Proiect CIA

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Grupa: 2127

1)Amplificator diferential

Amplificator diferential	Topologie	Amplificator diferential de tip P cu sarcina sursa
	Produs amplificare banda [MHz]	65
	Capacitate de sarcina [pF]	5

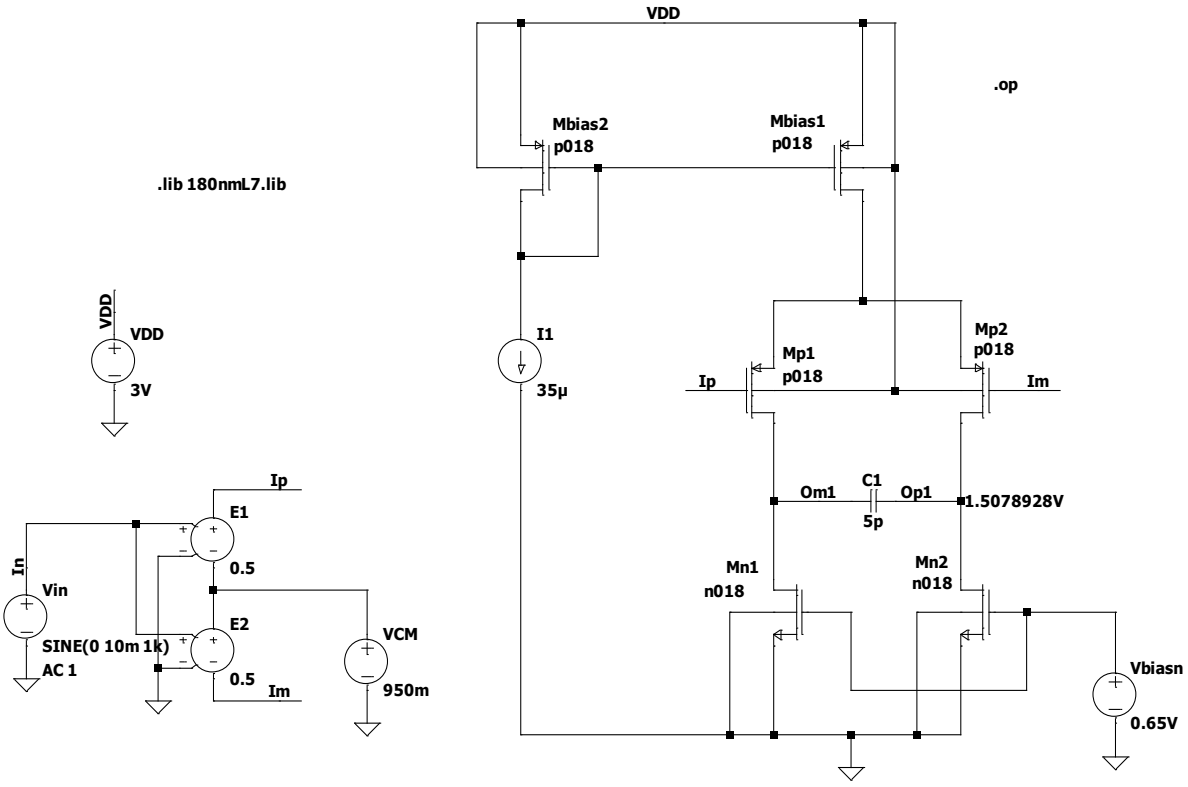


Figura 1. Schema electrica a amplificatorului diferential de tip P cu sarcina sursa

DIMENSIONARE

Amplificator diferențial

DIMENSIONARE $\begin{cases} GBW = 65\,MHz \\ C_L = 5\,pF \end{cases}$

$$GBW = \frac{G_m}{2\pi C_L} \Rightarrow G_m = GBW \cdot 2\pi \cdot C_L = 130 \cdot 10^6 \cdot 2 \cdot 3{,}14 \cdot 5 \cdot 10^{-12} = 4082\,\mu S$$

$$GBW = [1{,}5 \dots 2] \cdot GBW_{min}$$

$$GBW = 2 \cdot 65\,MHz = 130\,MHz$$

$$g_{m\text{-}m_{1,2}} = 2 \cdot G_m = 8{,}164\,mS \qquad V_{DSAT} = 200\,mV$$

$$g_{m\text{-}m_{1,2}} = \frac{2 I_{D\text{-}m_{1,2}}}{V_{DSAT\text{-}m_{1,2}}} \Rightarrow I_{D\text{-}m_{1,2}} = \frac{g_{m\text{-}m_{1,2}} \cdot V_{DSAT\text{-}m_{1,2}}}{2} = \frac{8{,}164 \cdot 10^{-3} \cdot 200 \cdot 10^{-3}}{2} =$$

$$= 816\,\mu A$$

→ M_{m_1}, M_{m_2}

$$\frac{I_{Dref}}{I_D} = \frac{(W/L)_{ref}}{W/L} \cdot \left(\frac{V_{DSAT\,ref}}{V_{DSAT}}\right)^2$$

$$\frac{50\mu}{816\mu} = \frac{5\mu/1\mu}{W/L} \cdot \left(\frac{240m}{200m}\right)^2 \Rightarrow \left(\frac{W}{L}\right)_{m_1,m_2} = 117{,}5$$

