UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

PROIECT CIRCUITE INTEGRATE DIGITALE

Membrii: Sîngerean Ramona Delia

Negoiță Adrian-Florin

1.SURSA DE CURENT CU TRANZISTOR NMOS CU DEGENERARE REZISTIVA

Curent de iesire: 60uA

Tensiunea de iesire minima: 600 mV

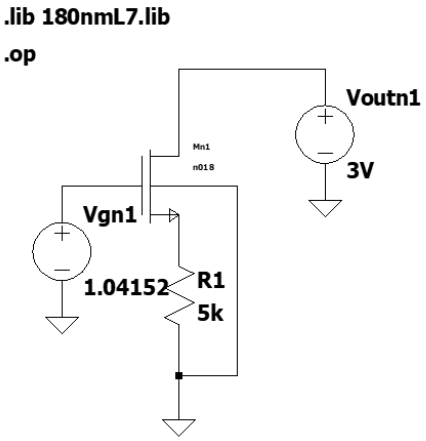

Figura 1. Schema electrică la nivel de tranzistor a sursei de curent după ajustare

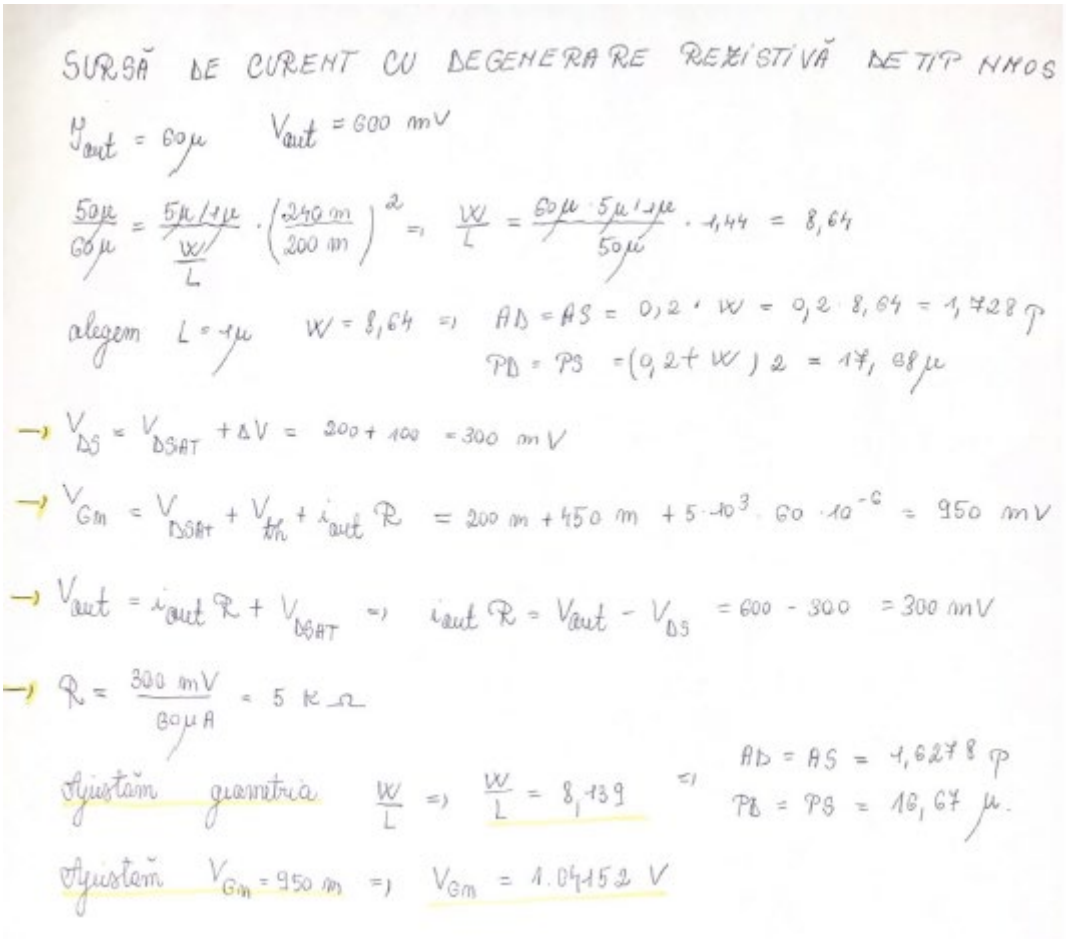

