Circuit pentru măsurarea nivelului de iluminare

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Grupa: 2121

Cerință:

Să se proiecteze un circuit electronic pentru măsurarea nivelului de iluminare in domeniul specificat. Circuitul este prevazut cu 4 sau mai multe indicatoare luminoase (LED) care semnalizeaza depasirea pragurilor. De asemenea, circuitul este alimentat de la tensiunea ±VCC. LED-urile trebuie sa fie de culori diferite pentru fiecare domeniu specificat. Rezistenta electrica a traductorului de lumina variaza neliniar cu valoarea nivelului de iluminare măsurat - se va proiecta un circuit de liniarizare pentru aceasta. Suplimentar, circuitul trebuie prevazut cu extinderea domeniului de masura, luand in calcul valoarea maxima a VCC. Modul de aprindere al LED-urilor este specificat in coloana Mod semnalizare si poate fi de tip coloana (fiecare LED este aprins si ramane aprins cu depasirea domeniului) sau individual (fiecare LED se aprinde doar in domeniul pe care il semnalizeaza).

Datele de proiectare

Domeniul de variatie al rezistentei traductorului de lumina: 60k-70k

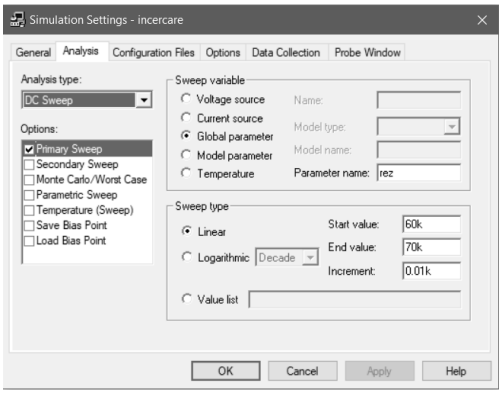
Intensitate luminoasa [lux] : 20-400

Semnalizari [lux]: <20, 20-200, 200-400, >400

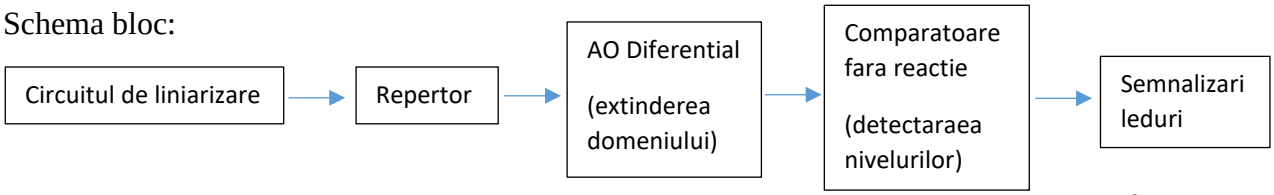
Tensiunea de alimentare, ±VCC: 10V

Mod semnalizare: Individual

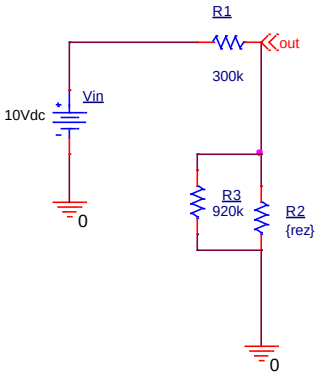
Profilul de simulare in care variem parametrul global “rez”:



Schema bloc:

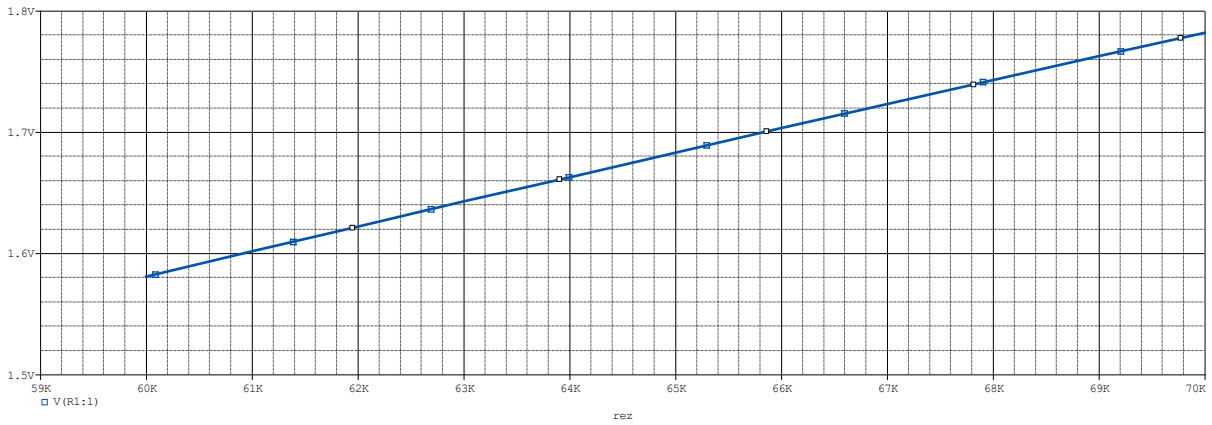


Punem in paralel cu senzorul (R2) o rezistenta R3 de valoare mai mare (aleasa pentru a facilita citirea graficului si sa evitarea numerelelor cu multe zecimale), astfel incat sa liniarizam caracteristica:



Rech=R2 || R3 = $\frac{R2*R3}{R2+R3}$ (1)
Rech min=56.326kΩ($R2 = 60k\Omega$)
Rech max=60.05kΩ($R2 = 70k\Omega$)

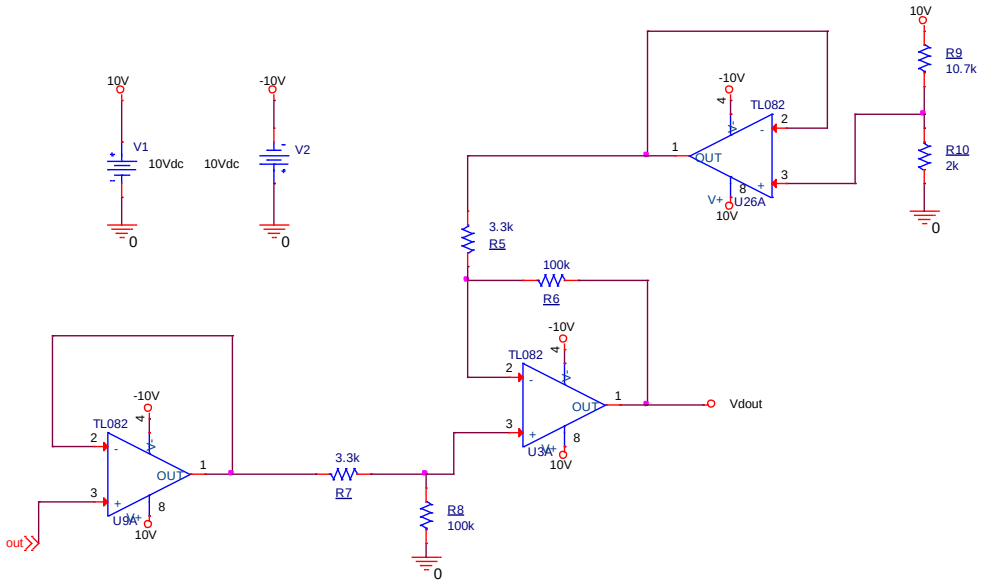
$V(out) = \frac{Rech}{R1+Rech} Vcc$ (2)
$V(out)min = 1.5808V$ (Rech min)
$V(out)max = 1.7818V$ (Rech max)



Observam din caracteristica ca am obtinut un domeniu: **1.58V-1.78V**

Pentru a extinde domeniul, voi utiliza un amplificator diferential.

Am ales sa fac extinderea deoarece vreau sa am diferente mai mari intre pragurile comparatoarelor pe care le voi folosi ulterior, pentru detectarea niveluiui de luminozitate (acest lucru are ca si consecinta efectuarea unor masuratori mai precise).



Am considerat ca este necesar sa pun un repertor de tensiune intre prima parte a circuitului si amplificatorul diferential pentru a "separa" cele doua circuite. Acest lucru a fost posibil datorita faptului ca repertorul are o impedanta mare de intrare.

Deoarece sursele sunt costisitoare, am preferat sa divizez tensiunea de alimentare VCC=10V pentru a imi seta o tensiune fixa in acel nod. Pentru rigurozitatea calculelelor am preferat sa pun un repertor care sa repete tensiunea fixa de pe divizor. Daca aplic divizorul de tensiune pe R10:

VR10=$\frac{R10}{R10+R9}$*10V=$\frac{2k}{2k+10.7k}$*10V =1.574V=> VR10=1.574V (3)

Scad din domeniul de tensiuni obtinut in V(out) tensiunea VR10 si obtin:

$V(out)min = 1.580V$ (Rech min) − 1.574V
$V(out)max = 1.781V$ (Rech max)

(VR10)
0.006V
0.207V

*30.303

Domeniul extins:

0.1818V
6.272V

Daca R5=R7 si R6=R8, atunci Vdout pentru amplificatorul nostru diferential este:

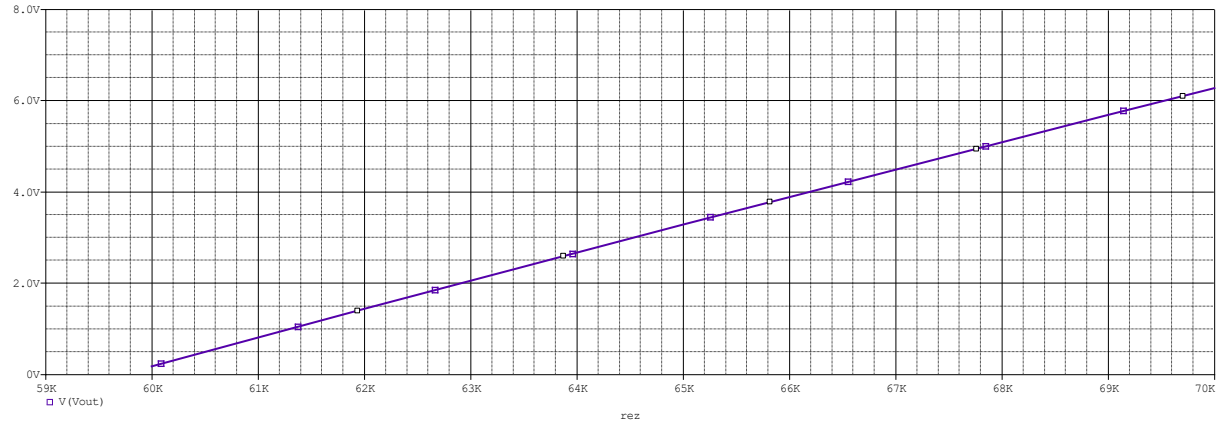
Vdout = $\frac{R6}{R5}$ * (V (out) -VR10) (4)

Aleg raportul $\frac{R6}{R5} = \frac{100k}{3.3k} = 30.303$

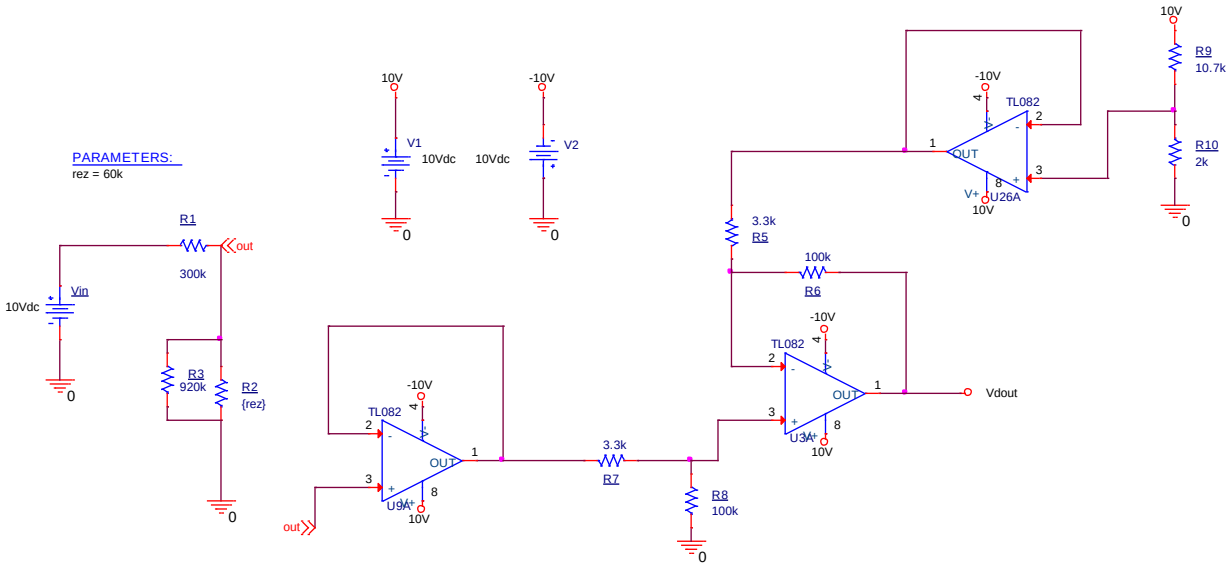
Vdoutmin=$\frac{100k}{3.3k}$*(1.580-1.574)= 30.303***0.006**=**0.1818V**

Vdoutmax=$\frac{100k}{3.3k}$*(1.781-1.574)= 30.303***0.207**=**6.272V**

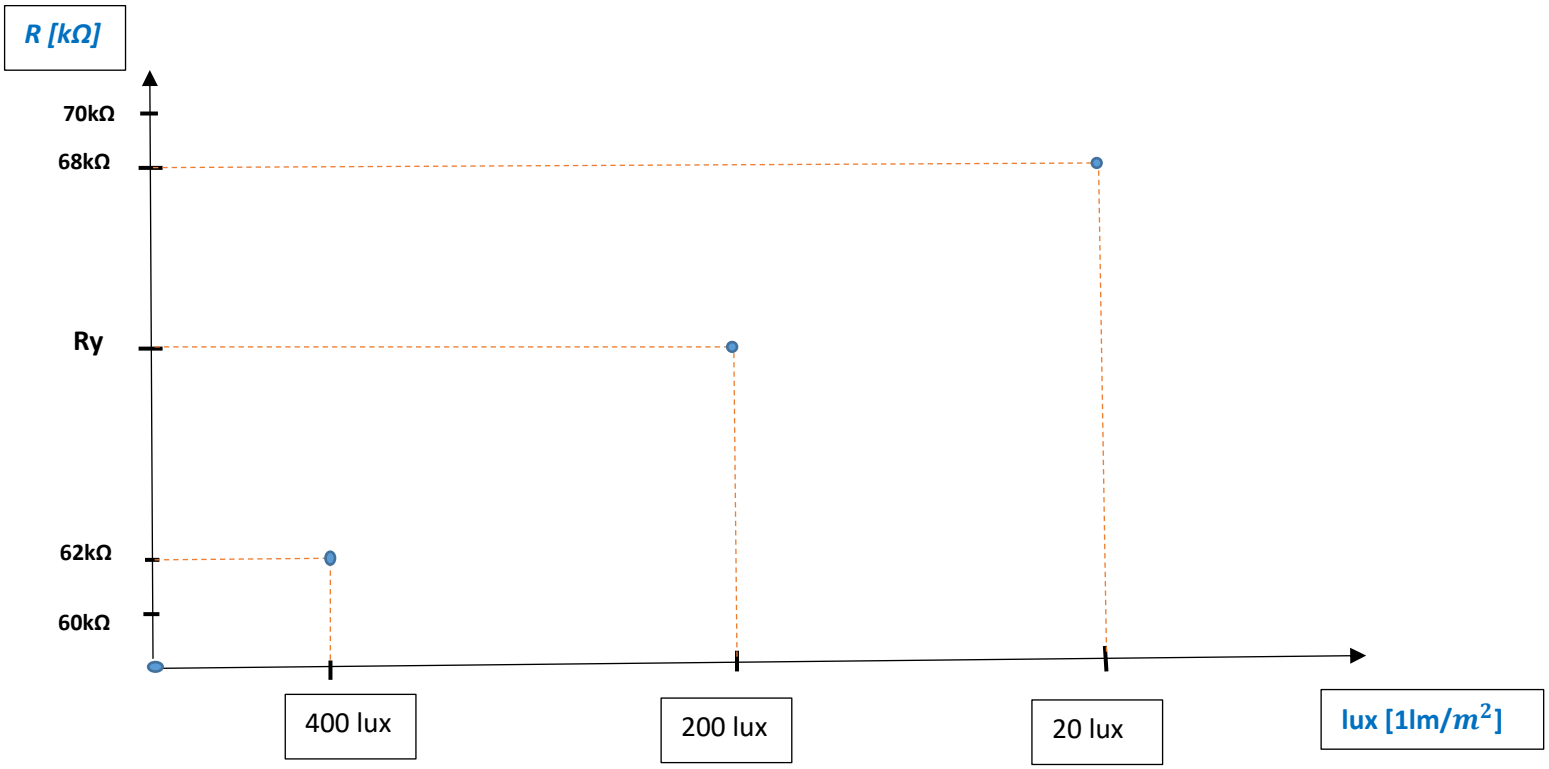
Apar mici pierderi la iesire datorita amplificatorului operational neideal (le neglijam).



Prima parte a circuitului (liniarizare+extinderea domeniului):



Corespondenta lux-R si V:



62k=400a+b

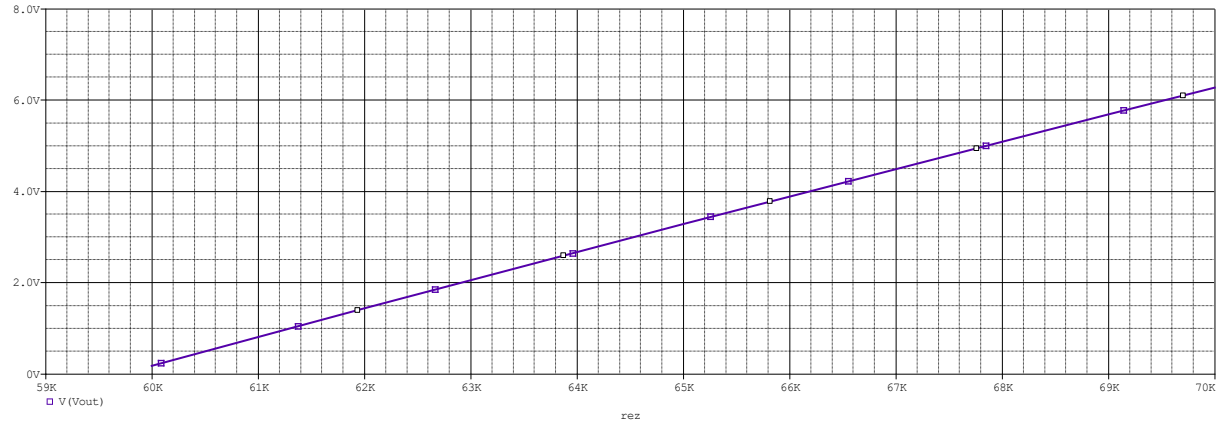
68k=20a+b (-)

-6000=380a=> a= - $\frac{300}{19}$

b=68000-20*($\frac{-300}{19}$)=68315.789

Ry = 200 * $\left(\frac{-300}{19}\right)$ + 68315.789 => **Ry =65.157kΩ (pentru 200 lux)**

Citim informatiile corespunzatoare de pe graficul Vout (de la iesirea AO diferential):



De pe grafic:

- La 62k=>Vout=1.4294V
- La 68k=>V=5.0845V
- La 65.157k=>V=3.3712V

400lux……....62kΩ……1.4294V

200lux…….65.157kΩ……..…3.3712V

20lux…….68kΩ……..…5.0845V

Vom avea 4 semnalizari:

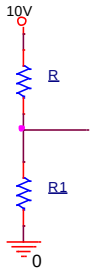
(1) 0.1V-1.42V **> 400 lux**

(2) 1.42V-3.37 V **400-200 lux**

(3) 3.37V-5.08V **200-20lux**

(4) 5.08V -8.33V **<20 lux**

Observatie: R1 si R sunt niste rezistente cu nume aleator alese care ne ajuta doar la calcularea pragurilor!