Alegem $L = 1\mu \Rightarrow W = 117{,}5\mu$

$$AD = AS = 0{,}2\mu \cdot 117{,}5\mu = 23{,}5p$$

$$PD = PS = 2(0{,}2\mu + 117{,}5\mu) = 235{,}4\mu$$

→ M_{p_1}, M_{p_2}

$$I_{D\text{-}p_{1,2}} = I_{D\text{-}m_{1,2}} = 816\,\mu A$$

$$\frac{50\mu}{816\mu} = \frac{15\mu/1\mu}{W/L} \cdot \left(\frac{257m}{200m}\right)^2 \Rightarrow \left(\frac{W}{L}\right)_{p_1,p_2} = 404{,}2$$

Alegem $L = 1\mu \Rightarrow W = 404{,}2\mu$

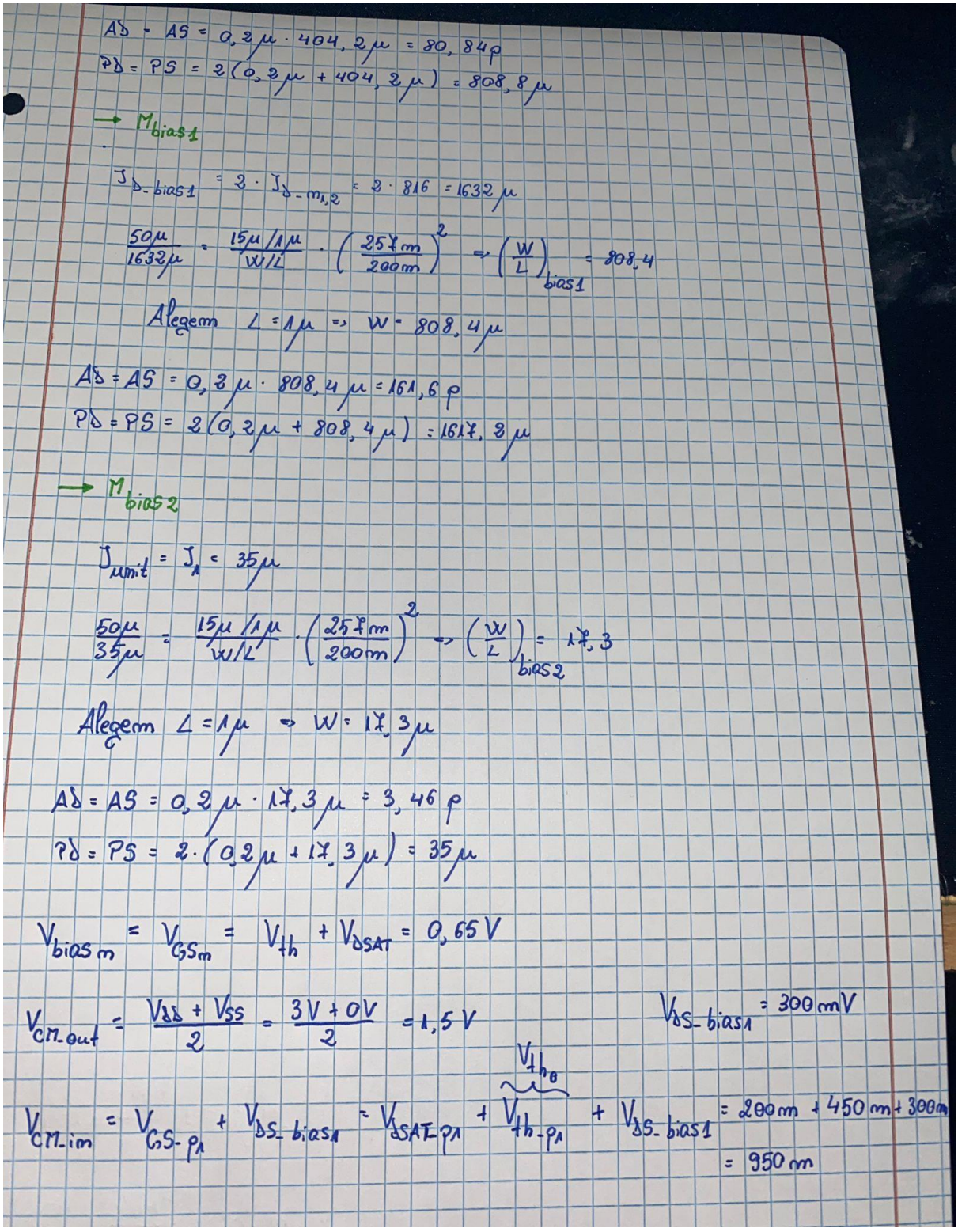


Figura 2. Datele de proiectare ale amplificatorului

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Amplificator diferential\amplificator_diferential.log

```
Circuit: * C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Amplificator diferential\amplificator_diferential.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                        --- BSIM3 MOSFETS ---
Name:         mp2          mp1        mbias2       mbias1         mn1
Model:       p018         p018         p018         p018        n018
Id:       -8.25e-04    -8.25e-04    -3.50e-05    -1.65e-03    8.25e-04
Vgs:      -1.25e+00    -1.25e+00    -7.31e-01    -7.31e-01    6.50e-01
Vds:      -6.35e-02    -6.35e-02    -7.31e-01    -8.02e-01    2.13e+00
Vbs:       8.02e-01     8.02e-01     0.00e+00     0.00e+00    0.00e+00
Vth:      -6.44e-01    -6.44e-01    -4.46e-01    -4.46e-01    4.46e-01
Vdsat:    -4.31e-01    -4.31e-01    -2.04e-01    -2.04e-01    1.92e-01
Gm:        1.34e-03     1.34e-03     2.40e-04     1.13e-02    6.48e-03
Gds:       1.20e-02     1.20e-02     4.29e-06     1.99e-04    6.68e-05
Gmb        3.49e-04     3.49e-04     6.50e-05     3.06e-03    2.08e-03
Cbd:       9.23e-13     9.23e-13     4.15e-14     1.88e-12    1.72e-13
Cbs:       9.39e-13     9.39e-13     5.52e-14     2.55e-12    2.72e-13
Cgsov:     2.20e-13     2.20e-13     9.42e-15     4.40e-13    6.41e-14
Cgdov:     2.20e-13     2.20e-13     9.31e-15     4.32e-13    5.61e-14
Cgbov:     0.00e+00     0.00e+00     0.00e+00     0.00e+00    0.00e+00
dQgdVgb:   3.52e-12     3.52e-12     1.30e-13     6.05e-12    8.62e-13
dQgdVdb:  -1.56e-12    -1.56e-12    -9.36e-15    -4.34e-13   -5.61e-14