Figura 2. Proiectarea sursei de curent după specificații

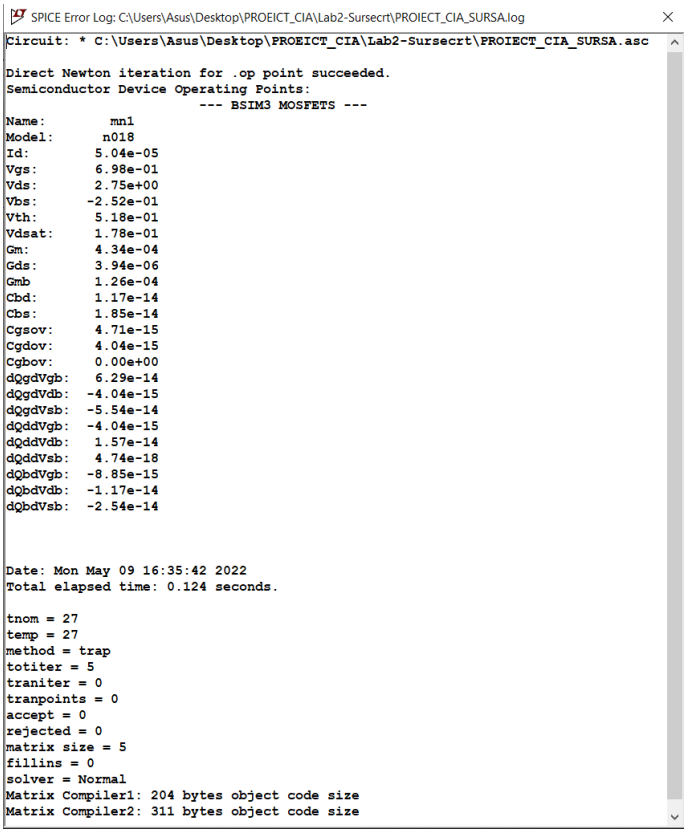

Figura 3. Captură de ecran al fișierului de ieșire înainte de ajustare

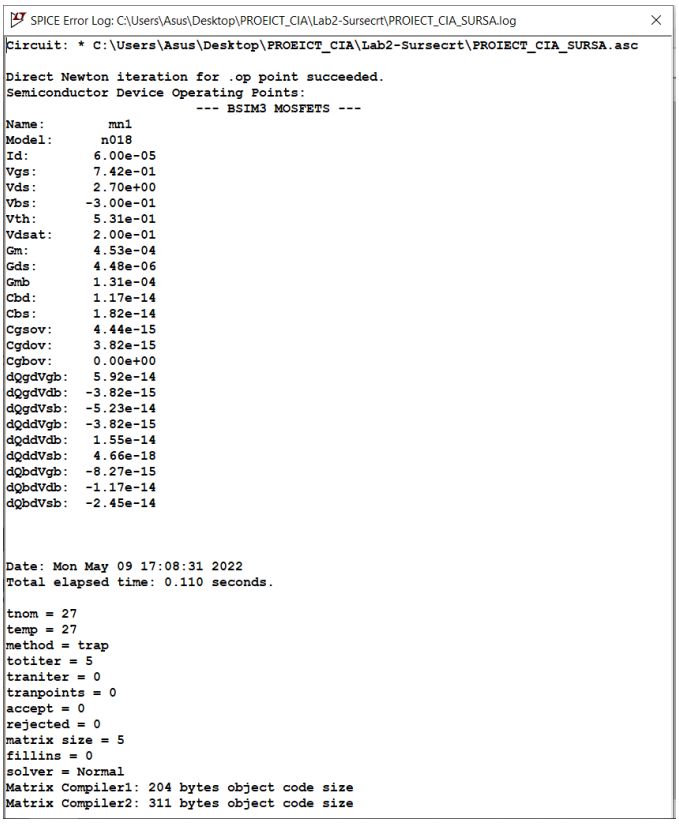

Figura 4 . Captură de ecran al fișierului de ieșire după ajustare

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mv]	Vgs [mv]	gm [uS]	gds [uS]
Mn1	8.139	60	200	2700	531	742	453	4.48

