Proiect CIA

Plesa Diana Simona

Vitca Diana Nicoleta

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

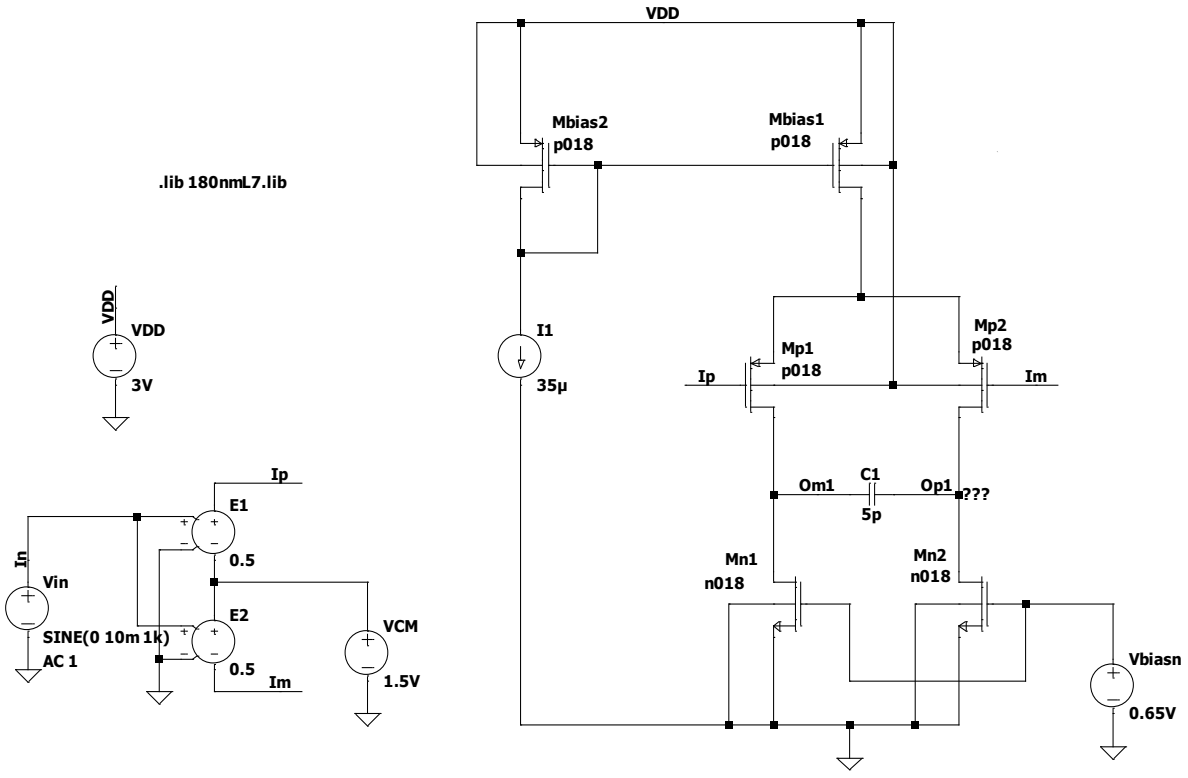
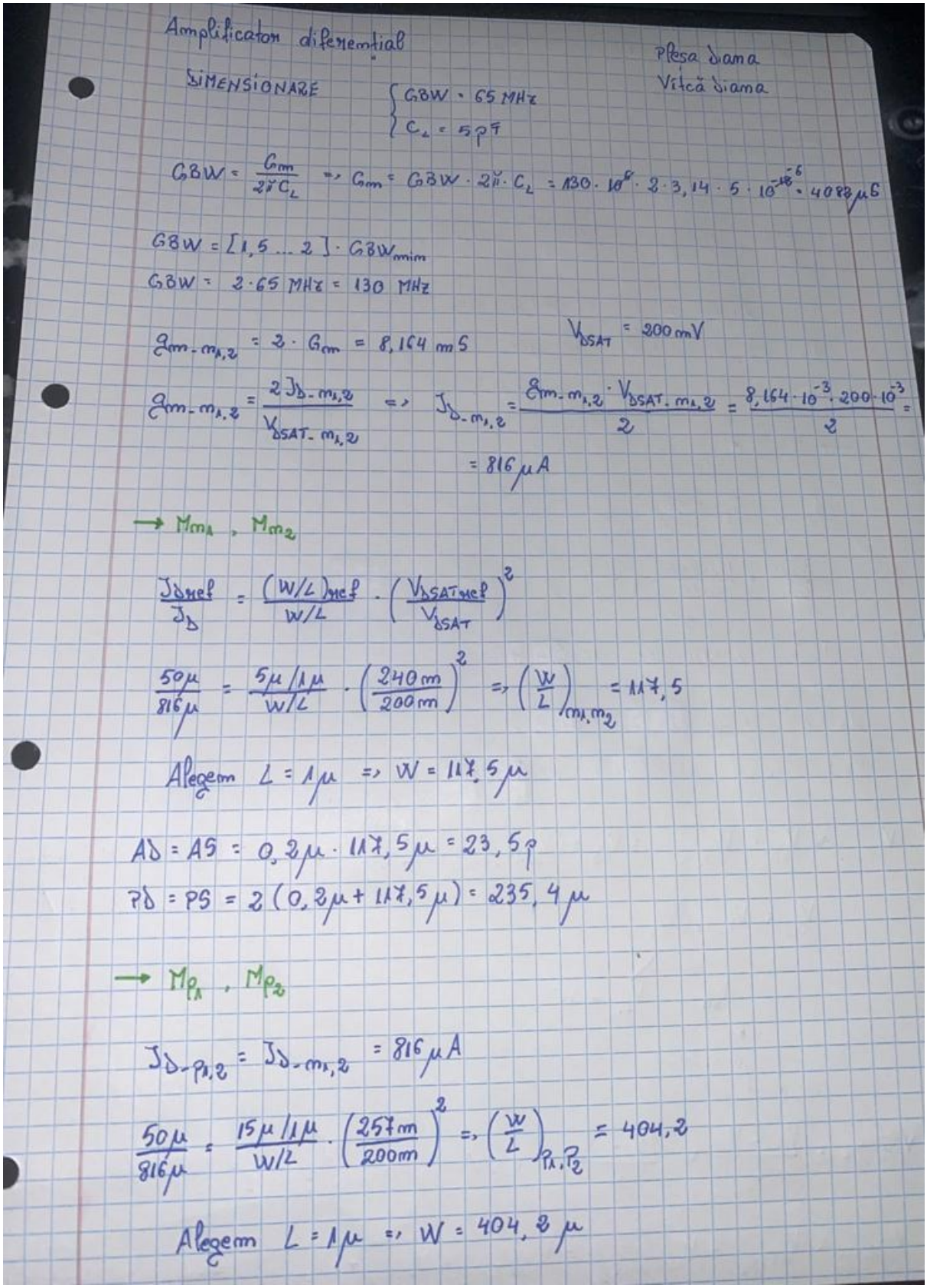


Figura 1. Schema electrica a amplificatorului diferential de tip P cu sarcina sursa

DIMENSIONARE



Amplificator diferențial

Plesa Ioana
Vițcă Ioana

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

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

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

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

$g_{m\_m_{1,2}} = 2 \cdot G_m = 8,164\,mS$

$V_{DSAT} = 200\,mV$

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

$= 816\,\mu A$

→ 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}

$I_{D\_p_{1,2}} = I_{D\_m_{1,2}} = 816\,\mu A$

$\frac{50\mu}{816\mu} = \frac{15\mu/1\mu}{W/L} \cdot \left(\frac{257m}{200m}\right)^2 \Rightarrow \left(\frac{W}{L}\right)_{P_1,P_2} = 404,2$

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

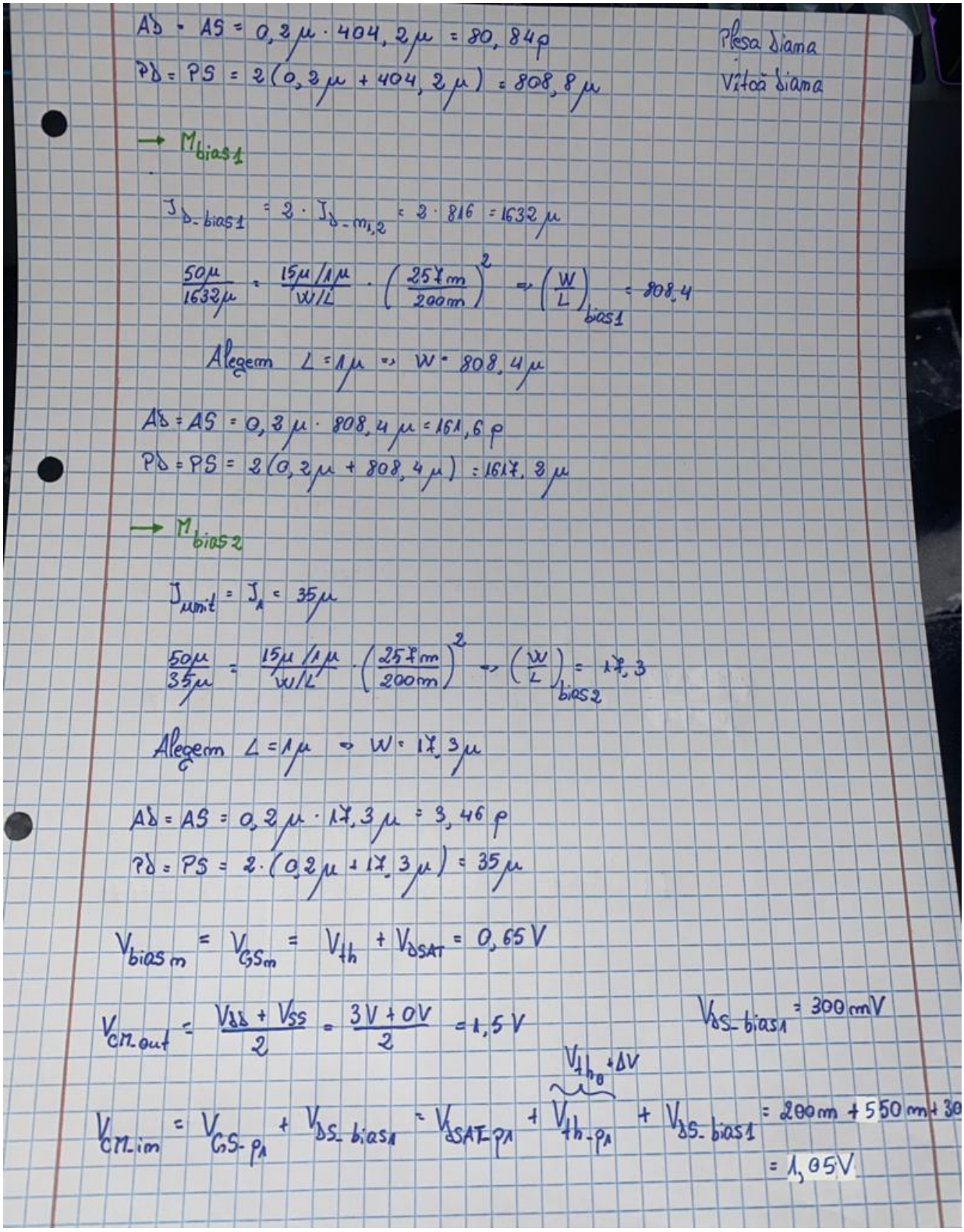


Figura 2. Datele de proiectare ale amplificatorului

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 inainte de ajustarea amplificatorului diferential de tip P cu sarcina sursa