dQgdVsb:  -1.96e-12    -1.96e-12    -1.14e-13    -5.34e-12   -7.54e-13
dQddVgb:  -1.72e-12    -1.72e-12    -9.51e-15    -4.40e-13   -5.62e-14
dQddVdb:   4.75e-12     4.75e-12     5.09e-14     2.31e-12    2.28e-13
dQddVsb:  -1.80e-12    -1.80e-12     1.29e-16     5.06e-15    1.12e-16
dQbdVgb:  -1.92e-14    -1.92e-14    -2.23e-14    -1.04e-12   -1.25e-13
dQbdVdb:  -2.00e-12    -2.00e-12    -4.15e-14    -1.88e-12   -1.72e-13
dQbdVsb:  -5.05e-13    -5.05e-13    -6.49e-14    -3.01e-12   -3.88e-13
```

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\L

```
dQddVdb:   4.75e-12    4.75e-12     5.09e-1
dQddVsb:  -1.80e-12   -1.80e-12     1.29e-1
dQbdVgb:  -1.92e-14   -1.92e-14    -2.23e-1
dQbdVdb:  -2.00e-12   -2.00e-12    -4.15e-1
dQbdVsb:  -5.05e-13   -5.05e-13    -6.49e-1

Name:         mn2
Model:       n018
Id:       8.25e-04
Vgs:      6.50e-01
Vds:      2.13e+00
Vbs:      0.00e+00
Vth:      4.46e-01
Vdsat:    1.92e-01
Gm:       6.48e-03
Gds:      6.68e-05
Gmb       2.08e-03
Cbd:      1.72e-13
Cbs:      2.72e-13
Cgsov:    6.41e-14
Cgdov:    5.61e-14
Cgbov:    0.00e+00
dQgdVgb:  8.62e-13
dQgdVdb: -5.61e-14
dQgdVsb: -7.54e-13
dQddVgb: -5.62e-14
dQddVdb:  2.28e-13
dQddVsb:  1.12e-16
dQbdVgb: -1.25e-13
dQbdVdb: -1.72e-13
dQbdVsb: -3.88e-13


Date: Mon May 09 14:32:55 2022
Total elapsed time: 0.032 seconds.
```

Figura 3. Fisierul de iesire rezultat dupa dimensionarea amplificatorului diferential de tip P cu sarcina sursa

AJUSTARE

V_{biasn} -> ajustat la 0.66V

$(W/L)_{n1,2}$ -> ajustat la 113.3/1

⇨ AD = AS = 0.2u * 113.3u = 22.66p

⇨ PD = PS = 2*(0.2u + 113.3u) = 227u

$(W/L)_{p1,2}$ -> ajustat la 490/1

⇨ AD = AS = 98p

⇨ PD = PS = 980.4u

$(W/L)_{bias1}$ -> ajustat la 780/1

⇨ AD = PS = 156p

⇨ PD = PS = 1560.4u

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [uS]
Mn1	113.3/1	816	199	1.5V	446	660	6.21m	68,5
Mn2	113.3/1	816	199	1.5V	446	660	6.21m	68,5
Mp1	490/1	816	206	492	686	924	6.05m	102
Mp2	490/1	816	206	492	492	924	6.05m	102
Mbias1	780/1	1630	204	1.01V	446	731	11.1m	191
Mbias2	17.3/1	35	204	731	446	731	240	4,29