Tabelul 1. Parametrii tranzistoarelor după ajustare

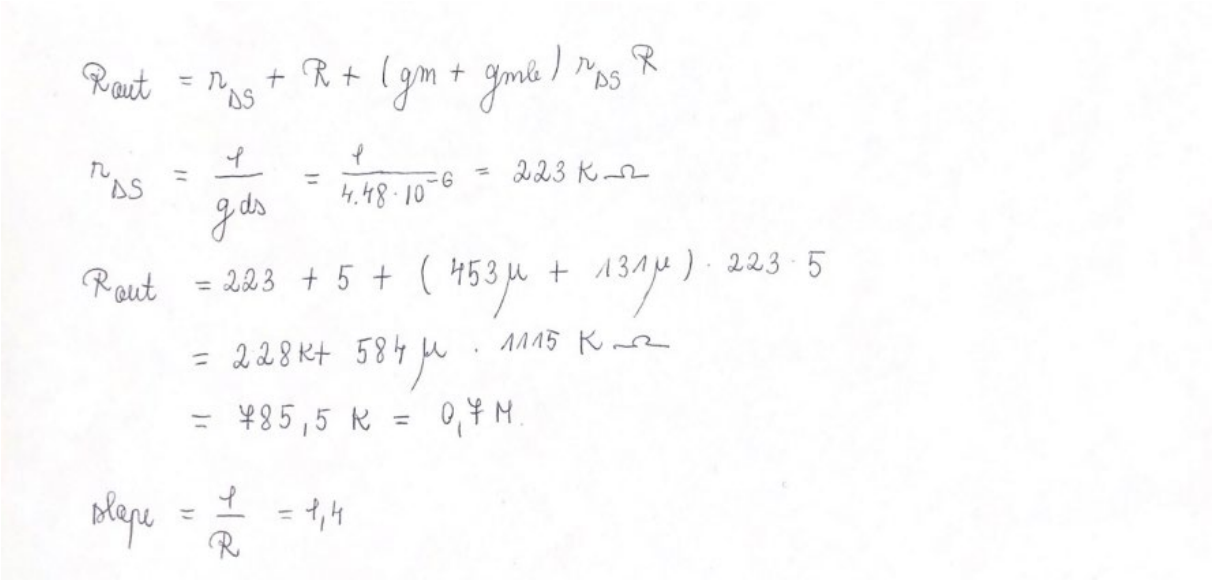

Figura 5. Calculul rezistenței de ieșire

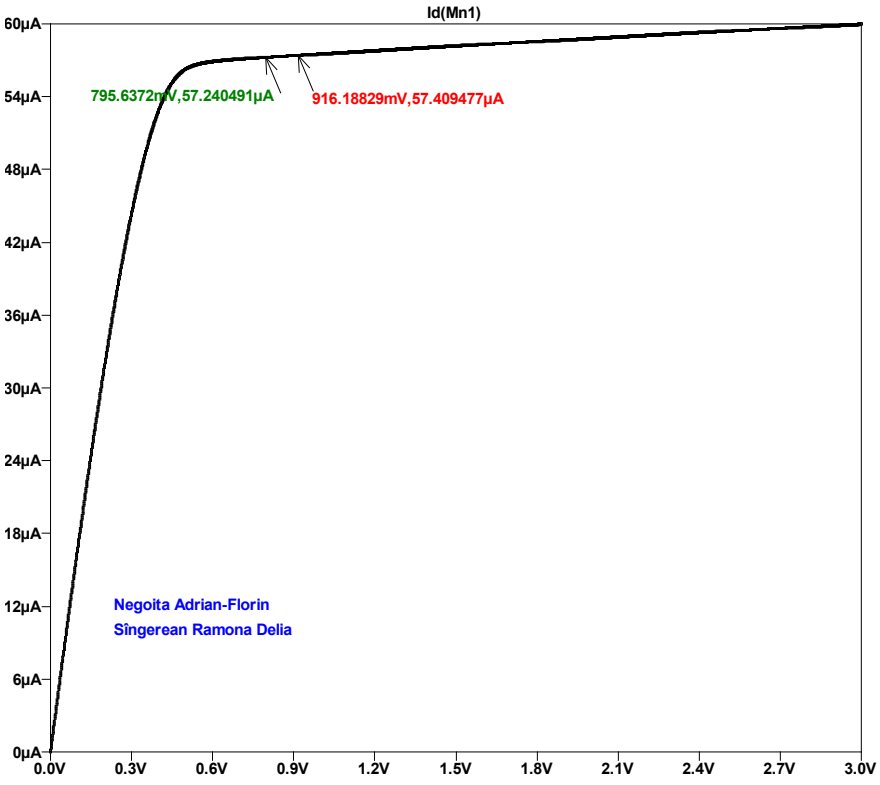

Figura 6. Caracteristica de ieșire

Parametru	Calculat	Măsurat
Rout [MΩ]	0.7	0.713

Tabel 2 . Valorile calculate și măsurate ale rezistenței de ieșire

2.AMPLIFICATOR DIFERENTIAL DE TIP P CU SARCINA SURSA

Produs de amplificare banda: 35 MHz

Capacitate de sarcina: 3pF

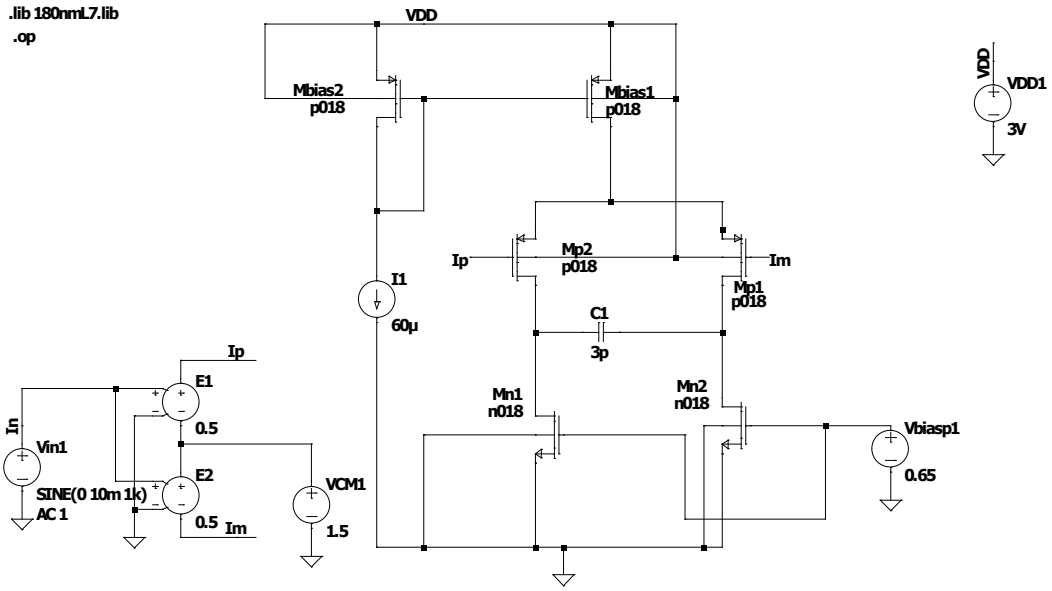

Figura 7. Schema electrică la nivel de tranzistor a amplificatorului diferențial

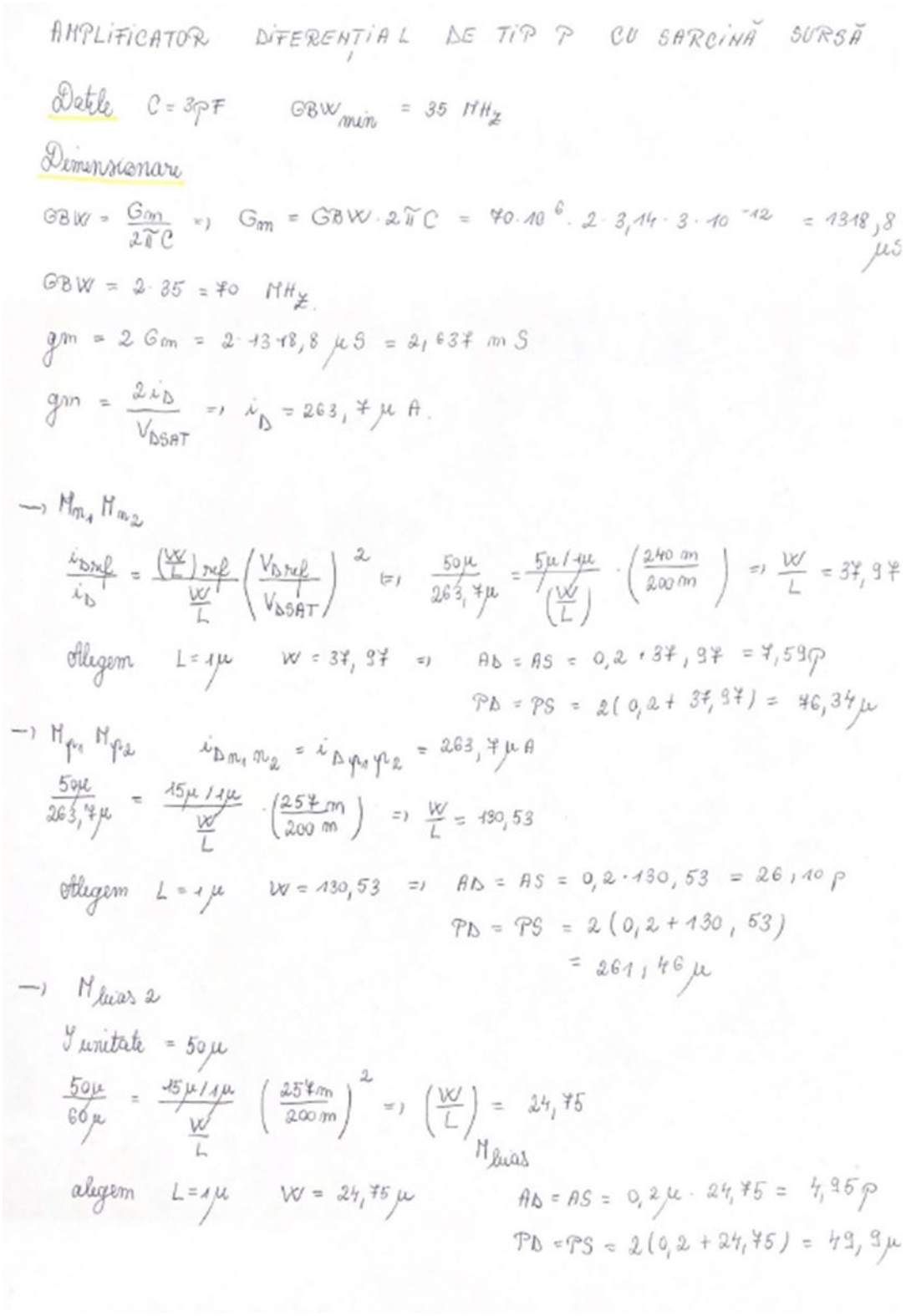

Figura 8. Proiectarea amplificatorului diferențial după specificații

```
Circuit: * C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_AO.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                        --- BSIM3 MOSFETS ---