AJUSTARE

V_{biasn} -> ajustat la 0.6597V

$(W/L)_{n1,2}$ -> ajustat la 113.6/1

- ⇨ AD = AS = 0.2u * 113.6u = 22.72p
- ⇨ PD = PS = 2*(0.2u + 113.6u) = 227.6u

$(W/L)_{p1,2}$ -> ajustat la 425/1

- ⇨ AD = AS = 85p
- ⇨ PD = PS = 850.4u

$(W/L)_{bias1}$ -> ajustat la 817/1

- ⇨ AD = PS = 163.4p
- ⇨ PD = PS = 1634.4u

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [uS]
Mn1	113.6/1	816	199	1.5V	446	660	6.22m	68.6
Mn2	113.6/1	816	199	1.5V	446	660	6.22m	68.6
Mp1	425/1	816	210	876	605	874	5.76m	93.2
Mp2	425/1	816	210	876	605	874	5.76m	93.2
Mbias1	817/1	1630	204	626	446	731	11.2m	205
Mbias2	17.3/1	35	204	731	446	731	240	4.29

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

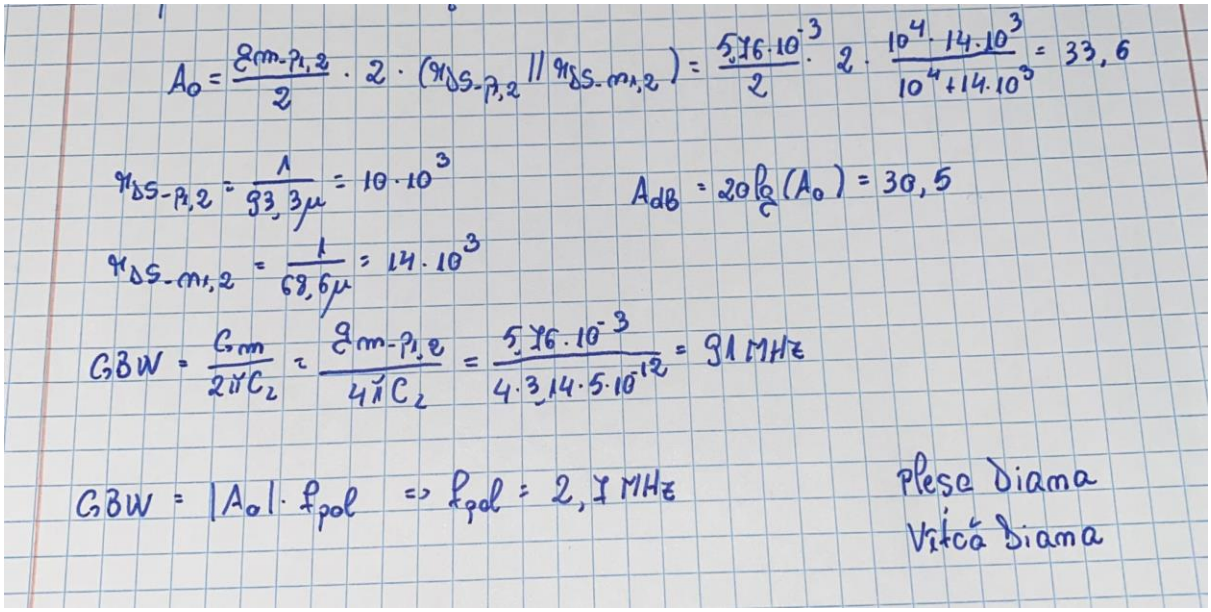


Figura 4. Calculul parametrilor A_0, GBW si f_{pol}

ANALIZA

.ac

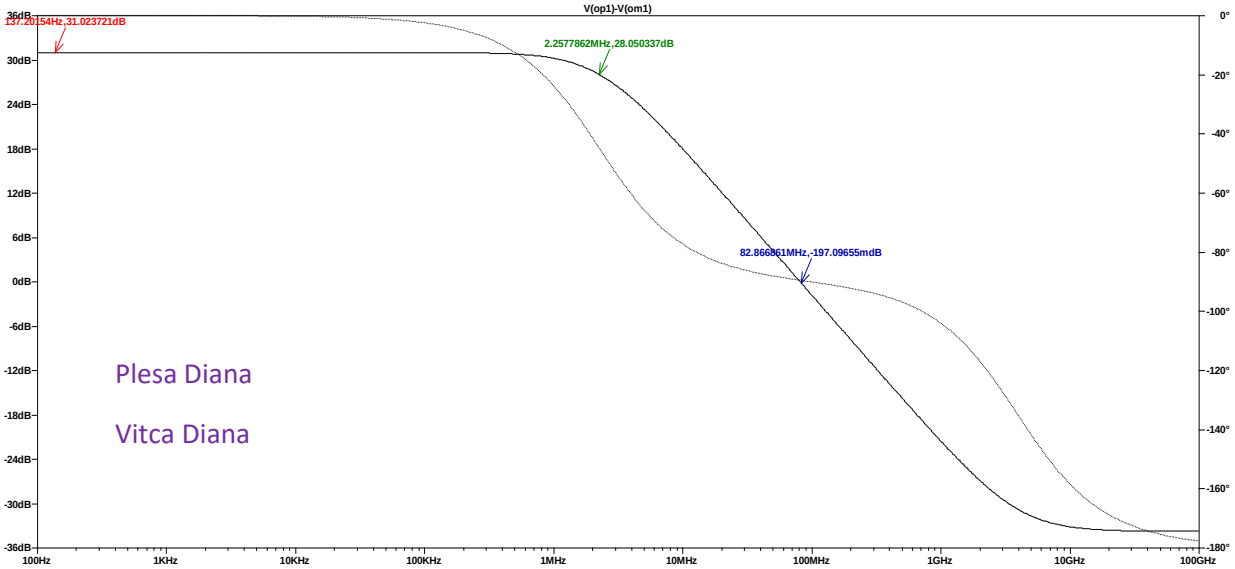


Figura 5. Caracteristica de modul si de faza (A_0-rosu, GBW-albastru, f_{pol}-verde)

Parametru	Calculat	Masurat
A_0 [dB]	30.5	31
GBW [MHz]	91	82.8
f_{pol} [kHz]	2.7M	2.25M

Tabel 2. Valorile calculate si masurate ale parametrilor A_0, GBW, f_{pol}

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

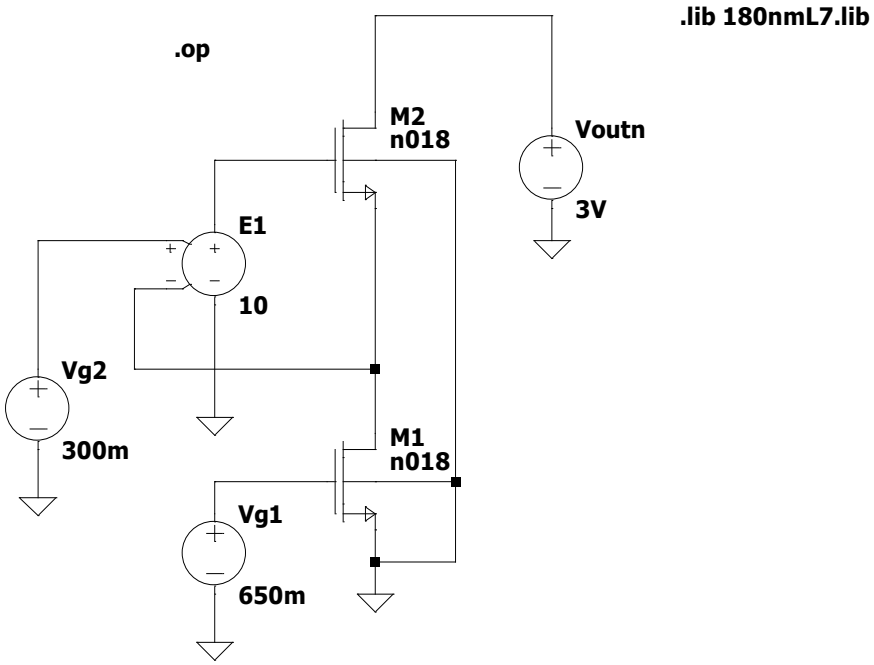


Figura 1 Schema electrica a sursei de curent cascoda cu rezistenta de iesire marita cu tranzistoare NMOS