Tabel 1. Valorile de punct static pentru amplificatorul diferential dupa ajustare

2) Sursa de curent

Sursa de curent	Topologie	Sursa de curent cascoda cu rezistenta de iesire marita cu tranzistoare NMOS
	Curent de iesire [uA]	35

	Tensiunea de iesire minima [mV]	400

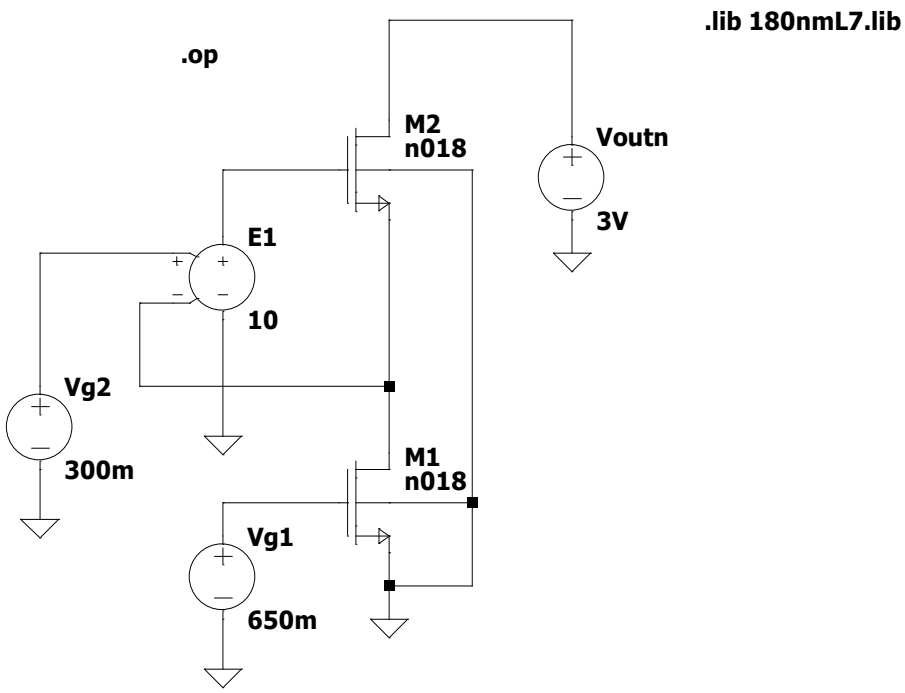


Figura 1 Schema electrica a sursei de curent cascoda cu rezistenta de iesire marita cu tranzistoare NMOS