Name:       mbias2      mbias1       mp2         mp1         mn2
Model:       p018        p018        p018        p018        n018
Id:       -5.00e-05   -5.20e-04   -2.60e-04   -2.60e-04    2.60e-04
Vgs:      -7.31e-01   -7.31e-01   -8.83e-01   -8.83e-01    6.50e-01
Vds:      -7.31e-01   -6.17e-01   -5.53e-01   -5.53e-01    1.83e+00
Vbs:       0.00e+00    0.00e+00    6.17e-01    6.17e-01    0.00e+00
Vth:      -4.46e-01   -4.46e-01   -6.03e-01   -6.03e-01    4.46e-01
Vdsat:    -2.04e-01   -2.04e-01   -2.17e-01   -2.17e-01    1.92e-01
Gm:        3.43e-04    3.57e-03    1.76e-03    1.76e-03    2.05e-03
Gds:       6.13e-06    6.56e-05    3.21e-05    3.21e-05    2.16e-05
Gmb        9.29e-05    9.67e-04    3.95e-04    3.95e-04    6.57e-04
Cbd:       5.91e-14    6.41e-13    2.77e-13    2.77e-13    5.78e-14
Cbs:       7.87e-14    8.24e-13    3.21e-13    3.21e-13    8.80e-14
Cgsov:     1.35e-14    1.42e-13    7.11e-14    7.11e-14    2.07e-14
Cgdov:     1.33e-14    1.41e-13    7.10e-14    7.10e-14    1.84e-14
Cgbov:     0.00e+00    0.00e+00    0.00e+00    0.00e+00    0.00e+00
dQgdVgb:   1.85e-13    1.96e-12    9.64e-13    9.64e-13    2.79e-13
dQgdVdb:  -1.34e-14   -1.43e-13   -7.19e-14   -7.19e-14   -1.84e-14
dQgdVsb:  -1.63e-13   -1.72e-12   -8.52e-13   -8.52e-13   -2.44e-13
dQddVgb:  -1.36e-14   -1.46e-13   -7.44e-14   -7.44e-14   -1.85e-14
dQddVdb:   7.26e-14    7.86e-13    3.50e-13    3.50e-13    7.63e-14
dQddVsb:   1.85e-16    2.66e-15    1.58e-15    1.58e-15    4.97e-17
dQbdVgb:  -3.19e-14   -3.35e-13   -1.52e-13   -1.52e-13   -4.04e-14
dQbdVdb:  -5.92e-14   -6.42e-13   -2.77e-13   -2.77e-13   -5.79e-14