Avem pragurile pentru comparatoare si aflam valorile rezistentelor potrivite:

Aleg **0.1V** pentru a semnaliza **> 400 lux:**

$$Vp = \frac{R1}{R1+R} * 10 \quad (5)$$

Aleg R1=1kΩ

$\frac{R1}{R1+R}$*10=0.1V=>R=99kΩ=>aleg R=100kΩ

Aleg R1=10kΩ

$\frac{R1}{R1+R}$*10=1.42V=>R=<u>60kΩ</u>

Aleg R1=<u>10kΩ</u>

$\frac{R1}{R1+R}$*10=3.37V=>R=19.67Ω=> R=<u>19.6kΩ</u>

Aleg R1=<u>5kΩ</u>

$\frac{R1}{R1+R}$*10=5.08V=>R=<u>4.8kΩ</u>

Aleg V=**8.33V** pentru a semnaliza **<20 lux:**

Aleg R1=<u>10 kΩ</u>

$\frac{R1}{R1+R}$*10=8.33V=>R=<u>2kΩ</u>

Observatie: La valori mari ale tensiunii avem nivel de luminozitate mic!!!

Calculez valorile rezistentelor dinaintea LED-urilor cu ajutorul datelor culese din foile de catalog ale LED-urilor, dar si pe baza formulei:

$$R = \frac{VCC' - (-VCC' + Vp)}{Id}$$ **(6) (cazul in care Va>Vk pentru diodele led)**

VCC'-iesirea comparatorului

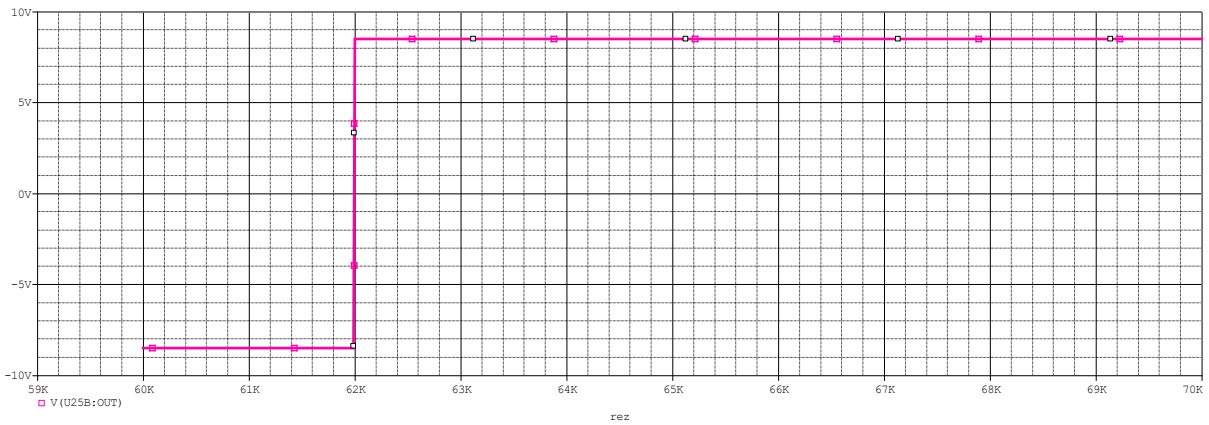
Id=20mA=0.02A (Continuous Forward Current)

Am grija să nu aplic prea mult curent unui LED, altfel risc să distrug și să sting LED-ul (in mod practic). Două specificații sunt enumerate pe fișa de date a LED-ului, care arată **curentul maxim pe care îl poate primi un LED**. Acesta este curentul de vârf și de curent continuu (Continuous Forward Current)**.**

Observatie: Nu aplicați niciodată mai mult curent unui LED decât aceste specificații.

În circuitele practice tensiunea de ieșire a comparatorului este cu 2-3V mai mică decât tensiunea de alimentare din cauza căderilor de tensiune din interiorul circuitului integrat.

Astfel, masor cat am la iesirea comparatoarelor mele, aplicand o sonda de tensiune la iesirea unuia dintre comparatoare si observam ca tensiunea maxima scoasa la iesire este +8.5V /-8.5V.



Deci in calcul voi considera tensiunea de la iesirea comparatorului ca fiind +8.5V /-8.5V si o notez cu +/-VCC'.

Din relatia (6)=>

Red:

Vp = 1.8V

$R13 = \frac{VCC\prime-(-VCC'+Vp)}{Id} = \frac{8.5-(-8.5+1.8)}{0.02} = 760\ \Omega$

Yellow:

Vp = 1.8V

$R40 = \frac{VCC\prime-(-VCC'+Vp)}{Id} = \frac{8.5-(-8.5+1.8)}{0.02} = 760\ \Omega$

Blue:

Vp = 2.9V

$R24 = \frac{VCC\prime-(-VCC'+Vp)}{Id} = \frac{8.5-(-8.5+2,9)}{0.02} = 705\ \Omega$

Green:

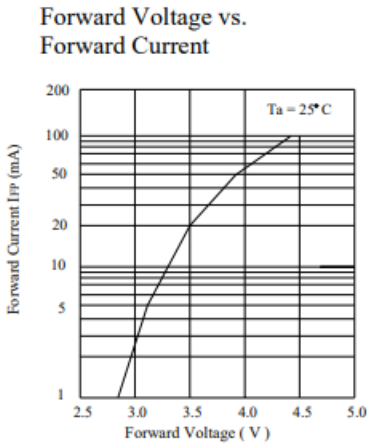
Vp = 2.9V

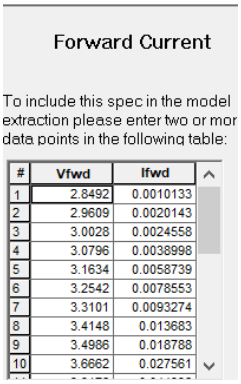
$R27 = \frac{VCC\prime-(-VCC'+Vp)}{Id} = \frac{8.5-(-8.5+2,9)}{0.02} = 705\ \Omega$

Modelarea Ledurilor:

Modelarea ledurilor se face dupa specificatiile din foile de catalog.

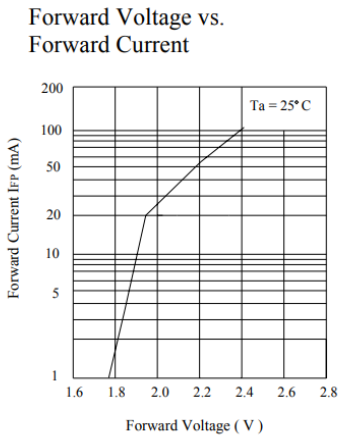
green led

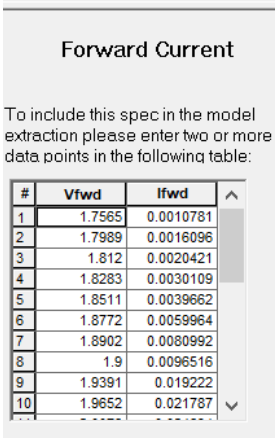




https://descargas.cetronic.es/WW05A3SGQ4-N.pdf

red led





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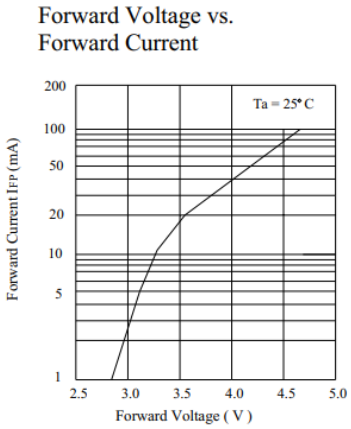
blue led



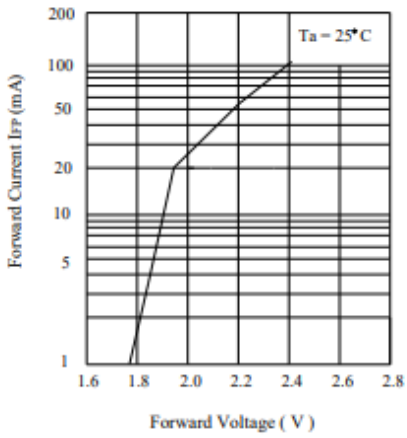
Forward Current

To include this spec in the model extraction please enter two or mor data points in the following table:

#	Vfwd	Ifwd
1	2.8312	0.0010497
2	2.8961	0.001474
3	2.9481	0.0020202
4	3.0065	0.0029065
5	3.0844	0.0038881
6	3.1169	0.0049551
7	3.1818	0.006958
8	3.2662	0.0098897
9	3.4935	0.017914
10	3.6818	0.02339

http://descargas.cetronic.es/WW05A3SBQ4-N.pdf

yellow led



Forward Current

To include this spec in the model extraction please enter two or more data points in the following table:

#	Vfwd	Ifwd
1	1.7588	0.0010201
2	1.7952	0.0016276
3	1.8134	0.0020254
4	1.8343	0.0028399
5	1.8447	0.0039034
6	1.8603	0.0048096
7	1.8707	0.0058674
8	1.8811	0.006879
9	1.8915	0.0084758
10	1.9124	0.011421

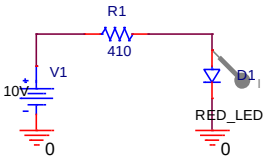
http://descargas.cetronic.es/WW05C3AYP4-N2.pdf