DIMENSIONARE

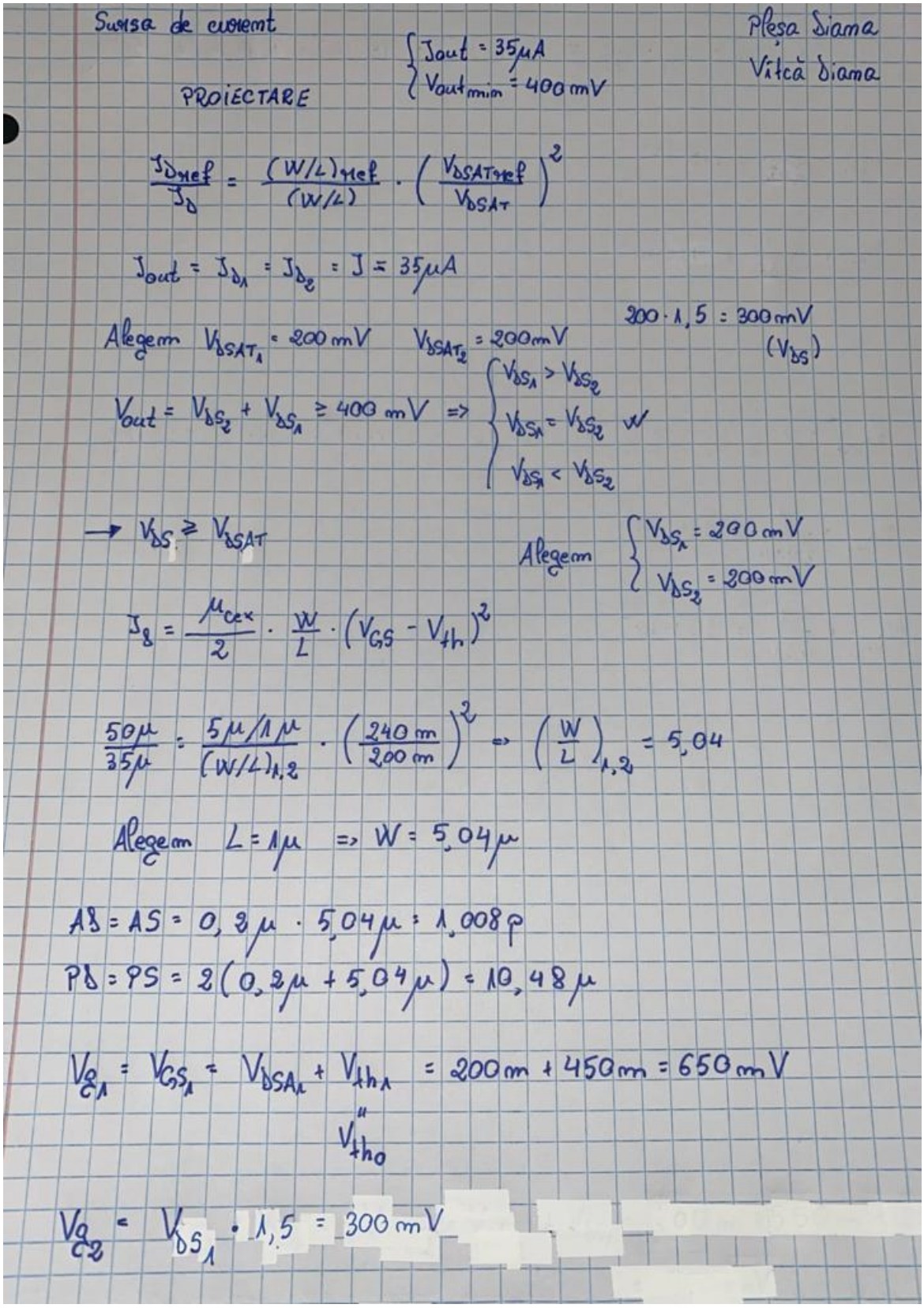


Figura 1. Datele de proiectare ale sursei

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 inainte de ajustarea 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 [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [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

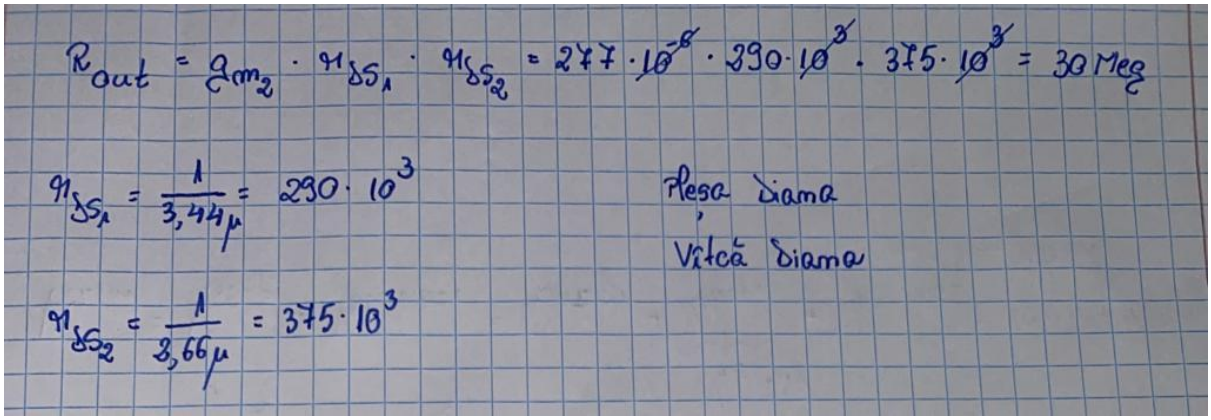


Figura 3. Calculul rezistentei de iesire Rout

ANALIZA

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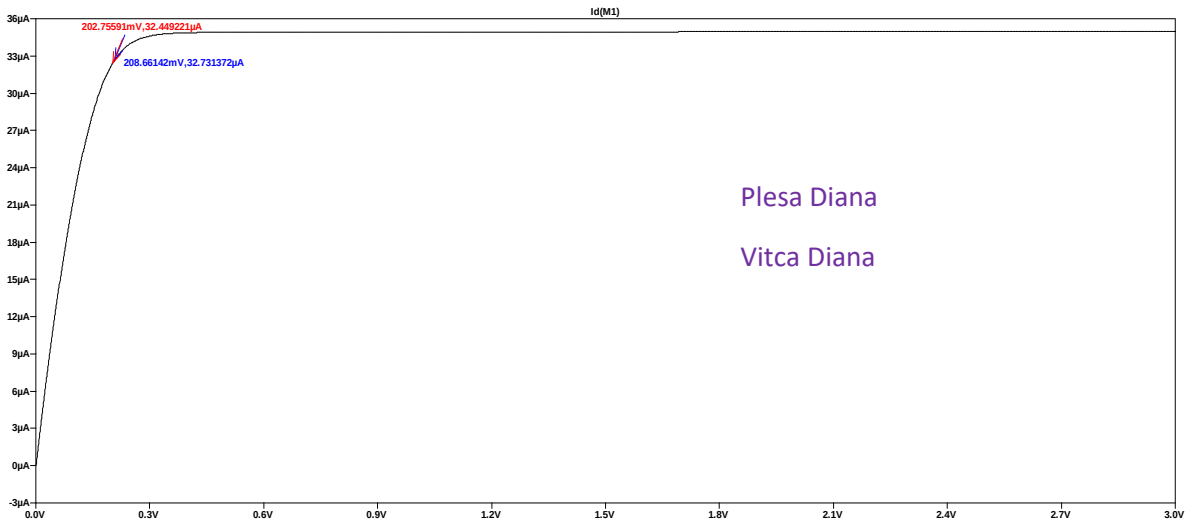


Figura 4. Caracteristica de iesire

R_{out} = 1/panta

panta ≈ 4e-005

=> R_{out} ≈ 25 MΩ

Parametru	Calculat	Masurat
Rout [MΩ]	30Meg	25Meg

Tabel 2. Valoarea calculata si masurata a rezistentei de iesire

3) Oglinzi de curent Wilson

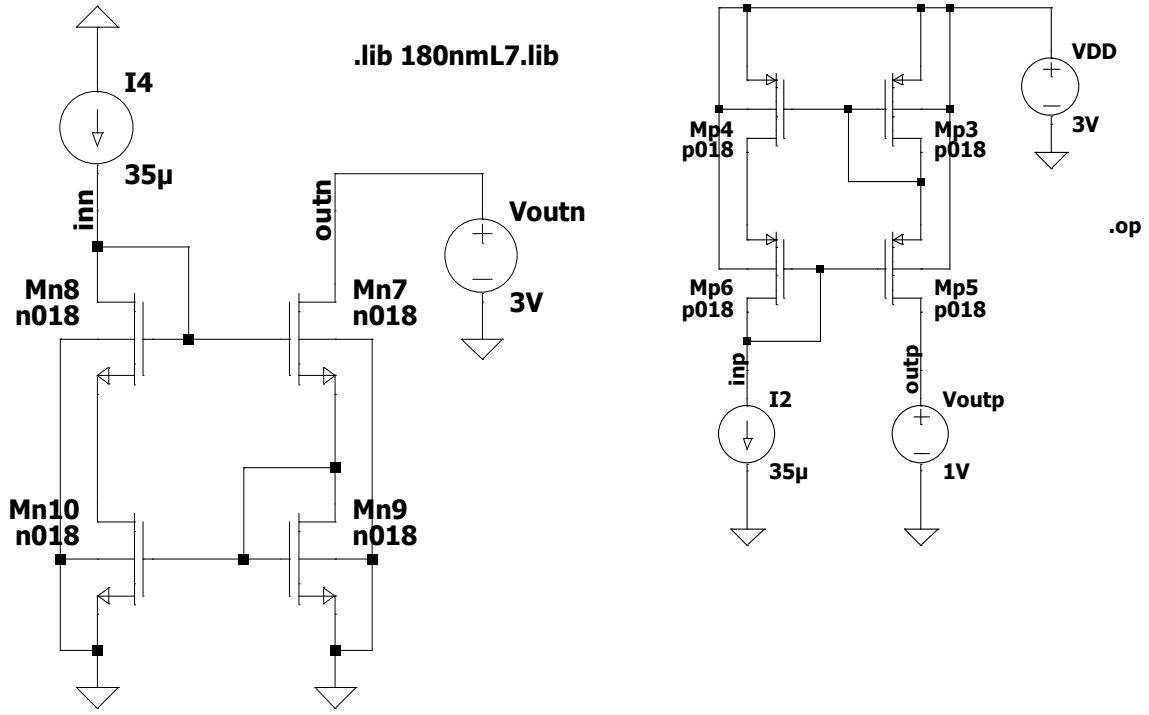


Figura 1. Schema electrica a oglinzii de curent Wilson cu tranzistor NMOS/ oglinzii de curent Wilson cu tranzistor PMOS