dQbdVsb:  -9.27e-14   -9.72e-13   -3.59e-13   -3.59e-13   -1.25e-13

Name:
```

SPICE Error Log: C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_AO.log

```
Name:        mn1
Model:       n018
Id:       2.60e-04
Vgs:      6.50e-01
Vds:      1.83e+00
Vbs:      0.00e+00
Vth:      4.46e-01
Vdsat:    1.92e-01
Gm:       2.05e-03
Gds:      2.16e-05
Gmb       6.57e-04
Cbd:      5.78e-14
Cbs:      8.80e-14
Cgsov:    2.07e-14
Cgdov:    1.84e-14
Cgbov:    0.00e+00
dQgdVgb:  2.79e-13
dQgdVdb: -1.84e-14
dQgdVsb: -2.44e-13
dQddVgb: -1.85e-14
dQddVdb:  7.63e-14
dQddVsb:  4.97e-17
dQbdVgb: -4.04e-14
dQbdVdb: -5.79e-14
dQbdVsb: -1.25e-13


Date: Tue May 10 13:27:00 2022
Total elapsed time: 0.118 seconds.

tnom = 27
temp = 27
method = trap
totiter = 13
traniter = 0
tranpoints = 0
accept = 0
rejected = 0
matrix size = 16
fillins = 0
solver = Normal
```