DIMENSIONARE

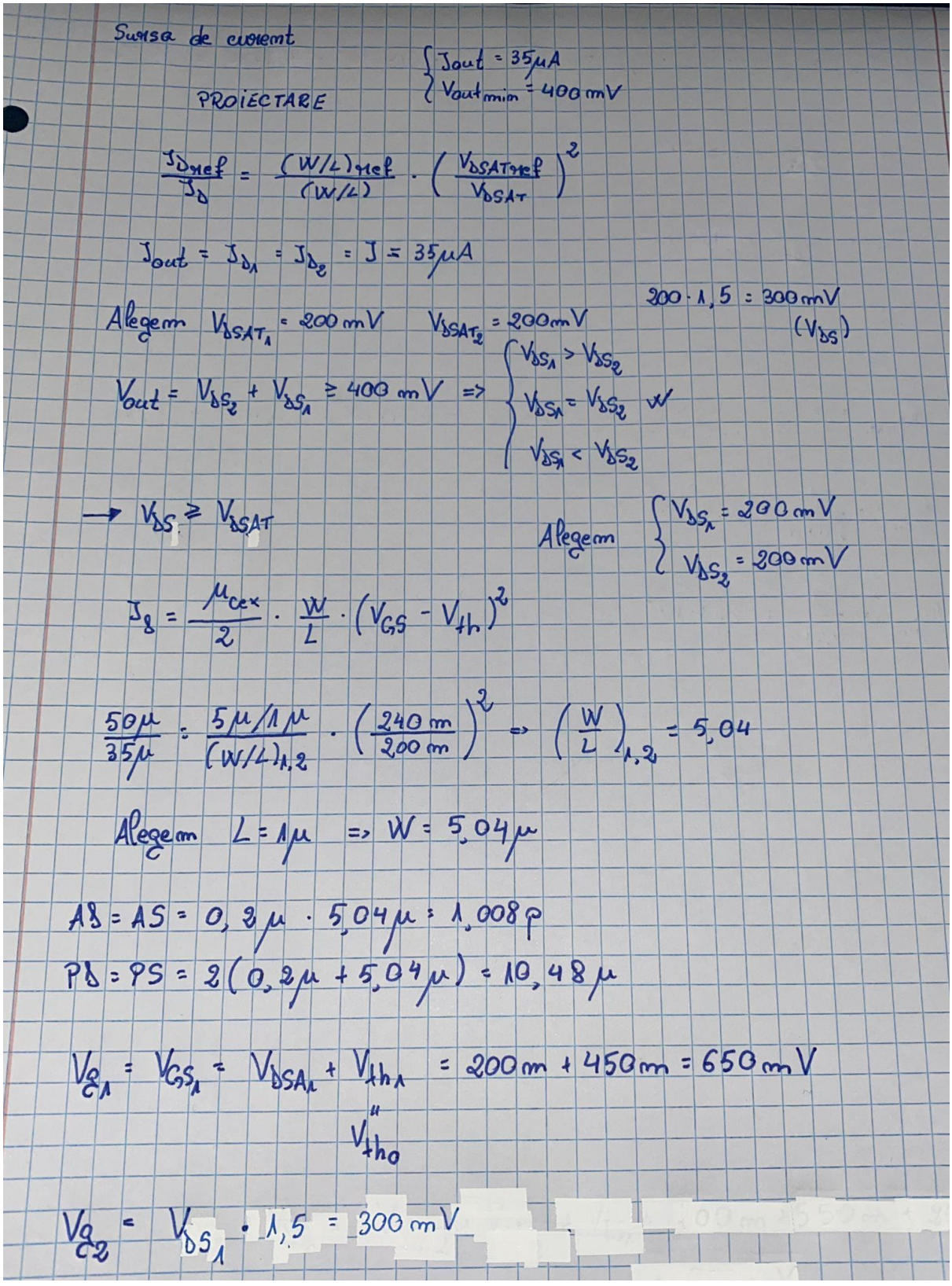


Figura 1. Datele de proiectare ale sursei

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Sursa de curent\Sursa_de_curent.log

```
Circuit: * C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Sursa de curent\Sursa_de_curent.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                         --- BSIM3 MOSFETS ---
Name:         m1           m2
Model:      n018         n018
Id:        3.15e-05     3.15e-05
Vgs:       6.50e-01     8.56e-01
Vds:       7.86e-01     2.21e+00
Vbs:       0.00e+00    -7.86e-01
Vth:       4.46e-01     6.49e-01
Vdsat:     1.92e-01     2.00e-01
Gm:        2.53e-04     2.44e-04
Gds:       2.90e-06     2.35e-06
Gmb        8.08e-05     6.17e-05
Cbd:       9.43e-15     6.90e-15
Cbs:       1.20e-14     9.43e-15
Cgsov:     2.75e-15     2.75e-15
Cgdov:     2.68e-15     2.42e-15
Cgbov:     0.00e+00     0.00e+00
dQgdVgb:   3.73e-14     3.65e-14
dQgdVdb:  -2.69e-15    -2.42e-15
dQgdVsb:  -3.24e-14    -3.25e-14
dQddVgb:  -2.73e-15    -2.43e-15
dQddVdb:   1.21e-14     9.32e-15
dQddVsb:   3.83e-17     4.18e-18
dQbdVgb:  -5.35e-15    -4.94e-15
dQbdVdb:  -9.43e-15    -6.90e-15
dQbdVsb:  -1.69e-14    -1.21e-14



Date: Wed Apr 27 17:01:37 2022
Total elapsed time: 0.029 seconds.
```

Figura 2. Fisierul de iesire rezultat dupa dimensionarea sursei de curent cascoda cu rezistenta de iesire marita cu tranzistoare NMOS

AJUSTARE

V_{g1} -> ajustat la 675mV

V_{g2} -> ajustat la 300mV

W/L -> ajustat la 5.07u/1u

⇨ AD = AS = 0.2u*5.07u = 1.014p

⇨ PD = PS = 2(0.2u + 5.07u) = 10.54u

Tranzistor	W/L	ID	Vdsat	Vds	Vth	Vgs	Gm	Gds

		[uA]	[mV]	[mV]	[mV]	[mV]	[uS]	[uS]
M1	5.07/1	35	210	209	446	675	239	3,44
M2	5.07/1	35	191	2,79V	506	706	277	2,66