DIMENSIONARE

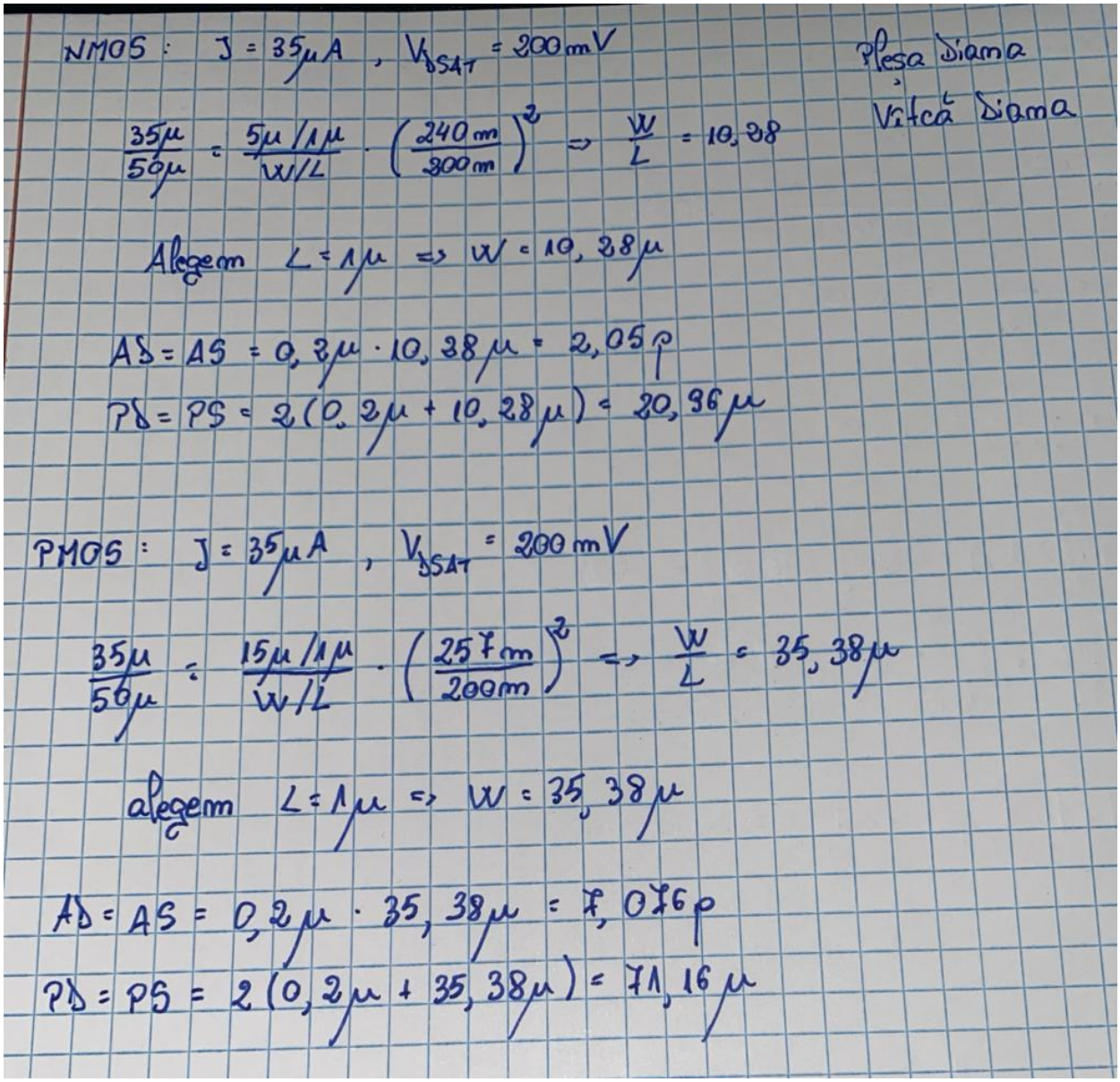


Figura 2. Datele de proiectare ale oglinzilor Wilson

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

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

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                         --- BSIM3 MOSFETS ---
Name:        mn10         mn9          mn8          mn7
Model:       n018         n018         n018         n018
Id:       3.50e-05     3.50e-05     3.50e-05     3.50e-05
Vgs:      5.87e-01     5.87e-01     7.48e-01     7.37e-01
Vds:      5.76e-01     5.87e-01     7.48e-01     2.41e+00
Vbs:      0.00e+00     0.00e+00    -5.76e-01    -5.87e-01
Vth:      4.46e-01     4.46e-01     6.00e-01     6.03e-01
Vdsat:    1.47e-01     1.47e-01     1.56e-01     1.46e-01
Gm:       3.73e-04     3.74e-04     3.61e-04     3.77e-04
Gds:      3.73e-06     3.73e-06     3.36e-06     2.93e-06
Gmb       1.17e-04     1.18e-04     9.33e-05     9.74e-05
Cbd:      1.99e-14     1.99e-14     1.71e-14     1.39e-14
Cbs:      2.40e-14     2.40e-14     1.99e-14     1.99e-14
Cgsov:    5.61e-15     5.61e-15     5.61e-15     5.61e-15
Cgdov:    5.55e-15     5.55e-15     5.55e-15     4.87e-15
Cgbov:    0.00e+00     0.00e+00     0.00e+00     0.00e+00
dQgdVgb:  7.57e-14     7.57e-14     7.50e-14     7.40e-14
dQgdVdb: -5.58e-15    -5.57e-15    -5.56e-15    -4.87e-15
dQgdVsb: -6.53e-14    -6.53e-14    -6.57e-14    -6.54e-14
dQddVgb: -5.70e-15    -5.69e-15    -5.63e-15    -4.88e-15
dQddVdb:  2.55e-14     2.55e-14     2.26e-14     1.87e-14
dQddVsb:  1.37e-16     1.32e-16     7.66e-17     6.96e-18
dQbdVgb: -1.10e-14    -1.10e-14    -1.02e-14    -1.03e-14
dQbdVdb: -1.99e-14    -1.99e-14    -1.71e-14    -1.39e-14
dQbdVsb: -3.42e-14    -3.42e-14    -2.64e-14    -2.62e-14


Date: Thu May 12 23:52:03 2022
Total elapsed time: 0.034 seconds.
```

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

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

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                         --- BSIM3 MOSFETS ---
Name:        mp6          mp5          mp4          mp3
Model:       p018         p018         p018         p018
Id:      -3.50e-05    -3.50e-05    -3.50e-05    -3.50e-05
Vgs:     -8.01e-01    -7.96e-01    -6.47e-01    -6.47e-01
Vds:     -8.01e-01    -1.35e+00    -6.42e-01    -6.47e-01
Vbs:      6.42e-01     6.47e-01     0.00e+00     0.00e+00
Vth:     -6.09e-01    -6.10e-01    -4.46e-01    -4.46e-01
Vdsat:   -1.56e-01    -1.52e-01    -1.48e-01    -1.48e-01
Gm:       3.59e-04     3.70e-04     3.59e-04     3.59e-04
Gds:      4.32e-06     4.04e-06     4.67e-06     4.67e-06
Gmb       7.92e-05     8.16e-05     9.73e-05     9.74e-05
Cbd:      7.10e-14     6.43e-14     8.66e-14     8.65e-14
Cbs:      8.66e-14     8.65e-14     1.12e-13     1.12e-13
Cgsov:    1.93e-14     1.93e-14     1.93e-14     1.93e-14
Cgdov:    1.90e-14     1.79e-14     1.91e-14     1.90e-14
Cgbov:    0.00e+00     0.00e+00     0.00e+00     0.00e+00
dQgdVgb:  2.60e-13     2.59e-13     2.65e-13     2.65e-13
dQgdVdb: -1.91e-14    -1.79e-14    -1.91e-14    -1.91e-14
dQgdVsb: -2.30e-13    -2.30e-13    -2.32e-13    -2.32e-13
dQddVgb: -1.93e-14    -1.80e-14    -1.95e-14    -1.95e-14
dQddVdb:  9.02e-14     8.22e-14     1.06e-13     1.06e-13
dQddVsb:  2.11e-16     7.36e-17     3.37e-16     3.32e-16
dQbdVgb: -4.15e-14    -4.15e-14    -4.58e-14    -4.58e-14
dQbdVdb: -7.11e-14    -6.43e-14    -8.67e-14    -8.65e-14
dQbdVsb: -9.70e-14    -9.67e-14    -1.33e-13    -1.33e-13


Date: Thu May 12 23:55:53 2022
Total elapsed time: 0.033 seconds.
```

Figura 3. Fisierul de iesire rezultat inainte de ajustarea oglinzilor de curent Wilson NMOS/PMOS

NMOS

AJUSTARE

W/L -> ajustat la 5.5/1

⇨ AD = AS = 0.2u*5.5u = 1.1p

⇨ PD = PS = 2*(0.2u + 5.5u) = 11.4u

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [uS]
Mn7	5.5/1	35	198	2.35V	619	823	274	2.63
Mn8	5.5/1	35	209	835	616	835	263	2.93
Mn9	5.5/1	35	195	654	446	654	278	3.28
Mn10	5.5/1	35	195	642	446	654	278	3.29