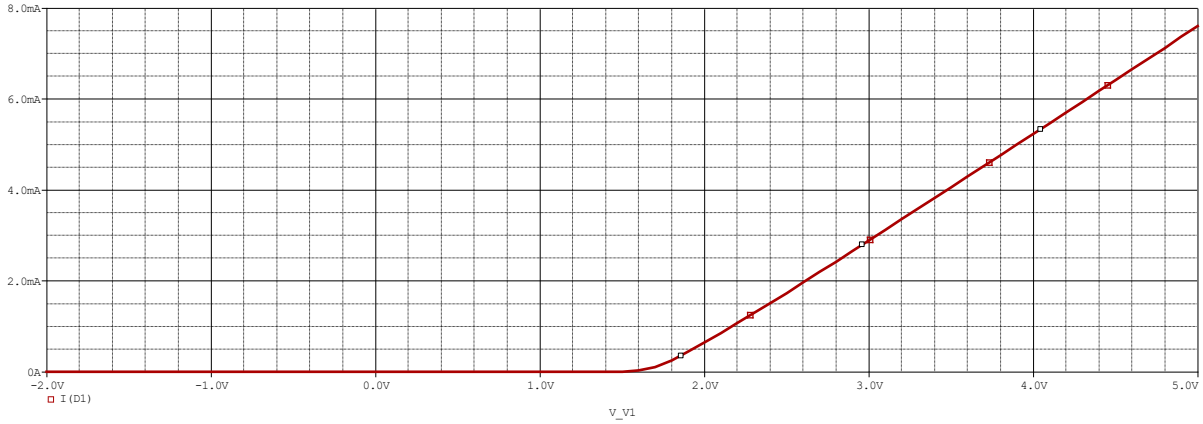
Am probat separat diodele dupa modelare, pentru a arata ca se deschid la valori diferite de prag:

RED_LED: Vp = 1.8V (aproximativ)

Id = 20mA= 0.02A

R1 = $\frac{V-Vp}{Id}$ (7) => $\frac{10-1.8}{0.02}$ =410 Ω

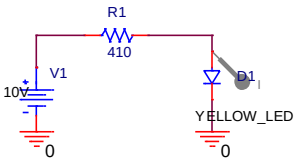


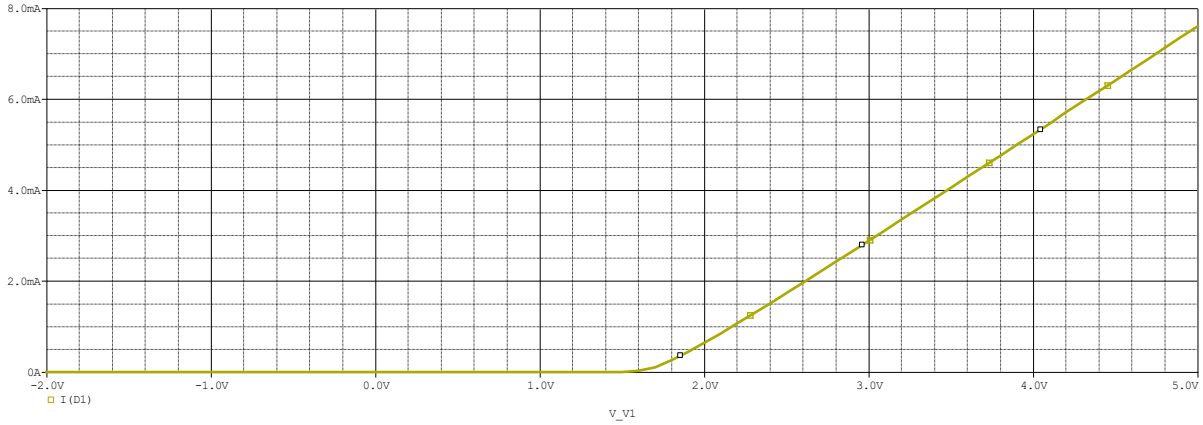


YELLOW_LED:

Vp= 1.8V (aproximativ); Id= 20mA= 0.02A

R1 = $\frac{V-Vp}{Id}$ = $\frac{10-1.8}{0.02}$=410 Ω



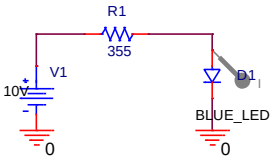


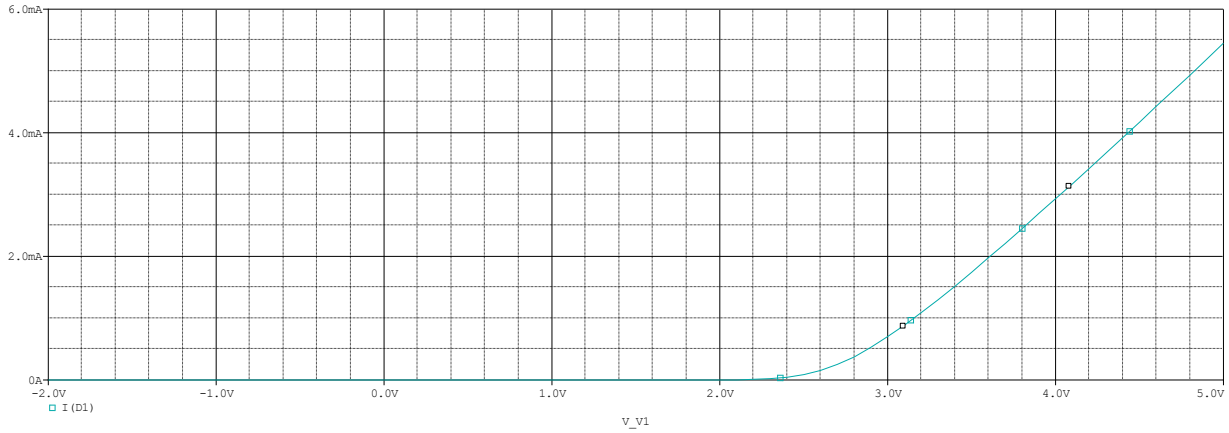
BLUE_LED:

Vp= 2.9V (aproximativ)

Id= 20mA= 0.02A

R1 = $\frac{V-Vp}{Id} = \frac{10-2.9}{0.02}$ =355 Ω

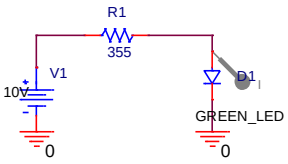


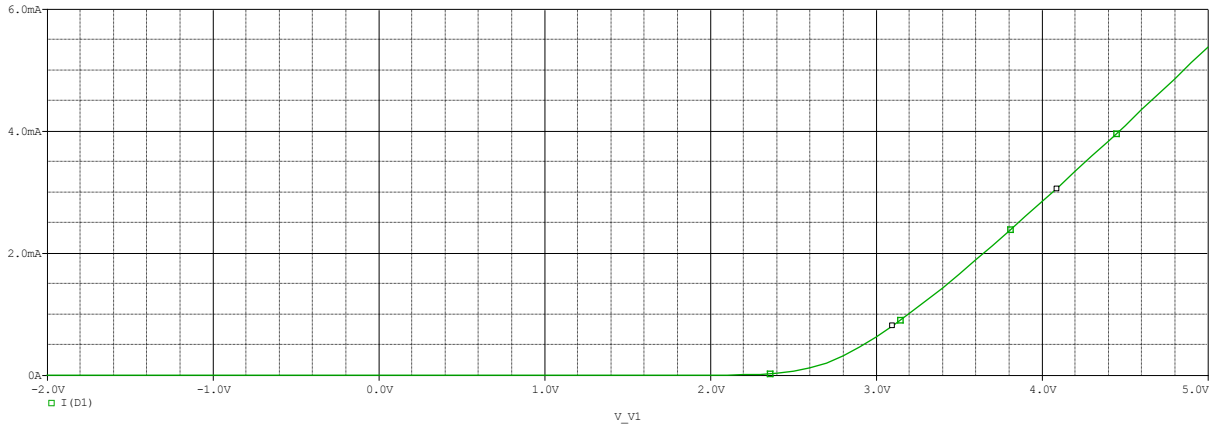


GREEN_LED:

Vp= 2.9V (aproximativ); Id= 20mA= 0.02A

R1 = $\frac{V-Vp}{Id} = \frac{10-2.9}{0.02}$ =355 Ω





A doua parte a circuitului (semnalizarea ledurilor):