Tabel 1. Valorile de punct static pentru sursa de curent dupa ajustare

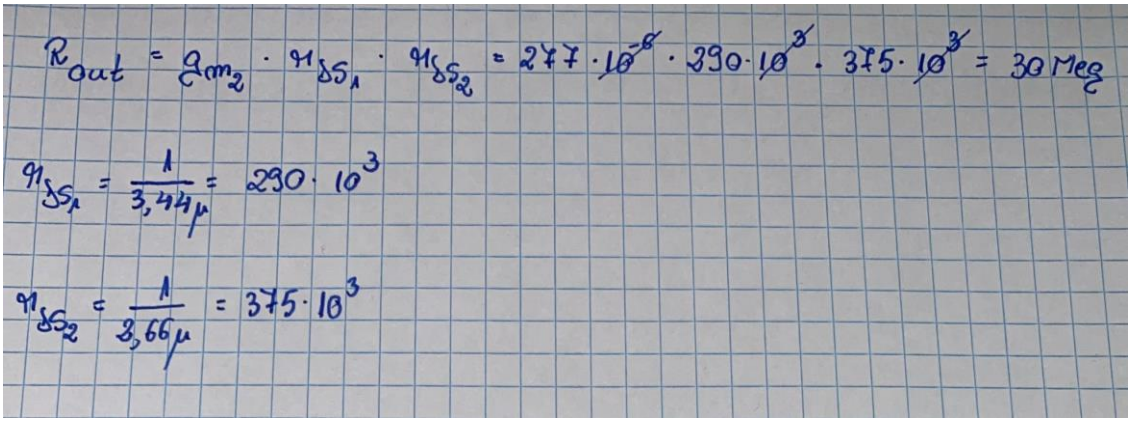


Figura 3. Calculul rezistentei de iesire Rout

ANALIZA

.dc

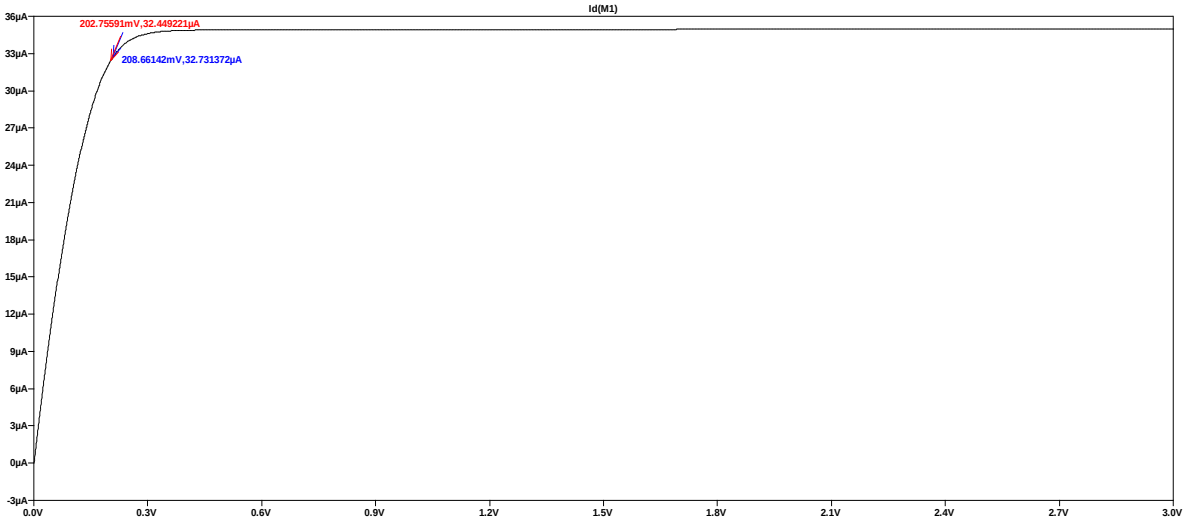


Figura 4. Caracteristica de iesire

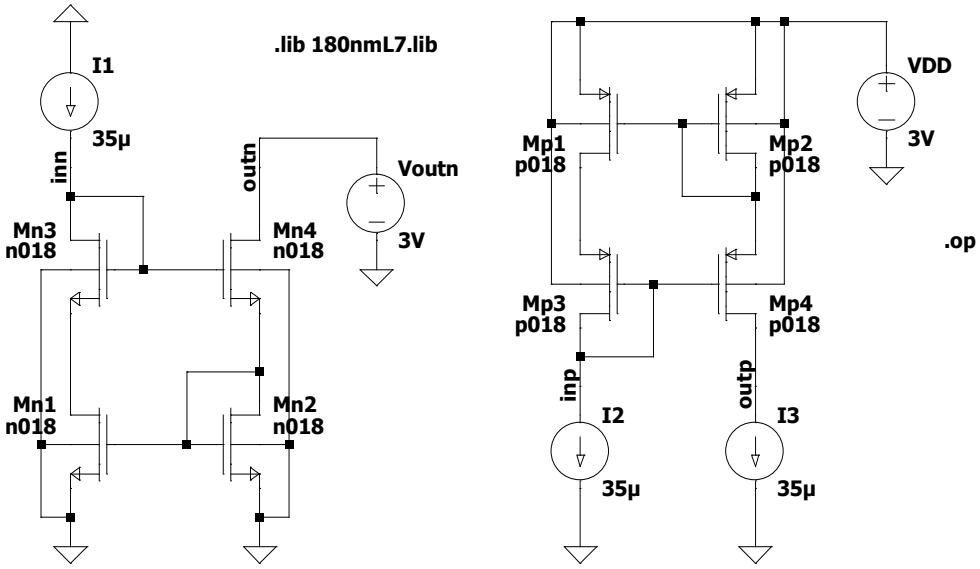
R_{out} = 1/panta

panta ≈ 4e-005 } => $R_{out} \approx 25\ M\Omega$

Parametru	Calculat	Masurat
Rout [MΩ]	30Meg	25Meg

Tabel 2. Valoarea calculata si masurata a rezistentei de iesire

3) Oglinzi de curent Wilson



DIMENSIONARE

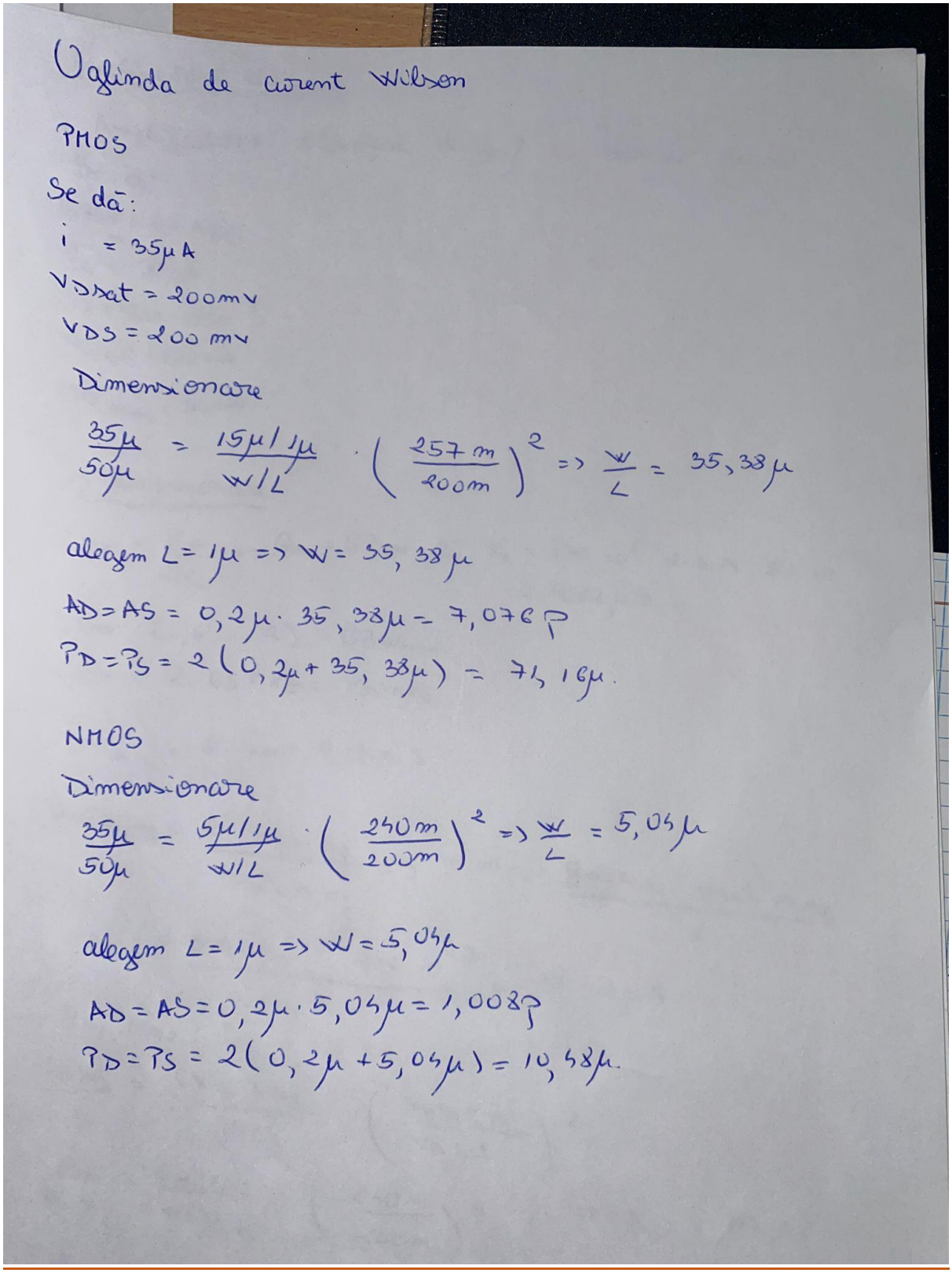


Figura 1. Datele de proiectare ale oglinzilor Wilson

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\LTSpice\oglinda wilson\oglinda wilson\ogl-wilson-MOS.log

```
Circuit: * C:\Users\Diana\Downloads\Proiect CIA\LTSpice\oglinda wilson\oglinda wilson\ogl-wilson-MOS.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                        --- BSIM3 MOSFETS ---
Name:         mn1          mn2          mn3          mn4          mp3
Model:       n018         n018         n018         n018         p018
Id:       3.50e-05     3.50e-05     3.50e-05     3.50e-05    -3.50e-05
Vgs:      6.65e-01     6.65e-01     8.50e-01     8.38e-01    -8.02e-01
Vds:      6.53e-01     6.65e-01     8.50e-01     2.33e+00    -8.02e-01
Vbs:      0.00e+00     0.00e+00    -6.53e-01    -6.65e-01     6.47e-01
Vth:      4.46e-01     4.46e-01     6.19e-01     6.22e-01    -6.10e-01
Vdsat:    2.03e-01     2.03e-01     2.18e-01     2.06e-01    -1.56e-01
Gm:       2.65e-04     2.66e-04     2.51e-04     2.60e-04     3.59e-04