Tabel 1. Valorile de punct static pentru oglinda NMOS dupa ajustare

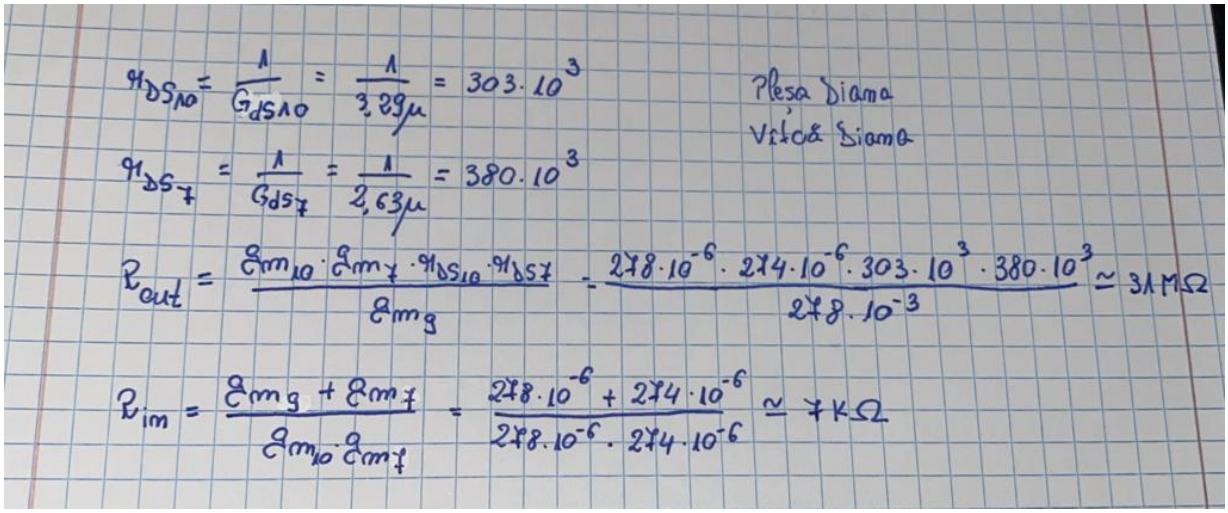


Figura 3. Calculul rezistentei de iesire/rezistentei de intrare

ANALIZA

.dc

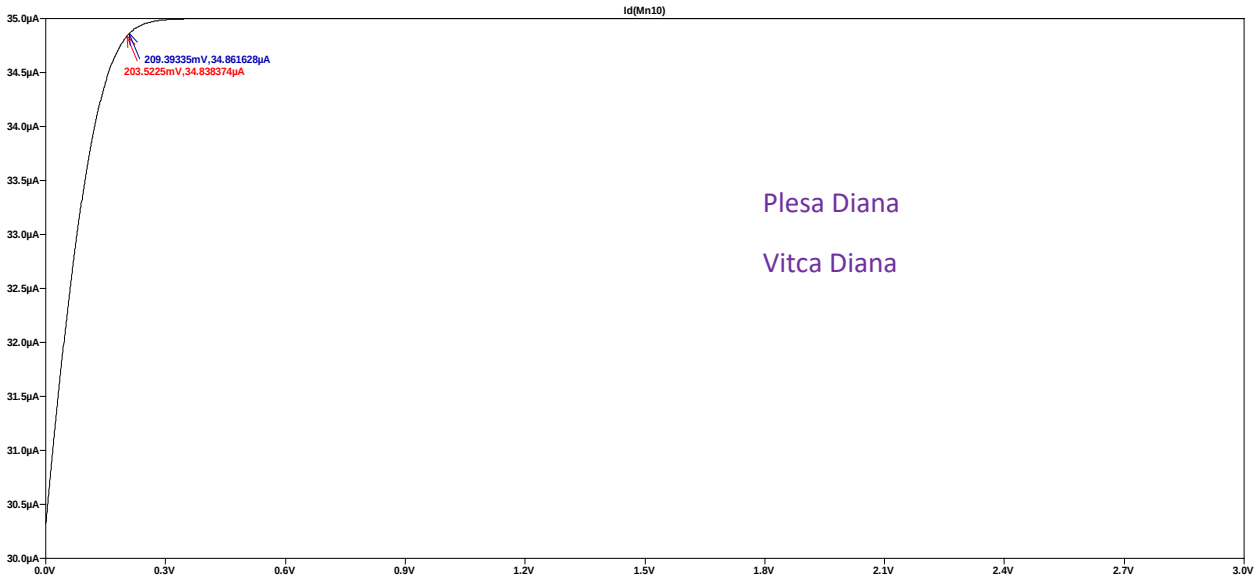


Figura 4. Caracteristica de iesire

R_{out} = 1/panta

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

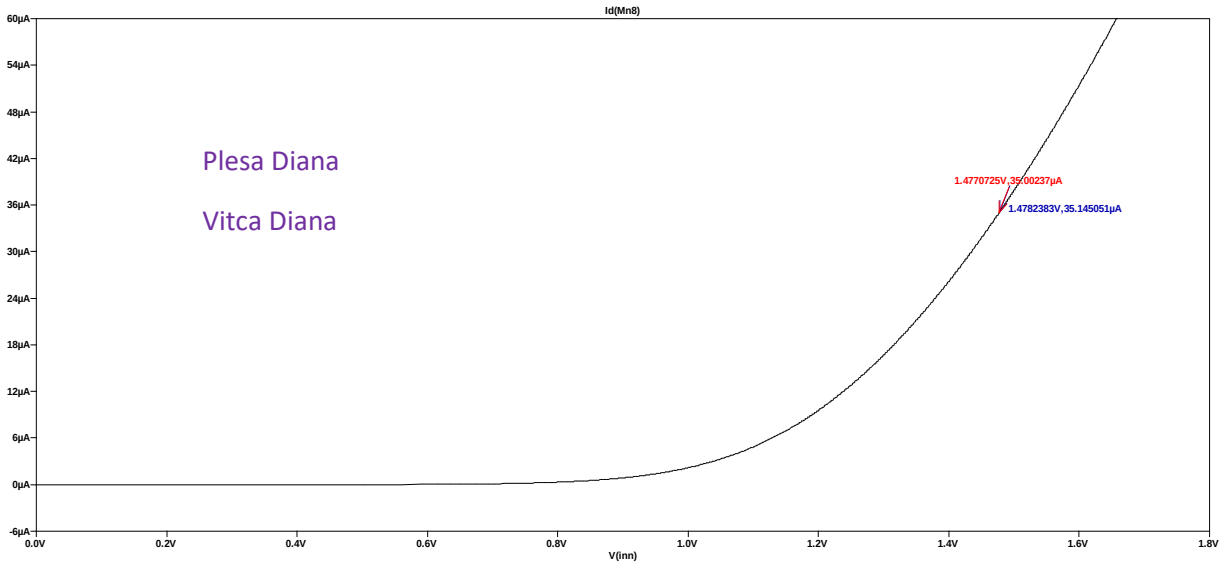


Figura 5. Caracteristica de intrare

R_{out} = 1/panta

panta ≈ $1.2 * 10^{-4}$ } => $R_{out} \approx 8\ k\Omega$

Parametru	Masurat	Calculat
R_{in} [kΩ]	8	7
R_{out} [MΩ]	25	31

Tabel 2. Valoarea calculata si masurata a rezistentei de iesire/intrare

PMOS

AJUSTARE

W/L -> ajustat la 19/1

⇨ AD = AS = 0.2u*19u = 3.8p

⇨ PD = PS = 2*(0.2u + 19u) = 38.4u

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [uS]
Mp3	20/1	35.1	196	718	446	718	254	4.35
Mp4	20/1	35	196	702	446	718	253	4.36
Mp5	20/1	35.1	194	2.28V	625	869	272	3.46
Mp6	20/1	35	207	885	622	885	253	3.99