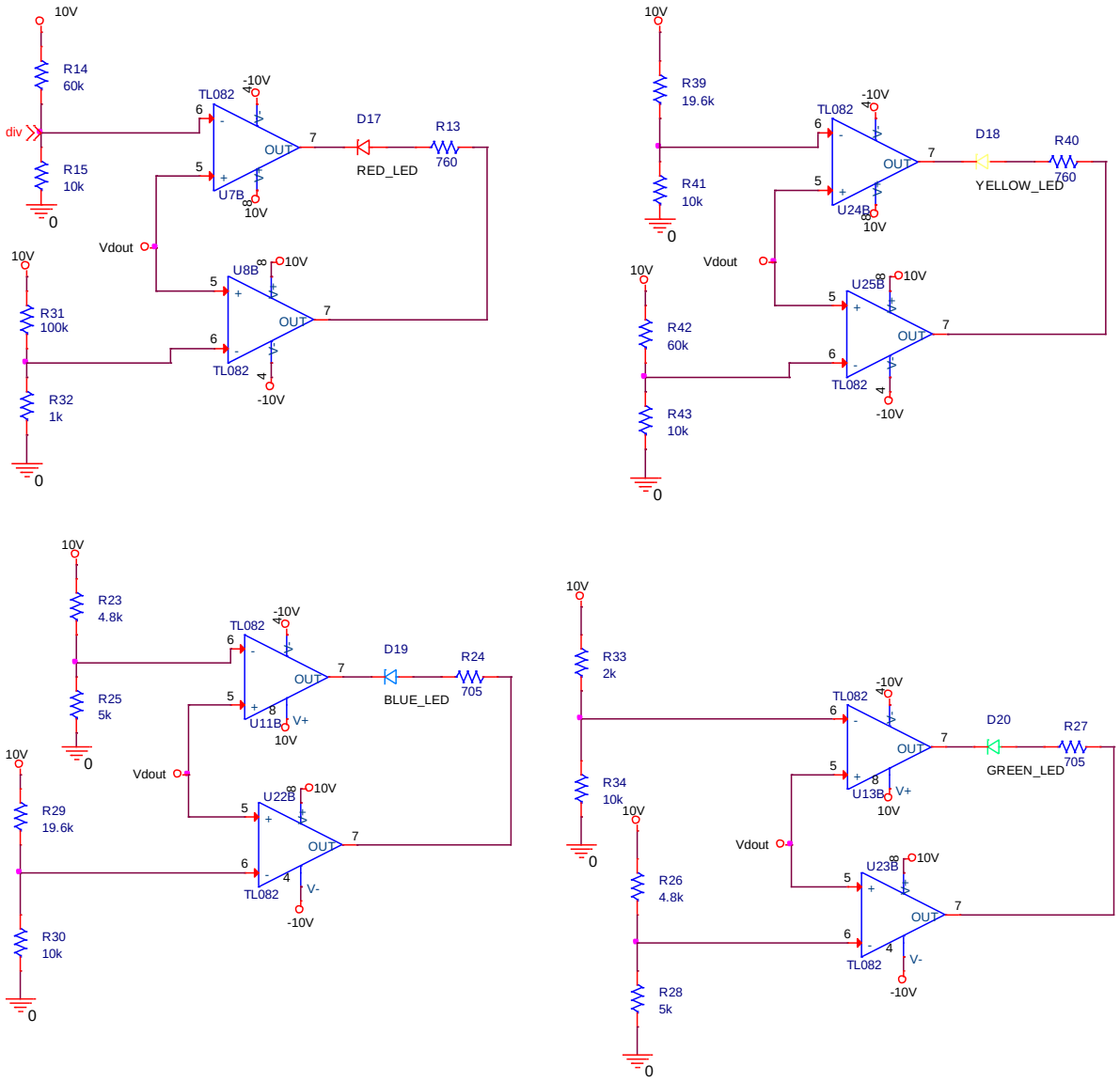
Am ales sa folosesc doua comparatoare fara reactie(“detectoare de prag”), unul pentru aprinderea ledului (cand intra in domeniul de tensiune ce trebuie semnalizat) si unul pentru stingerea lui (cand trece de domeniul care trebuie sa fie semnalizat).

Vref rezulta din divizoarele de tensiune.

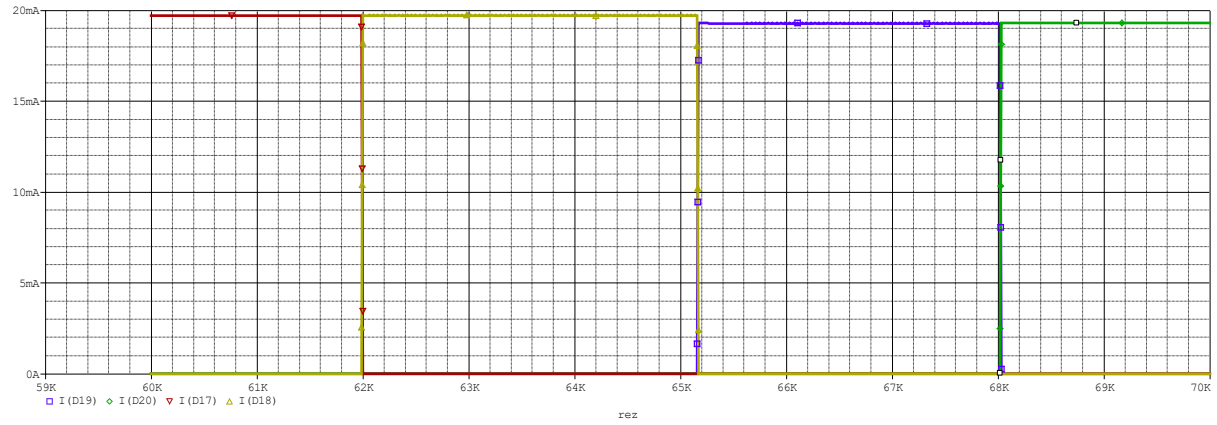
Principiul de functionare:

Cand Vdout(V+)>Vref(V-)=>la iesirea comparatorului vom avea +VCC(aproximativ).

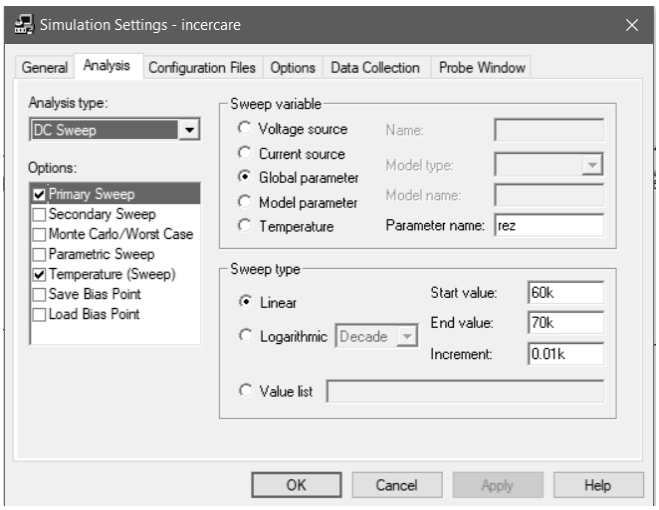
Cand Vdout(V+)<Vref(V-)=>la iesirea comparatorului vom avea -VCC(aproximativ).

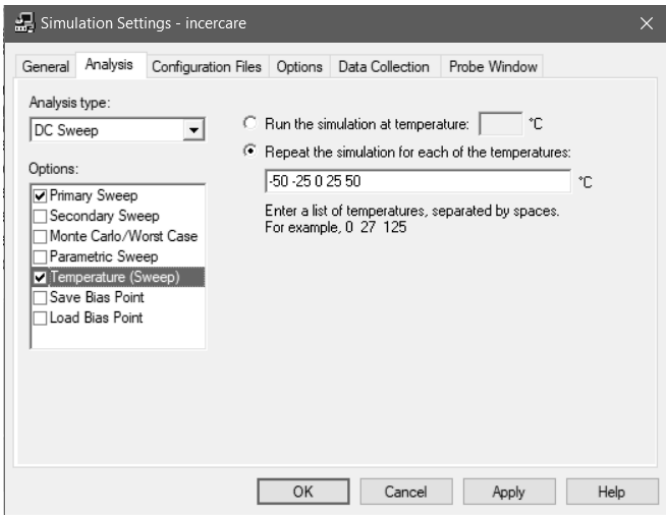


Semnalizari leduri:



Analizez comportarea circuitului la diferite niveluri de temperatura folosind o analiza de “Temperature (Sweep)”:

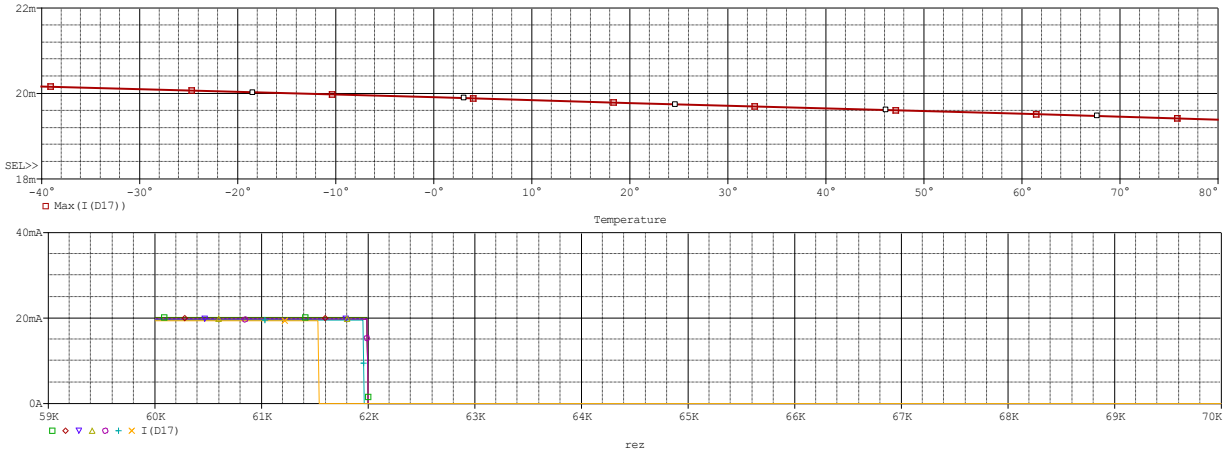




Analizez comportarea curentului prin ledul rosu (RED_LED)+ analiza de performanta:

In urma consultarii foii de catalog observ ca intervalul de temperatura de functionare este:

-40°C la +80°C pentru RED_LED.