Gds:      3.22e-06     3.21e-06     2.87e-06     2.59e-06     4.32e-06
Gmb       8.48e-05     8.49e-05     6.55e-05     6.80e-05     7.91e-05
Cbd:      9.72e-15     9.69e-15     8.25e-15     6.90e-15     7.09e-14
Cbs:      1.20e-14     1.20e-14     9.72e-15     9.69e-15     8.65e-14
Cgsov:    2.75e-15     2.75e-15     2.75e-15     2.75e-15     1.93e-14
Cgdov:    2.72e-15     2.72e-15     2.72e-15     2.41e-15     1.90e-14
Cgbov:    0.00e+00     0.00e+00     0.00e+00     0.00e+00     0.00e+00
dQgdVgb:  3.73e-14     3.73e-14     3.69e-14     3.66e-14     2.60e-13
dQgdVdb: -2.74e-15    -2.73e-15    -2.73e-15    -2.41e-15    -1.91e-14
dQgdVsb: -3.24e-14    -3.24e-14    -3.25e-14    -3.25e-14    -2.30e-13
dQddVgb: -2.80e-15    -2.79e-15    -2.76e-15    -2.41e-15    -1.93e-14
dQddVdb:  1.25e-14     1.25e-14     1.10e-14     9.30e-15     9.01e-14
dQddVsb:  5.75e-17     5.53e-17     3.14e-17     3.79e-18     2.10e-16
dQbdVgb: -5.33e-15    -5.33e-15    -4.96e-15    -4.97e-15    -4.15e-14
dQbdVdb: -9.73e-15    -9.70e-15    -8.26e-15    -6.90e-15    -7.10e-14
dQbdVsb: -1.69e-14    -1.69e-14    -1.27e-14    -1.26e-14    -9.68e-14

Name:         mp4          mp1          mp2
```

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\LTSpice\oglinda wilson\oglinda wilson\ogl-wilson-MOS.log

```
Name:         mp4          mp1          mp2
Model:       p018         p018         p018
Id:       -3.50e-05    -3.50e-05    -3.50e-05
Vgs:      -8.02e-01    -6.47e-01    -6.47e-01
Vds:      -8.02e-01    -6.47e-01    -6.47e-01