Tabel 3. Valorile de punct static pentru oglinda NMOS dupa ajustare

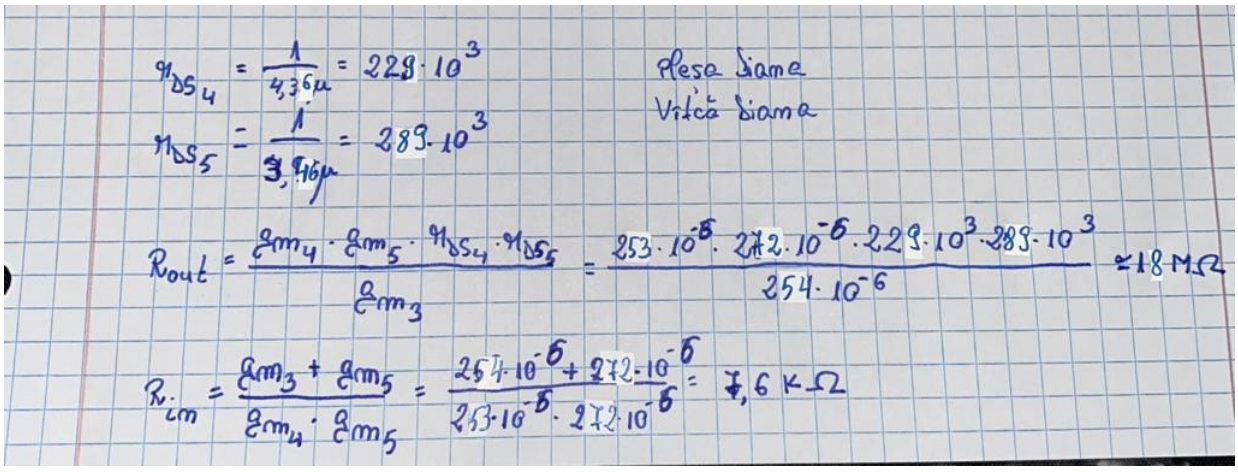


Figura 6. Calculul rezistentei de iesire/rezistentei de intrare

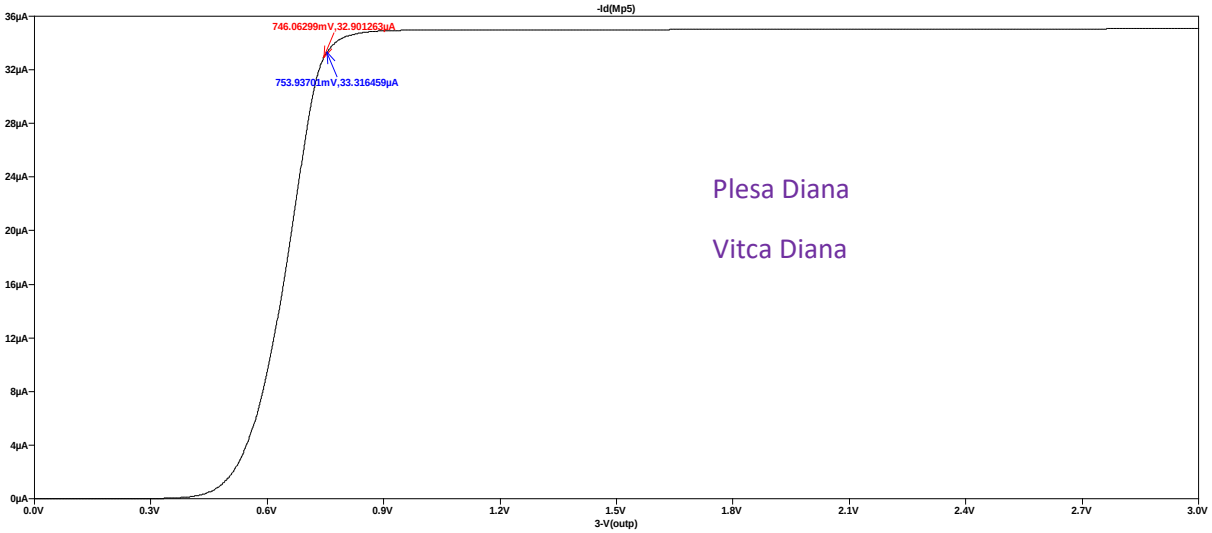


Figura 7. Caracteristica de iesire

R_{out} = 1/panta

panta ≈ 5.2e-005 } => $R_{out} \approx 19\ M\Omega$

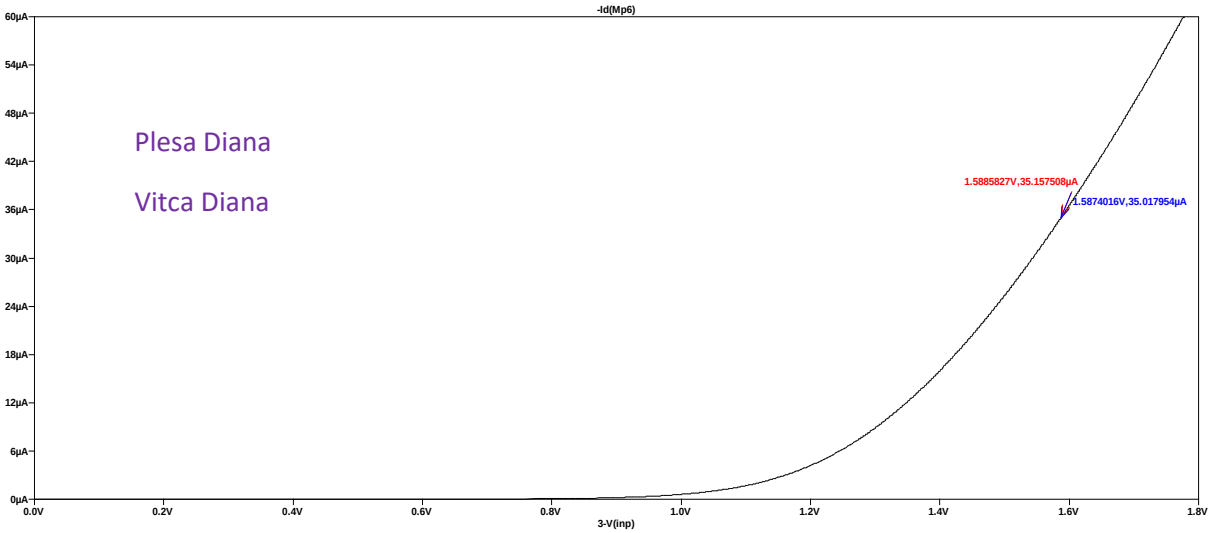


Figura 8. Caracteristica de intrare

R_{out} = 1/panta

panta ≈ $1.18 * 10^{-4}$ } => $R_{out} \approx 8.4\ k\Omega$

Parametru	Masurat	Calculat
R_{in} [kΩ]	8.4	7,6
R_{out} [MΩ]	19	18

Tabel 4. Valoarea calculata si masurata a rezistentei de iesire/intrare

4) Circuitul final

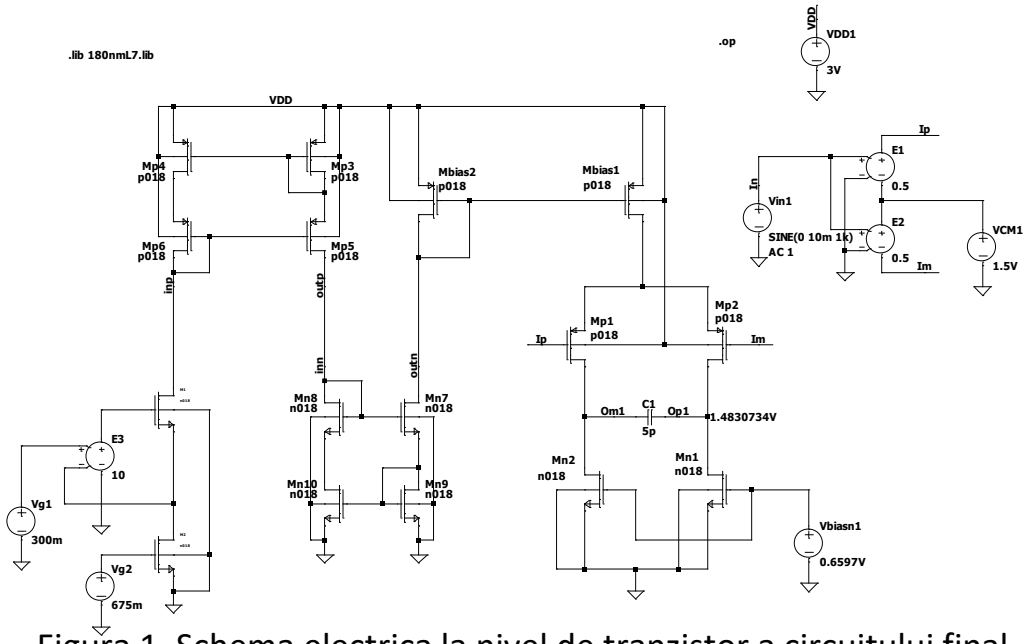


Figura 1. Schema electrica la nivel de tranzistor a circuitului final

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Circuit final\circuit_final.log

```
Circuit: * C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Circuit final\circuit_final.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                        --- BSIM3 MOSFETS ---
Name:         mp6          mp5          mp4          mp3          mp2
Model:       p018         p018         p018         p018         p018
Id:      -3.49e-05    -3.49e-05    -3.49e-05    -3.49e-05    -8.15e-04
Vgs:     -8.80e-01    -8.81e-01    -7.11e-01    -7.11e-01    -8.74e-01
Vds:     -8.80e-01    -8.06e-01    -7.12e-01    -7.11e-01    -8.91e-01
Vbs:      7.12e-01     7.11e-01     0.00e+00     0.00e+00     6.26e-01
Vth:     -6.24e-01    -6.24e-01    -4.46e-01    -4.46e-01    -6.05e-01
Vdsat:   -2.02e-01    -2.03e-01    -1.91e-01    -1.91e-01    -2.10e-01
Gm:       2.60e-04     2.59e-04     2.61e-04     2.61e-04     5.76e-03
Gds:      4.00e-06     4.05e-06     4.36e-06     4.36e-06     9.29e-05
Gmb       5.69e-05     5.67e-05     7.08e-05     7.08e-05     1.29e-03
Cbd:      3.92e-14     3.97e-14     4.81e-14     4.81e-14     8.37e-13
Cbs:      4.81e-14     4.81e-14     6.37e-14     6.37e-14     1.04e-12
Cgsov:    1.09e-14     1.09e-14     1.09e-14     1.09e-14     2.31e-13
Cgdov:    1.08e-14     1.08e-14     1.08e-14     1.08e-14     2.29e-13
Cgbov:    0.00e+00     0.00e+00     0.00e+00     0.00e+00     0.00e+00
dQgdVgb:  1.47e-13     1.47e-13     1.50e-13     1.50e-13     3.13e-12
dQgdVdb: -1.08e-14    -1.09e-14    -1.08e-14    -1.08e-14    -2.29e-13
dQgdVsb: -1.30e-13    -1.30e-13    -1.32e-13    -1.32e-13    -2.77e-12
dQddVgb: -1.09e-14    -1.10e-14    -1.10e-14    -1.10e-14    -2.31e-13
dQddVdb:  5.00e-14     5.06e-14     5.90e-14     5.90e-14     1.07e-12
dQddVsb:  1.01e-16     1.20e-16     1.58e-16     1.58e-16     2.10e-15
dQbdVgb: -2.33e-14    -2.32e-14    -2.58e-14    -2.58e-14    -4.98e-13
dQbdVdb: -3.92e-14    -3.98e-14    -4.82e-14    -4.82e-14    -8.37e-13
dQbdVsb: -5.34e-14    -5.35e-14    -7.51e-14    -7.51e-14    -1.16e-12
```

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Circuit final\circuit_final.log

Name:	mp1	mbias2	mbias1	m2	m1
Model:	p018	p018	p018	n018	n018
Id:	-8.15e-04	-3.50e-05	-1.63e-03	3.49e-05	3.49e-05
Vgs:	-8.74e-01	-7.31e-01	-7.31e-01	6.75e-01	7.21e-01
Vds:	-8.91e-01	-7.31e-01	-6.26e-01	2.07e-01	1.20e+00
Vbs:	6.26e-01	0.00e+00	0.00e+00	0.00e+00	-2.07e-01
Vth:	-6.05e-01	-4.46e-01	-4.46e-01	4.46e-01	5.06e-01
Vdsat:	-2.10e-01	-2.04e-01	-2.04e-01	2.10e-01	2.03e-01
Gm:	5.76e-03	2.40e-04	1.12e-02	2.38e-04	2.65e-04
Gds:	9.29e-05	4.28e-06	2.05e-04	3.54e-05	2.95e-06
Gmb	1.29e-03	6.50e-05	3.03e-03	7.69e-05	7.86e-05
Cbd:	8.37e-13	4.15e-14	2.00e-12	1.11e-14	8.43e-15
Cbs:	1.04e-12	5.52e-14	2.58e-12	1.20e-14	1.11e-14
Cgsov:	2.31e-13	9.42e-15	4.45e-13	2.77e-15	2.77e-15
Cgdov:	2.29e-13	9.31e-15	4.42e-13	2.76e-15	2.59e-15
Cgbov:	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
dQgdVgb:	3.13e-12	1.30e-13	6.13e-12	3.86e-14	3.72e-14
dQgdVdb:	-2.29e-13	-9.36e-15	-4.46e-13	-4.10e-15	-2.59e-15
dQgdVsb:	-2.77e-12	-1.14e-13	-5.40e-12	-3.27e-14	-3.26e-14
dQddVgb:	-2.31e-13	-9.51e-15	-4.57e-13	-5.46e-15	-2.61e-15
dQddVdb:	1.07e-12	5.09e-14	2.45e-12	1.71e-14	1.10e-14
dQddVsb:	2.10e-15	1.29e-16	8.11e-15	2.26e-16	1.56e-17
dQbdVgb:	-4.98e-13	-2.23e-14	-1.05e-12	-4.68e-15	-5.20e-15
dQbdVdb:	-8.37e-13	-4.15e-14	-2.00e-12	-1.20e-14	-8.43e-15
dQbdVsb:	-1.16e-12	-6.49e-14	-3.04e-12	-1.71e-14	-1.53e-14

SPICE Error Log: C:\Users\Diana\Downloads\Proiect CIA\LTSpice\Circuit final\circuit_final.log

Name:	mn10	mn9	mn8	mn7	mn2
Model:	n018	n018	n018	n018	n018
Id:	3.49e-05	3.50e-05	3.49e-05	3.50e-05	8.15e-04
Vgs:	6.54e-01	6.54e-01	8.37e-01	8.30e-01	6.60e-01
Vds:	6.47e-01	6.54e-01	8.37e-01	1.62e+00	1.48e+00
Vbs:	0.00e+00	0.00e+00	-6.47e-01	-6.54e-01	0.00e+00
Vth:	4.46e-01	4.46e-01	6.17e-01	6.19e-01	4.46e-01
Vdsat:	1.95e-01	1.95e-01	2.09e-01	2.03e-01	1.99e-01
Gm:	2.77e-04	2.78e-04	2.63e-04	2.68e-04	6.21e-03
Gds:	3.28e-06	3.27e-06	2.92e-06	2.75e-06	6.86e-05
Gmb	8.85e-05	8.85e-05	6.84e-05	6.98e-05	1.99e-03
Cbd:	1.06e-14	1.06e-14	9.01e-15	8.11e-15	1.82e-13
Cbs:	1.30e-14	1.30e-14	1.06e-14	1.06e-14	2.63e-13
Cgsov:	3.00e-15	3.00e-15	3.00e-15	3.00e-15	6.20e-14
Cgdov:	2.97e-15	2.97e-15	2.97e-15	2.74e-15	5.64e-14
Cgbov:	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
dQgdVgb:	4.07e-14	4.07e-14	4.03e-14	4.00e-14	8.36e-13
dQgdVdb:	-2.99e-15	-2.98e-15	-2.98e-15	-2.74e-15	-5.64e-14
dQgdVsb:	-3.53e-14	-3.53e-14	-3.54e-14	-3.54e-14	-7.30e-13
dQddVgb:	-3.05e-15	-3.05e-15	-3.01e-15	-2.75e-15	-5.66e-14
dQddVdb:	1.36e-14	1.36e-14	1.20e-14	1.08e-14	2.38e-13
dQddVsb:	6.31e-17	6.18e-17	3.50e-17	8.81e-18	2.31e-16
dQbdVgb:	-5.83e-15	-5.83e-15	-5.42e-15	-5.43e-15	-1.21e-13
dQbdVdb:	-1.06e-14	-1.06e-14	-9.02e-15	-8.11e-15	-1.82e-13
dQbdVsb:	-1.85e-14	-1.85e-14	-1.39e-14	-1.38e-14	-3.75e-13

