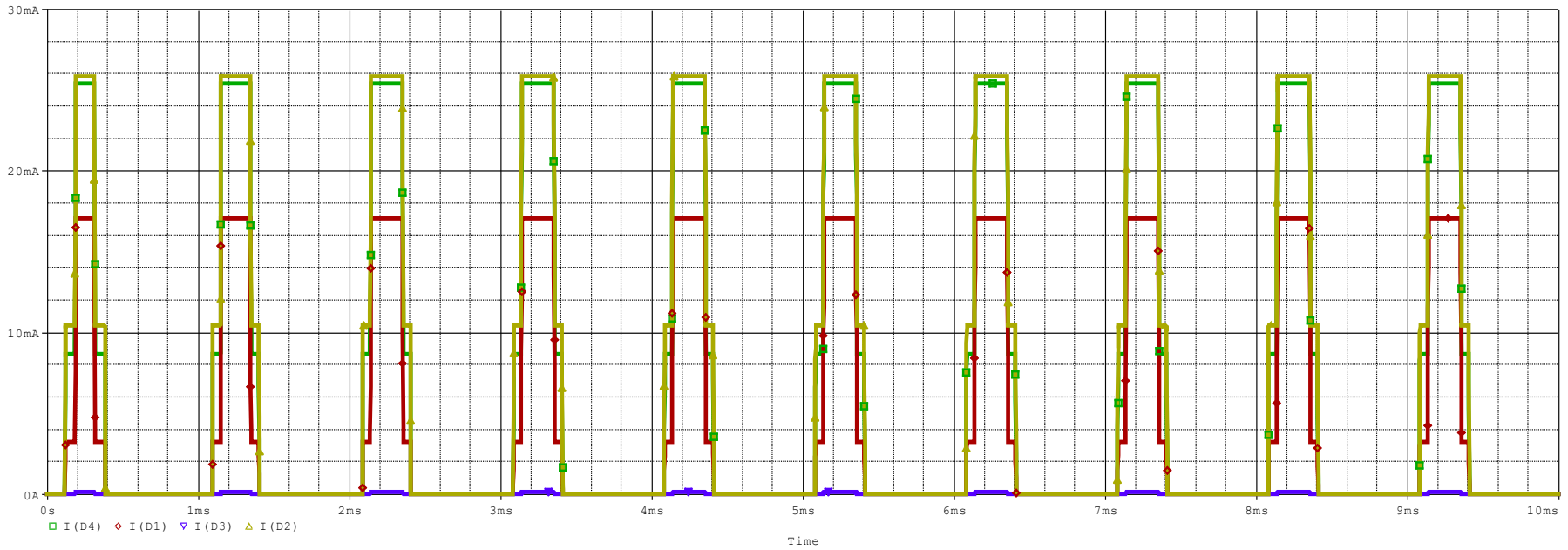


5. Circuitul final



Profil de simulare


VOFF = 0
VAMPL = 880u
FREQ = 1k
AC = 0
V4
R1
1k
R2
56k
U1A
TL082
VCC
-VCC
out1
-817.2uV
R3
1k
U2B
R4
100k
-831.0uV
out2
-83.96mV
R18
1k
U7A
R19
1k
out4
-167.9mV
C1
50n
R6
82k
R7
3k
out3
-86.34uV
C2
220p
R5
15k
12.95uV
V2
12Vdc
V3
-12Vdc
R15
0.6k
R16
1k
U5B
R17
430
D3
led
BLUELed
R12
1.4k
R13
1k
U4B
R14
510
D4
GREENLed
R9
3.8k
R10
1k
U3B
R11
510
D2
YELLOWLed
U6A
R8
510
D1
REDLed
12.00V
7.500V
5.000V
2.500V
-10.49V
-10.37V
0V


30mA
20mA
10mA
0A
0s
1ms
2ms
3ms
4ms
5ms
6ms
7ms
8ms
9ms
10ms
I(D4)
I(D1)
I(D3)
I(D2)
Time