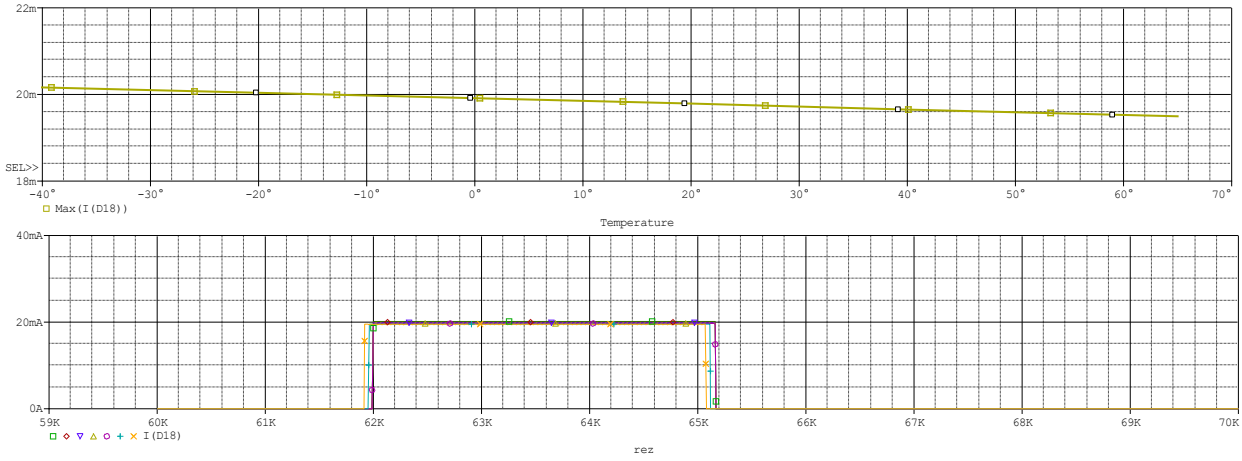


Observ ca o data cu scaderea temperaturii, creste curentul prin led, actiune care poate duce la stingerea/arderea ledului. Cand Id=20mA, t˚= -15.068 ˚C. In concluzie, pentru a mentine ledul rosu deschis, nu trebuie sa se treaca de aceasta temperatura.

t˚ ↗ => Id ↘

Analizez comportarea curentului prin ledul rosu (YELLOW_LED)+ analiza de performanta:

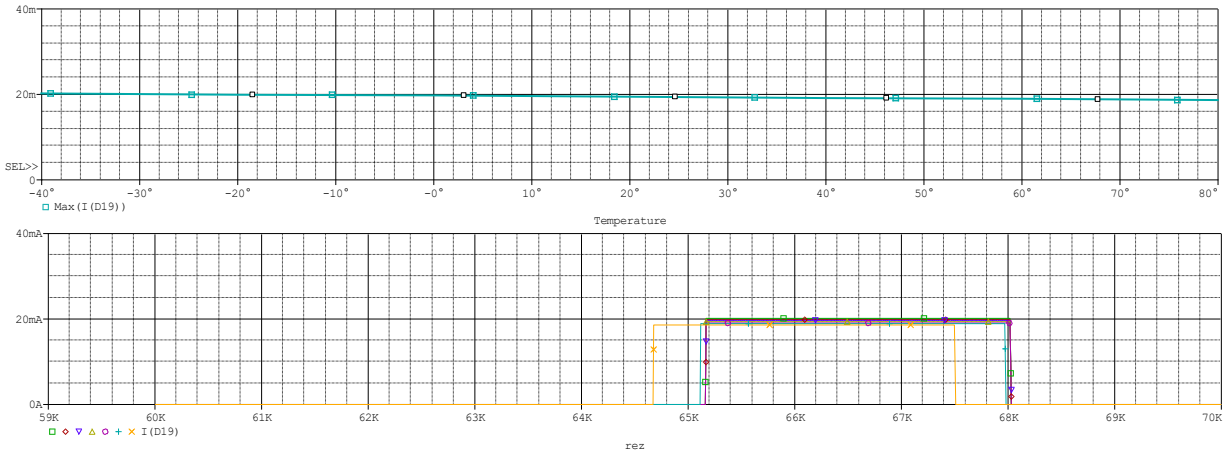
Intervalul de temperatura de functionare este: -40°C la +65°C pentru YELLOW _LED.



Cand Id=20mA, t˚= -14.907 ˚C. In concluzie, pentru a mentine ledul galben deschis, nu trebuie sa se treaca de aceasta temperatura.

Analizez comportarea curentului prin ledul rosu (BLUE_LED)+ analiza de performanta:

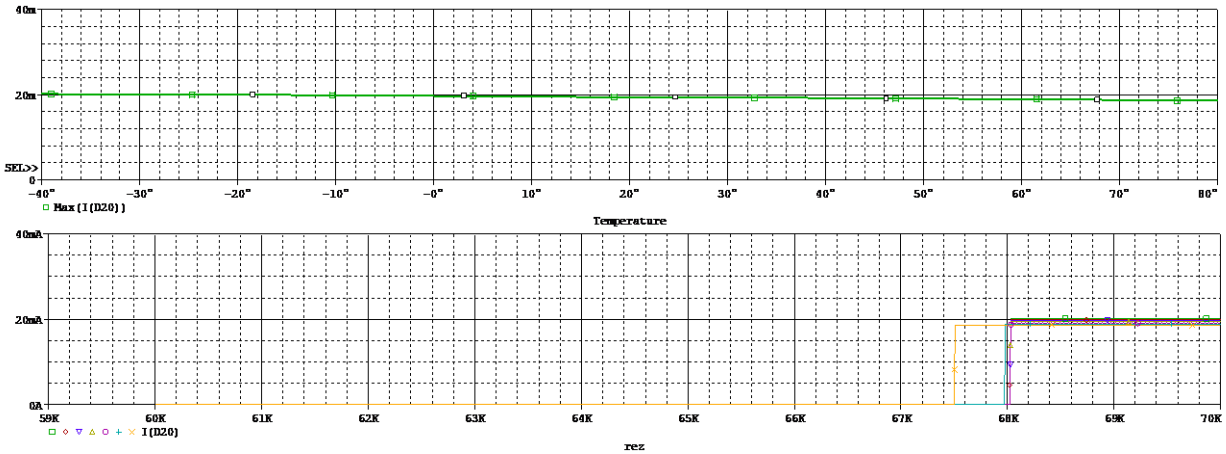
Intervalul de temperatura de functionare este: -40°C la +80°C pentru BLUE_LED.



Cand Id=20mA, t˚= -27.9 ˚C. In concluzie, pentru a mentine ledul albastru deschis, nu trebuie sa se treaca de aceasta temperatura.

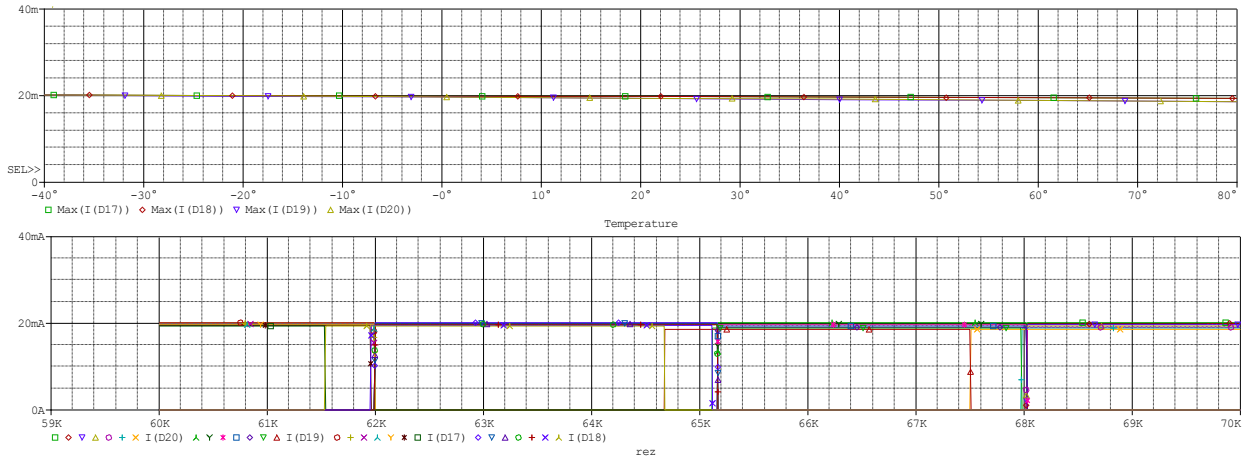
Analizez comportarea curentului prin ledul rosu (GREEN_LED)+ analiza de performanta:

Intervalul de temperatura de functionare este: -40°C la +80°C pentru GREEN_LED.



Cand Id=20mA, t˚= -25.33 ˚C. In concluzie, pentru a mentine ledul verde deschis, nu trebuie sa se treaca de aceasta temperatura.

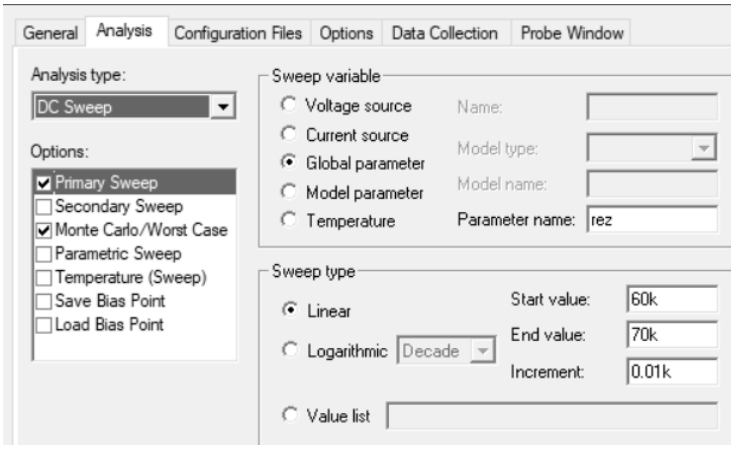
Cu toate ledurile:

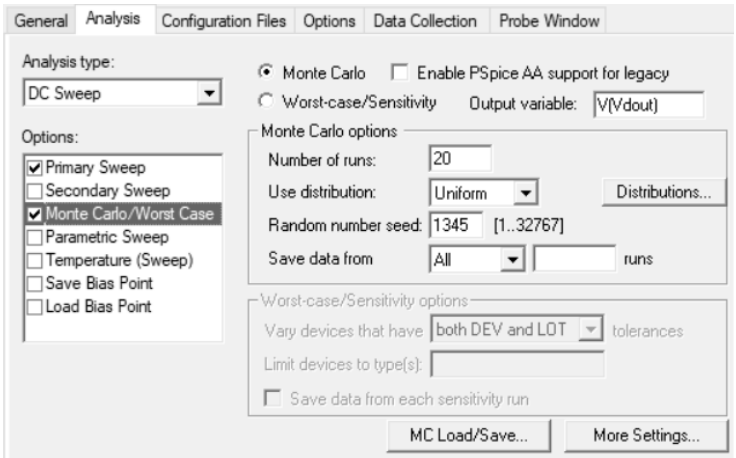


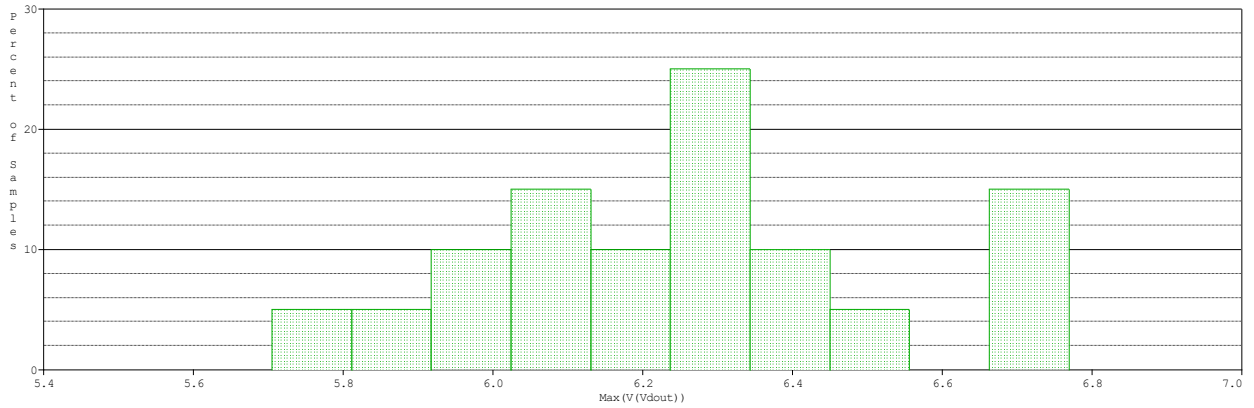
Monte Carlo:

Analiza Monte Carlo determina, statistic, comportarea circuitului cand valorile componentelor sunt modificate in domeniul lor de toleranta. Am ales sa fac aceasta analiza pentru a avea o imagine aproape reala a functionarii unui circuit in conditiile productiei de serie, atunci cand toata gama de componente folosite in linia de asamblare are toleranta.

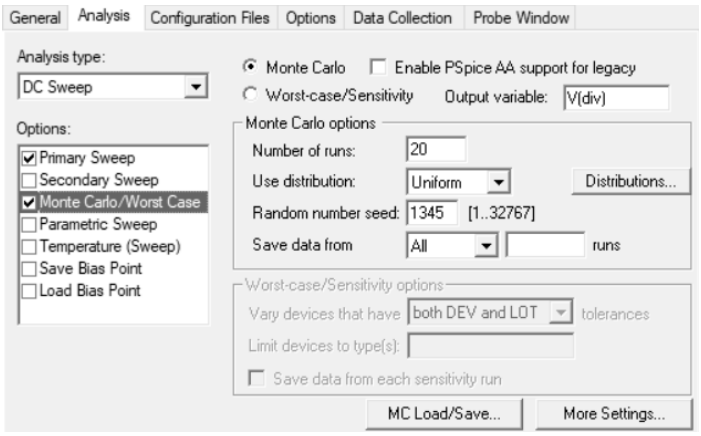
Aplic o simulare de acest tip la iesirea amplificatorului diferential in “Vdout”:

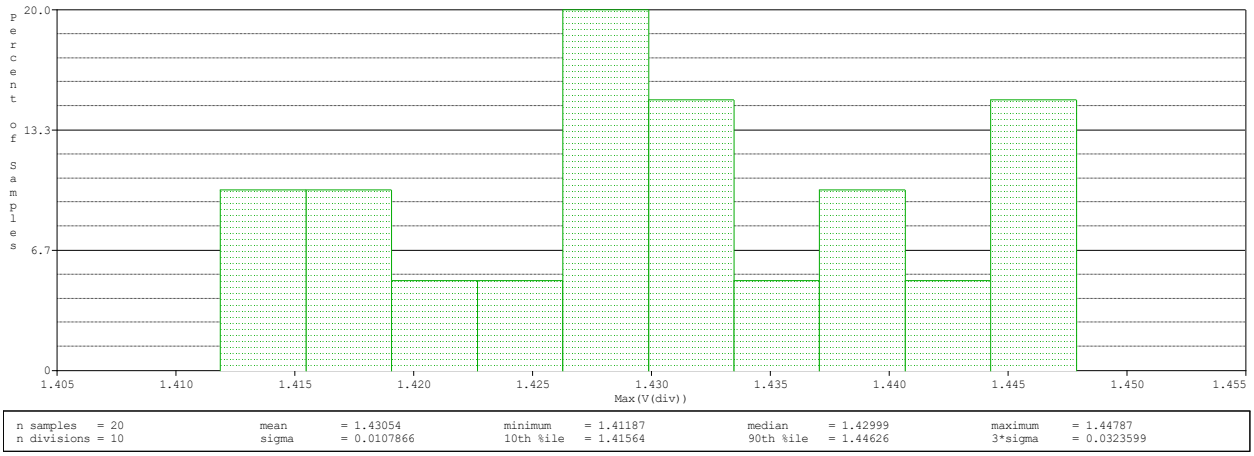






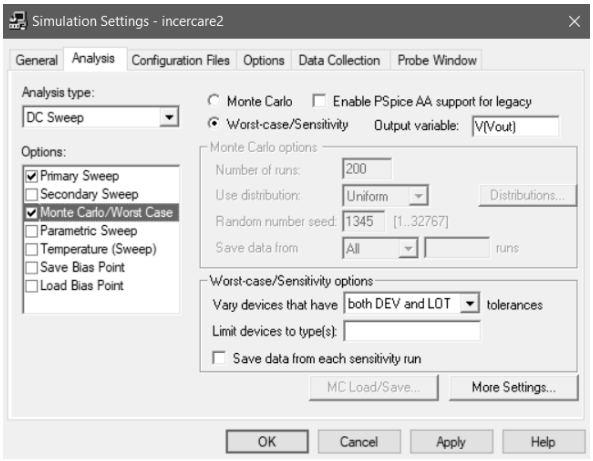
Aplic o astfel de simulare in nodul “div”:



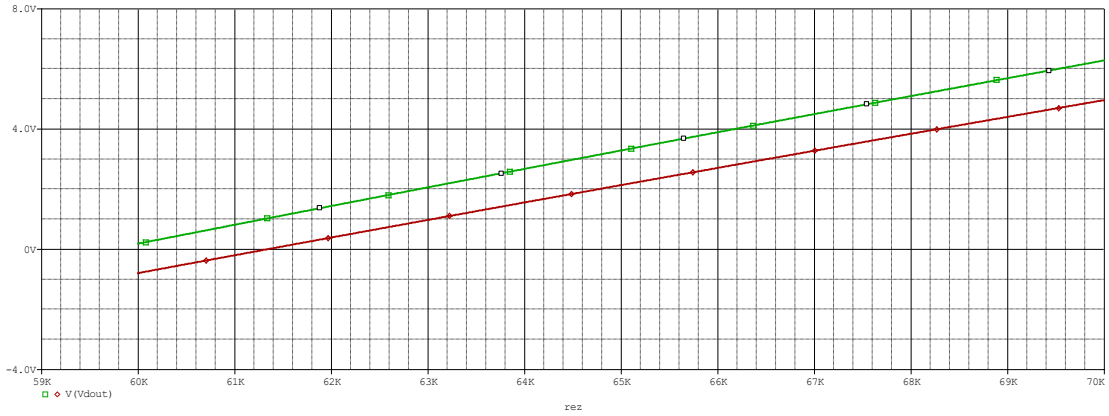


Analiza Worst Case:

Ma ajuta sa determin cel mai defavorabil caz.

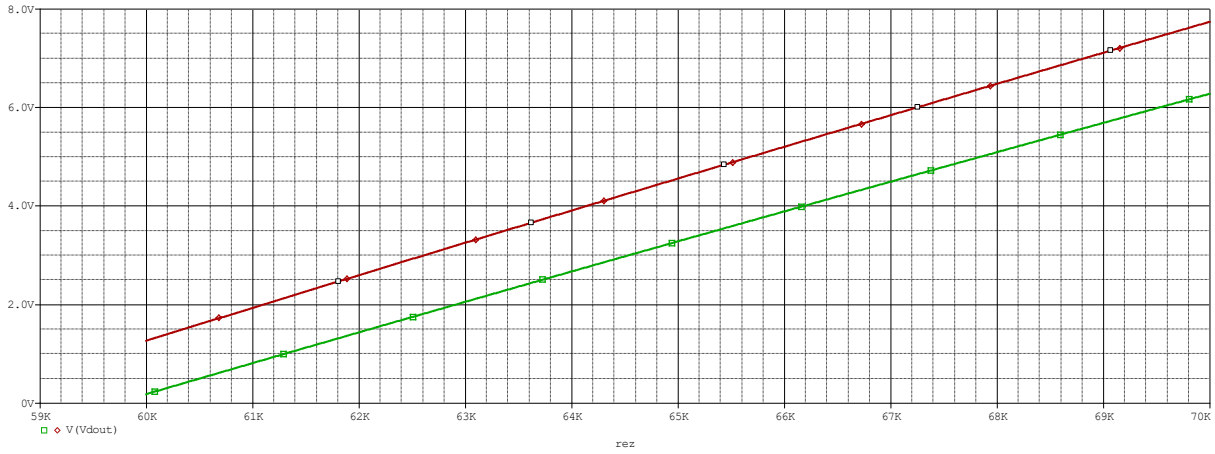


Low: (toleranta scade rezistentele)