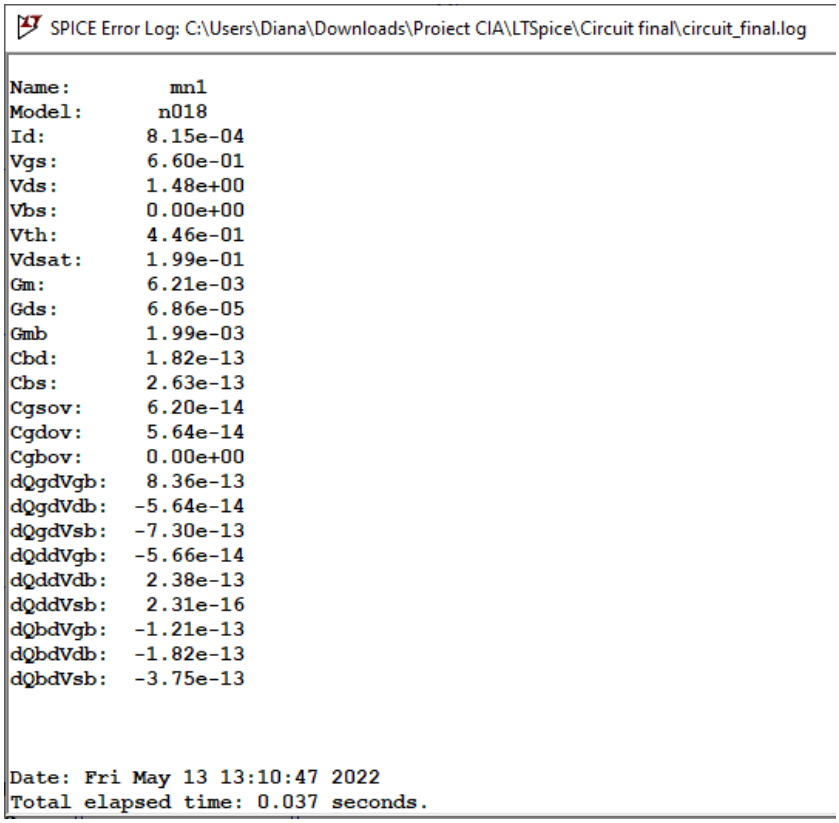


Figura 2. Fisierul de iesire rezultat inainte de ajustare

AJUSTARE

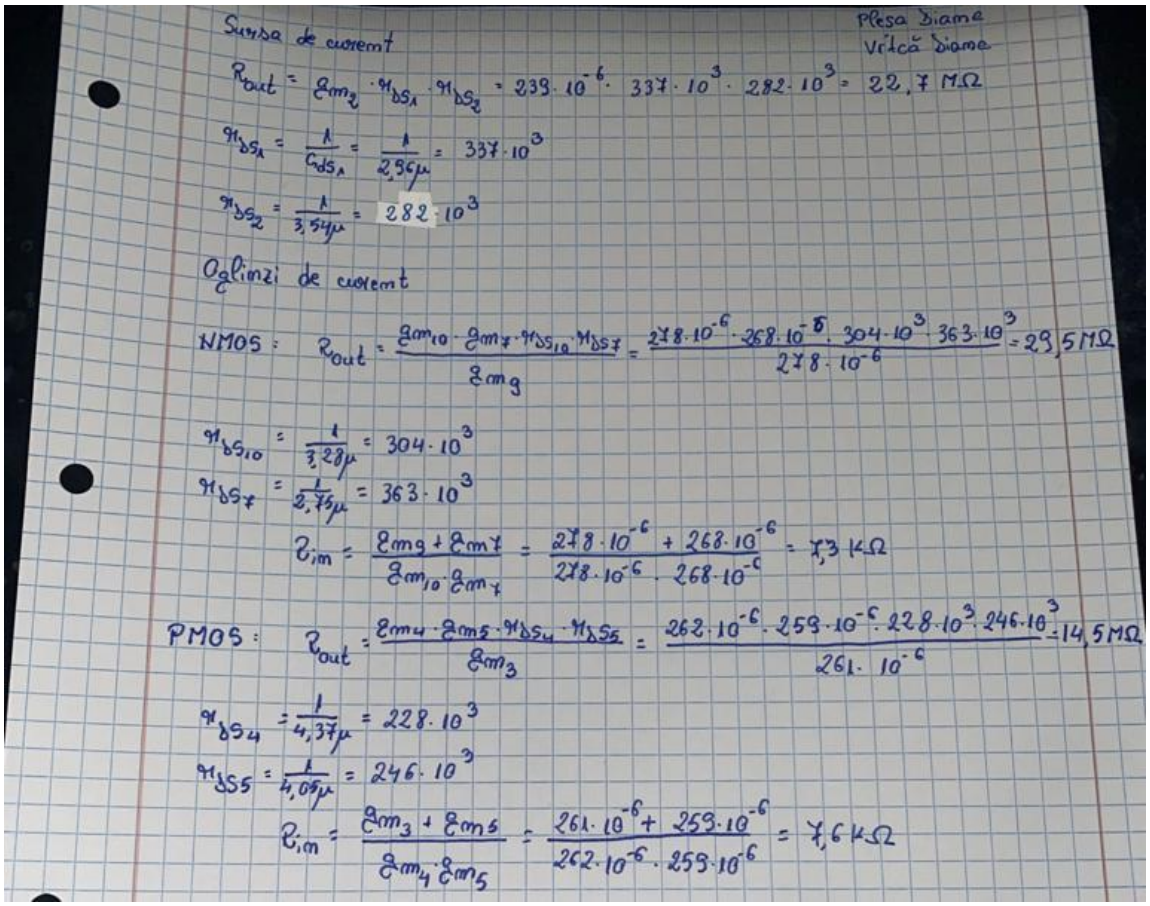
- Sursa de curent
  W/L -> ajustat la 5.08/1
  - ⇨ AS = AD = 0.2u*5.08u = 1.016p
  - ⇨ PD = PS = 2*(0.2u + 5.08u) = 10.56u
- Oglinda de curent PMOS

  W/L -> ajustat la 20/1
  - ⇨ AD = AS = 0.2u*20u = 4p
  - ⇨ PD = PS = 2*(0.2u + 20u) = 40.4u

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mV]	Vgs [mV]	Gm [uS]	Gds [uS]
Sursa de curent								
M1	5.08/1	35	203	1.2V	506	721	266	2.96
M2	5.08/1	35	210	207	446	675	239	3.54
Oglinzi de curent								

Mn7	5.5/1	35	203	1.62V	619	830	268	2.75
Mn8	5.5/1	35	209	837	618	837	263	2.93
Mn9	5.5/1	35	195	654	446	654	278	3.28
Mn10	5.5/1	35	195	647	446	654	278	3.28
Mp3	20/1	35	191	711	446	711	261	4.37
Mp4	20/1	35	191	712	446	711	262	4.37
Mp5	20/1	35	203	805	624	881	259	4.05
Mp6	20/1	35	202	880	624	880	260	4.01
Amplificator diferential								
Mn1	113.6/1	816	199	1.5V	446	660	6.22m	68.6
Mn2	113.6/1	816	199	1.5V	446	660	6.22m	68.6
Mp1	425/1	816	210	869	605	874	5.76m	93.3
Mp2	425/1	816	210	869	605	874	5.75m	93.3
Mbias1	817/1	1630	204	626	446	731	11.2m	205
Mbias2	17.3/1	35	204	731	446	731	240	4.29