Vbs:       6.47e-01     0.00e+00     0.00e+00
Vth:      -6.10e-01    -4.46e-01    -4.46e-01
Vdsat:    -1.56e-01    -1.48e-01    -1.48e-01
Gm:        3.59e-04     3.59e-04     3.59e-04
Gds:       4.32e-06     4.66e-06     4.66e-06
Gmb        7.91e-05     9.73e-05     9.73e-05
Cbd:       7.09e-14     8.65e-14     8.65e-14
Cbs:       8.65e-14     1.12e-13     1.12e-13
Cgsov:     1.93e-14     1.93e-14     1.93e-14
Cgdov:     1.90e-14     1.90e-14     1.90e-14
Cgbov:     0.00e+00     0.00e+00     0.00e+00
dQgdVgb:   2.60e-13     2.65e-13     2.65e-13
dQgdVdb:  -1.91e-14    -1.91e-14    -1.91e-14
dQgdVsb:  -2.30e-13    -2.32e-13    -2.32e-13
dQddVgb:  -1.93e-14    -1.95e-14    -1.95e-14
dQddVdb:   9.01e-14     1.06e-13     1.06e-13
dQddVsb:   2.10e-16     3.32e-16     3.32e-16
dQbdVgb:  -4.15e-14    -4.58e-14    -4.58e-14
dQbdVdb:  -7.10e-14    -8.65e-14    -8.65e-14
dQbdVsb:  -9.68e-14    -1.33e-13    -1.33e-13



Date: Tue May 10 12:32:33 2022
Total elapsed time: 0.036 seconds.
```

Figura 2. Fisierul de iesire rezultat dupa dimensionarea oglinzilor de curent Wilson

AJUSTARE

4) ***Circuitul final***

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [uS]
M1	5.07/1	34.9	203	1.21V	506	721	265	2.95
M2	5.07/1	34.9	210	207	446	675	238	35.4

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [uS]
Mn1	113.3/1	816	199	1.5V	446	660	6.21m	68,5
Mn2	113.3/1	816	199	1.5V	446	660	6.21m	68,5
Mp1	21.5/1	816	866	492	686	924	6.05m	102
Mp2	21.5/1	816	866	492	492	924	6.05m	102
Mbias1	780/1	1630	977	1.01V	446	731	11.1m	191
Mbias2	17.3/1	84.2	977	731	446	731	240	4,29