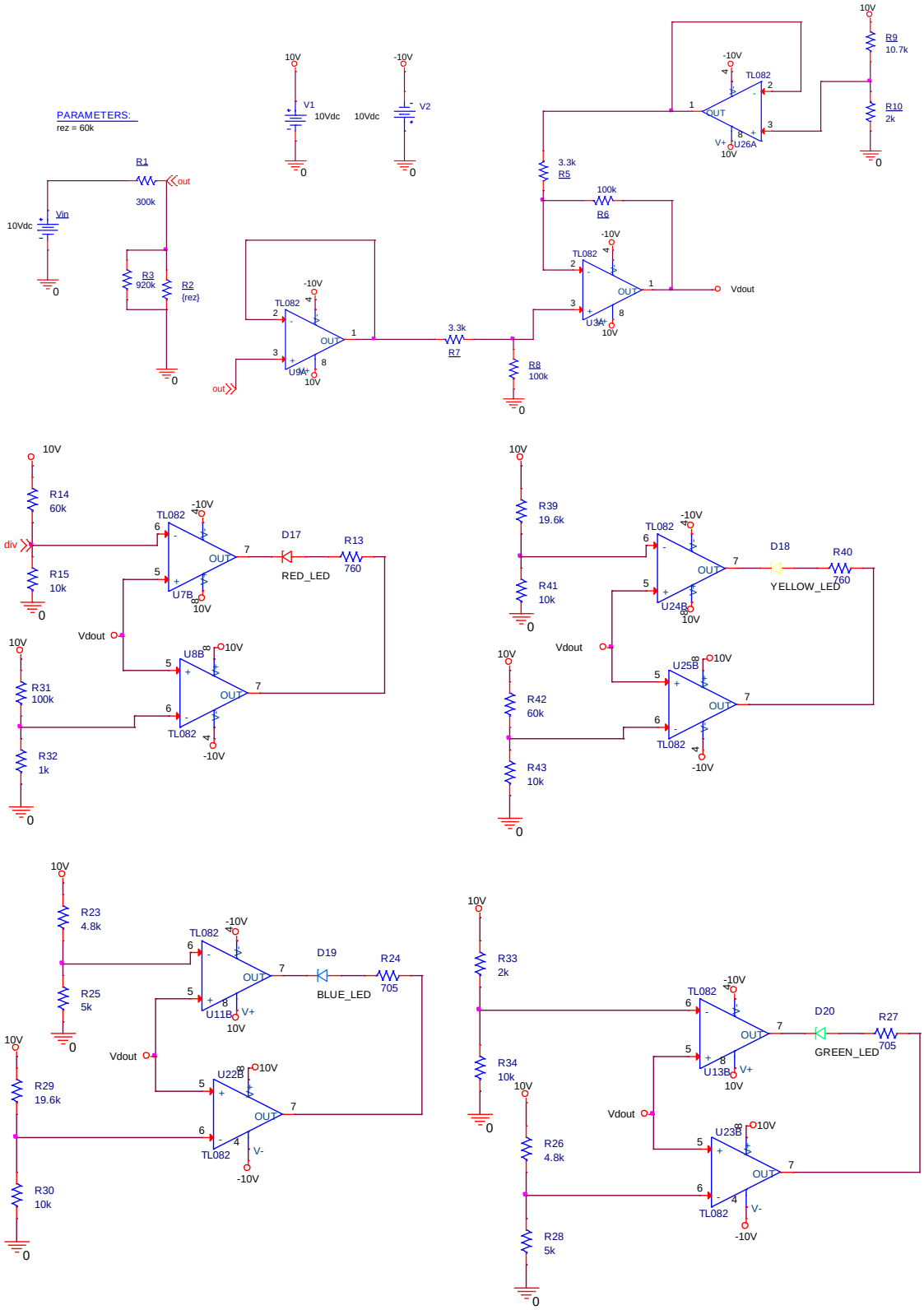


Hi: (toleranta creste rezistentele)

Observatie: Tensiunea nu este limitata.



Circuitul final:



Amplificatorul folosit (TL082):

https://ro.farnell.com/texas-instruments/tl082cp/ic-op-amp-dual-jfet-dip8/dp/3117815?CMP=KNC-GRO-GEN-KWL&mckv=_dc|pcrid|578349060675|&gclid=Cj0KCQjwgYSTBhDKARIsAB8KukszUHfbfAMNgBxvRzYvz8dn9n16UE8z39ETYIISTxe6NVrXo5l17LQaAlatEALw_wcB

Standardizarea rezistentelor:

Am preferat sa aleg rezistente din diferite serii, pentru a reduce costurile.

920k Ω (E192 0.5%)

https://de.farnell.com/en-DE/koa-speer-electronics/rn73h2attd9203b25/widerstand-920k-0-1-0-125w-0805/dp/3544207

301k Ω (E192 0.5%)

https://ro.farnell.com/multicomp/mcmf0w4df3013a50/res-301k-0-50-250mw-axial/dp/1563174?gclid=Cj0KCQjwg_iTBhDrARIsAD3Ib5iNac40JQK9QcAS8yYyGldXT_WbYo7xqZ90S5AowCND2MbYSPtI7dYaAkZNEALw_wcB&mckv=rAHaPDhr_dc|pcrid|580660128198|&CMP=KNC-GRO-GEN-SHOPPING-Whoop-7-June-2021&gross_price=true

100k Ω (E192 0.5%)

https://ro.farnell.com/multicomp/mcmf0w4df1003a50/res-100k-0-50-250mw-axial/dp/1563073?mckv=_dc|pcrid||plid||kword||match||slid||product|1563073|pgrid||ptaid||&gross_price=true&CMP=KNC-GRO-GEN-SHOPPING-PMax

3.3kΩ (E24 5%)

https://ro.farnell.com/multicomp/mf12-3k3/res-3k3-1-125mw-axial-metal-film/dp/9343040?cjevent=5265e4a5be2011ec82447c530a180514&cjdata=MXxZfDB8WXww&CMP=AFC-CJ-SK-8280252&gross_price=true&source=CJ

10.7kΩ E96(1%)

https://www.tme.eu/ro/details/pmr1t-11k/rezistente-metalizate-tht-1w/royal-ohm/pmr01tj0113a50/

2kΩ E96 (1%)

https://www.tme.eu/ro/details/mf0207fte-2k/rezistente-metalizate-tht-0-6w/yageo/mf0207fte52-2k/

60kΩ E192 (1%)

https://ro.ventronchip.com/parts/CMF5560K000BEBF/4217462.html

10kΩ E96 (1%)

https://ro.farnell.com/multicomp/mf50-10k/res-10k-1-500mw-axial-metal-film/dp/9339787?gclid=Cj0KCQjwmuiTBhDoARIsAPiv6L85Z81RyBrYm17xst6QBU7bwmlmYO2fp1CxhQ8DsO9mX22QdtP3QjsaAhEaEALw_wcB&mckv=vHVutQY6_dc|pcrid|579734362018|&CMP=KNC-GRO-GEN-SHOPPING-Whoop-7-June-2021&gross_price=true

100kΩ (E192 0.5%)

https://ro.farnell.com/multicomp/mcmf0w4df1003a50/res-100k-0-50-250mw-axial/dp/1563073?mckv=_dc|pcrid||plid||kword||match||slid||product|1563073|pgrid||ptaid||&gross_price=true&CMP=KNC-GRO-GEN-SHOPPING-PMax

1kΩ E96 (1%)

https://ro.farnell.com/multicomp/mf50-1k/res-1k-1-500mw-axial-metal-film/dp/9339779?gclid=Cj0KCQjwg_iTBhDrARIsAD3Ib5gSKbbZTjoOcugLvMXXnPTM0EgP-gm2Hht8dBb4kEjOjkBzyD0a1DgaAs5fEALw_wcB&mckv=3v1kcZmn_dc|pcrid|580660128873|&CMP=KNC-GRO-GEN-SHOPPING-Whoop-7-June-2021&gross_price=true

19.6kΩ E192 (0.5%)

https://seielect.zeano-ro.com/product/RNCF2512DKE19K6/04276735

10kΩ E96 (1%)

https://ro.farnell.com/multicomp/mf50-10k/res-10k-1-500mw-axial-metal-film/dp/9339787?gclid=Cj0KCQjwmuiTBhDoARIsAPiv6L-InZ5AAAcoPKQRtOkJyRsGbUZVYCs9UuIs7j6kx8YedS4sBODAMo0aAt1jEALw_wcB&mckv=vHVutQY6_dc|pcrid|579734362018|&CMP=KNC-GRO-GEN-SHOPPING-Whoop-7-June-2021&gross_price=true

4.7kΩ E24 (5%)

https://ro.farnell.com/multicomp-pro/mccfr0s2j0472a20/carbon-film-resistor-4-7kohm-500mw/dp/1128722?gclid=Cj0KCQjwmuiTBhDoARIsAPiv6L9gmVot4XlQ1QGabAKeha76FaN-4EBCo9tUFEo0XWWjfCGg1AzPI2gaApMiEALw_wcB&mckv=Lzs0etbX_dc|pcrid|526146951597|&CMP=KNC-GRO-GEN-SHOPPING-Whoop-7-June-2021&gross_price=true

5.1kΩ E96 (1%)

https://www.conexelectronic.ro/ro/rezistente-025-w-1/11087-5-1-K-0-25-W-1.html

750Ω E48 (2%)

https://www.emag.ro/rezistenta-750-cu-pelicula-metalica-2w-royal-ohm-mor02sj0751a10-t230254/pd/D1VSDPMBM/

715Ω E48 (2%)

https://ro.farnell.com/vishay/sfr2500007150fr500/metal-film-resistor-715-ohm-400mw/dp/3282739?mckv=_dc|pcrid||plid||kword||match||slid||product|3282739|pgrid||ptaid||&gross_price=true&CMP=KNC-GRO-GEN-SHOPPING-PMax

Bibliografie:

"PROIECTARE ASISTATA DE CALCULATOR-Aplicatii"- Ovidiu POP, Raul FIZESAN, Gabriel CHINDRIS

Laboratoar CEF-an2, sem 1 : "01_Circuite fundamentale cu AO"

https://sites.google.com/site/bazeleelectronicii/home/amplificatoare-operationale/11-comparator-amp-op

http://www.learningaboutelectronics.com/Articles/What-is-the-forward-current-of-an-LED

https://sites.google.com/site/bazeleelectronicii/home/amplificatoare-operationale/5-amplificator-diferential

https://koaha.org/wiki/Valori_standard_resistenze