Tabel 1. Valorile de punct static pentru circuitul final



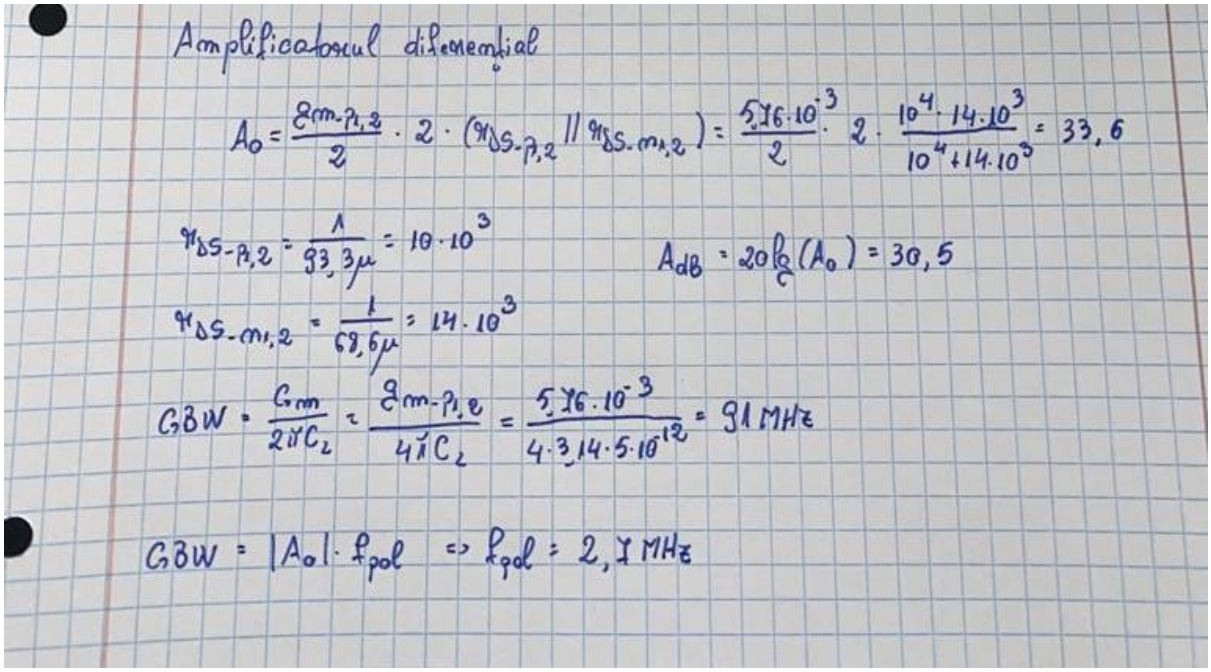


Figura 3. Calculul parametrilor

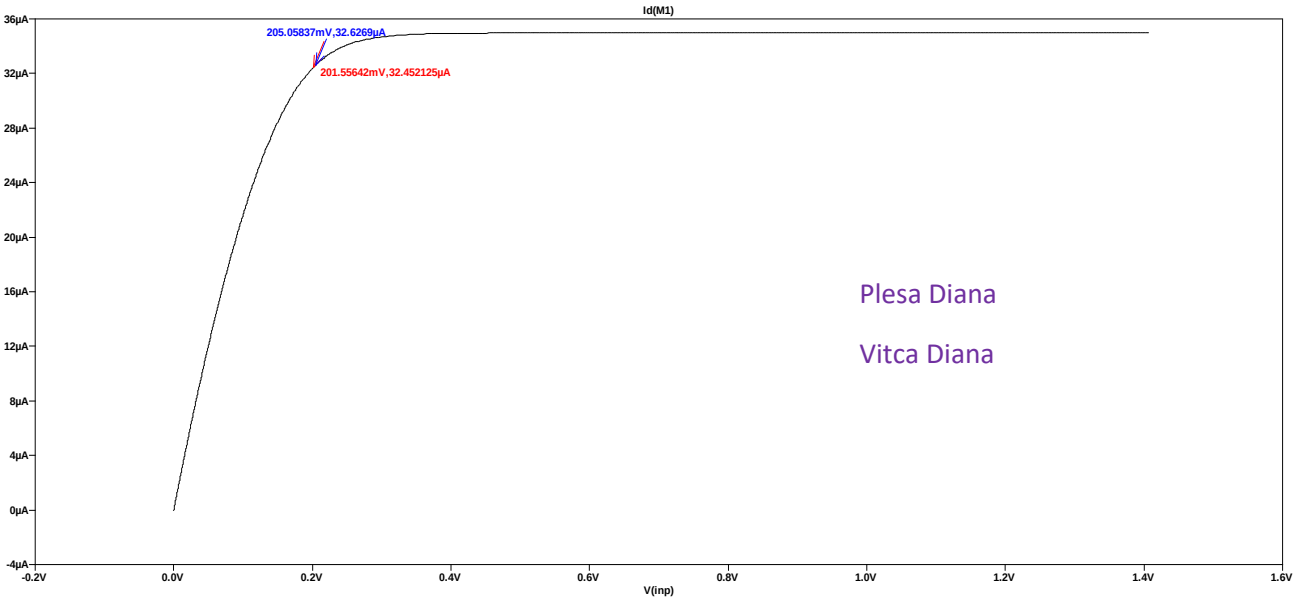


Figura 4. Caracteristica de iesire a sursei de curent

R_{out} = 1/panta

panta ≈ 4.9e-005 } => R_{out} ≈ 20.4 MΩ

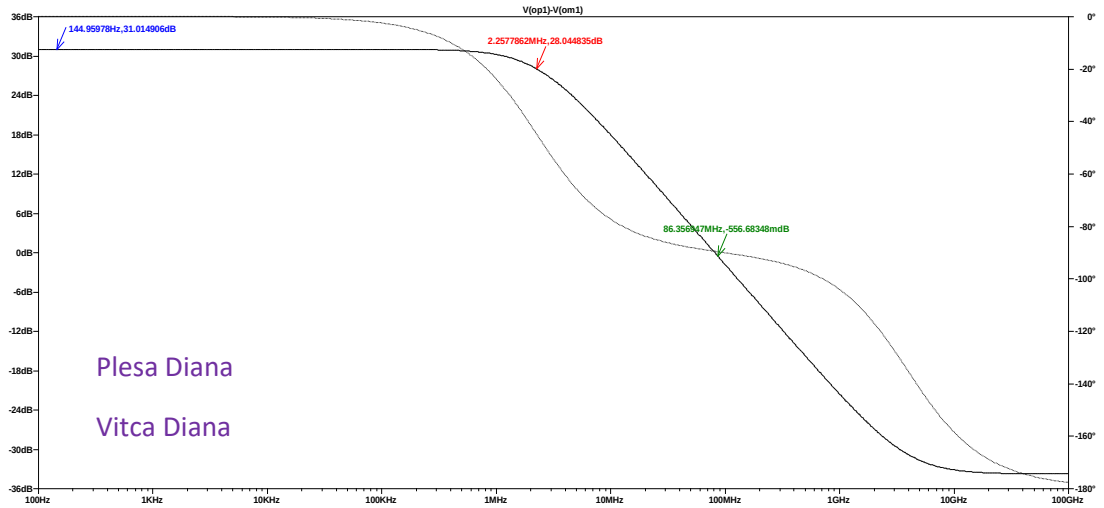


Figura 5. Caracteristica de modul si de faza (A_0-albastru, GBW-verde, f_{pol}-rosu)

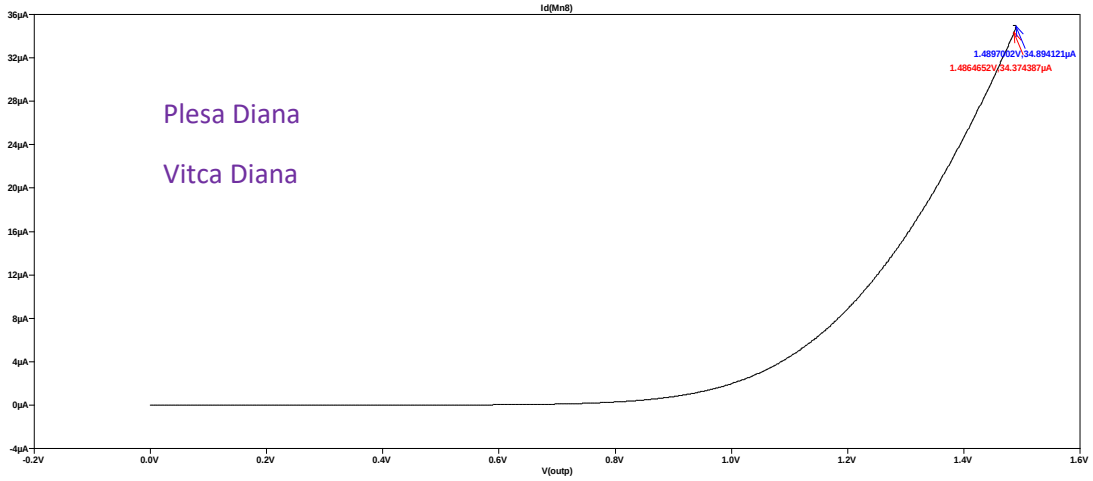


Figura 6. Caracteristica de intrare a oglinzii NMOS

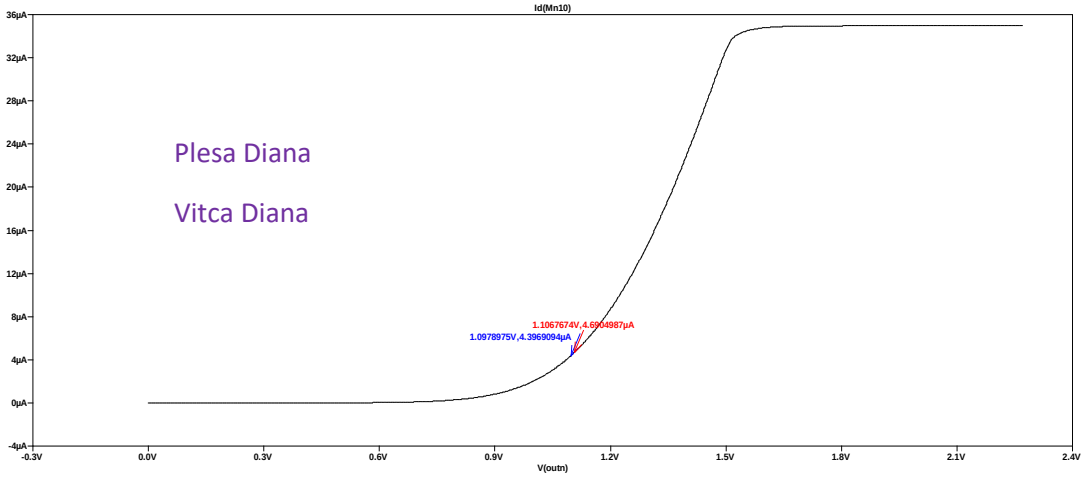
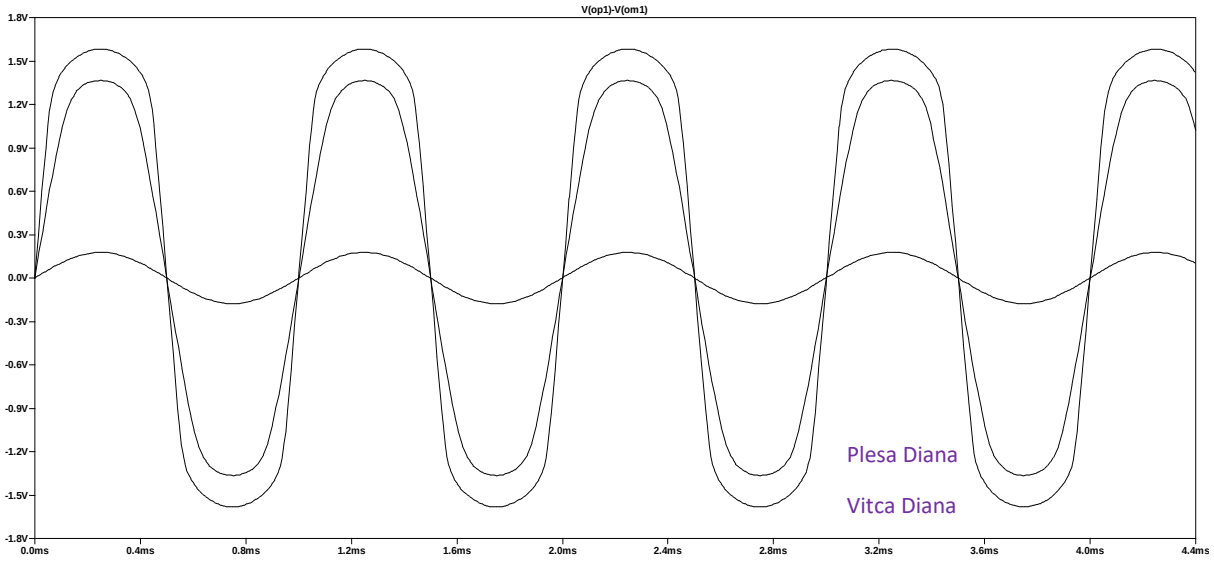


Figura 7. Caracteristica de iesire a oglinzii NMOS

Parametru	Calculat	Masurat
Sursa de curent		
Rout [MΩ]	22.7	20.4
Amplificator diferential		
A_0 [dB]	30.5	31
GBW [MHz]	91	86.3
f_{pol} [kHz]	2.7M	2.25M
Oglinzi de curent		
NMOS		
R_{in} [kΩ]	7.3	6.2
R_{out} [MΩ]	29.5	30
PMOS		
R_{in} [kΩ]	7.6	
R_{out} [MΩ]	14.5	

Tabel 2. Valoarea calculata si masurata a paremetrilor



Fgura 7. Raspunsul in timp al circuitului pentru trei semnale sinusoidale