Figura 9. Captura de ecran a fișierului de ieșire înainte de ajustare

SPICE Error Log: C:\Users\Asus\Desktop\PROIECT_CIA\Lab2-Sursecrt\PROIECT_CIA_AO.log

```
Circuit: * C:\Users\Asus\Desktop\PROIECT_CIA\Lab2-Sursecrt\PROIECT_CIA_AO.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                         --- BSIM3 MOSFETS ---
Name:       mbias2      mbias1       mp2         mp1         mn2
Model:       p018        p018        p018        p018        n018
Id:       -6.00e-05   -5.25e-04   -2.63e-04   -2.63e-04    2.63e-04
Vgs:      -7.30e-01   -7.30e-01   -8.86e-01   -8.86e-01    6.50e-01
Vds:      -7.30e-01   -6.14e-01   -4.36e-01   -4.36e-01    1.95e+00
Vbs:       0.00e+00    0.00e+00    6.14e-01    6.14e-01    0.00e+00
Vth:      -4.46e-01   -4.46e-01   -6.02e-01   -6.02e-01    4.46e-01
Vdsat:    -2.04e-01   -2.04e-01   -2.20e-01   -2.20e-01    1.92e-01
Gm:        4.12e-04    3.61e-03    1.75e-03    1.75e-03    2.07e-03
Gds:       7.36e-06    6.63e-05    3.61e-05    3.61e-05    2.16e-05
Gmb        1.12e-04    9.78e-04    3.93e-04    3.93e-04    6.62e-04
Cbd:       7.10e-14    6.48e-13    2.85e-13    2.85e-13    5.69e-14
Cbs:       9.45e-14    8.33e-13    3.21e-13    3.21e-13    8.80e-14
Cgsov:     1.62e-14    1.44e-13    7.11e-14    7.11e-14    2.07e-14
Cgdov:     1.60e-14    1.43e-13    7.10e-14    7.10e-14    1.83e-14
Cgbov:     0.00e+00    0.00e+00    0.00e+00    0.00e+00    0.00e+00
dQgdVgb:   2.23e-13    1.98e-12    9.65e-13    9.65e-13    2.79e-13
dQgdVdb:  -1.61e-14   -1.44e-13   -7.34e-14   -7.34e-14   -1.83e-14
dQgdVsb:  -1.97e-13   -1.75e-12   -8.52e-13   -8.52e-13   -2.44e-13
dQddVgb:  -1.64e-14   -1.48e-13   -7.82e-14   -7.82e-14   -1.83e-14
dQddVdb:   8.72e-14    7.95e-13    3.62e-13    3.62e-13    7.52e-14
dQddVsb:   2.23e-16    2.72e-15    2.20e-15    2.20e-15    4.36e-17
dQbdVgb:  -3.83e-14   -3.39e-13   -1.51e-13   -1.51e-13   -4.04e-14
dQbdVdb:  -7.10e-14   -6.49e-13   -2.87e-13   -2.87e-13   -5.69e-14
dQbdVsb:  -1.11e-13   -9.82e-13   -3.60e-13   -3.60e-13   -1.25e-13

Name:         mn1
```

SPICE Error Log: C:\Users\Asus\Desktop\PROIECT_CIA\Lab2-Sursecrt\PROIECT_CIA_AO.log

```
Name:         mn1
Model:       n018
Id:        2.63e-04
Vgs:       6.50e-01
Vds:       1.95e+00
Vbs:       0.00e+00
Vth:       4.46e-01
Vdsat:     1.92e-01
Gm:        2.07e-03
Gds:       2.16e-05
Gmb        6.62e-04
Cbd:       5.69e-14
Cbs:       8.80e-14
Cgsov:     2.07e-14
Cgdov:     1.83e-14
Cgbov:     0.00e+00
dQgdVgb:   2.79e-13
dQgdVdb:  -1.83e-14
dQgdVsb:  -2.44e-13
dQddVgb:  -1.83e-14
dQddVdb:   7.52e-14
dQddVsb:   4.36e-17
dQbdVgb:  -4.04e-14
dQbdVdb:  -5.69e-14
dQbdVsb:  -1.25e-13


Date: Fri May 13 15:46:27 2022
Total elapsed time: 0.063 seconds.
```

Figura 10. Captura de ecran a fișierului de ieșire după ajustare

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mv]	Vgs [mv]	gm [uS]	gds [uS]
Mbias2	24.55	60	204	731	446	731	343	6.13
Mbias1	264.78	525	204	614	446	731	3600	66.5
Mp2	130.53	263	220	440	602	886	1750	35.9
Mp1	130.53	263	220	440	602	886	1750	35.9
Mn2	38	263	192	1950	446	650	2070	21.6
Mn1	38	263	192	1950	446	650	2070	21.6

Tabelul 3. Parametrii tranzistoarelor după ajustare

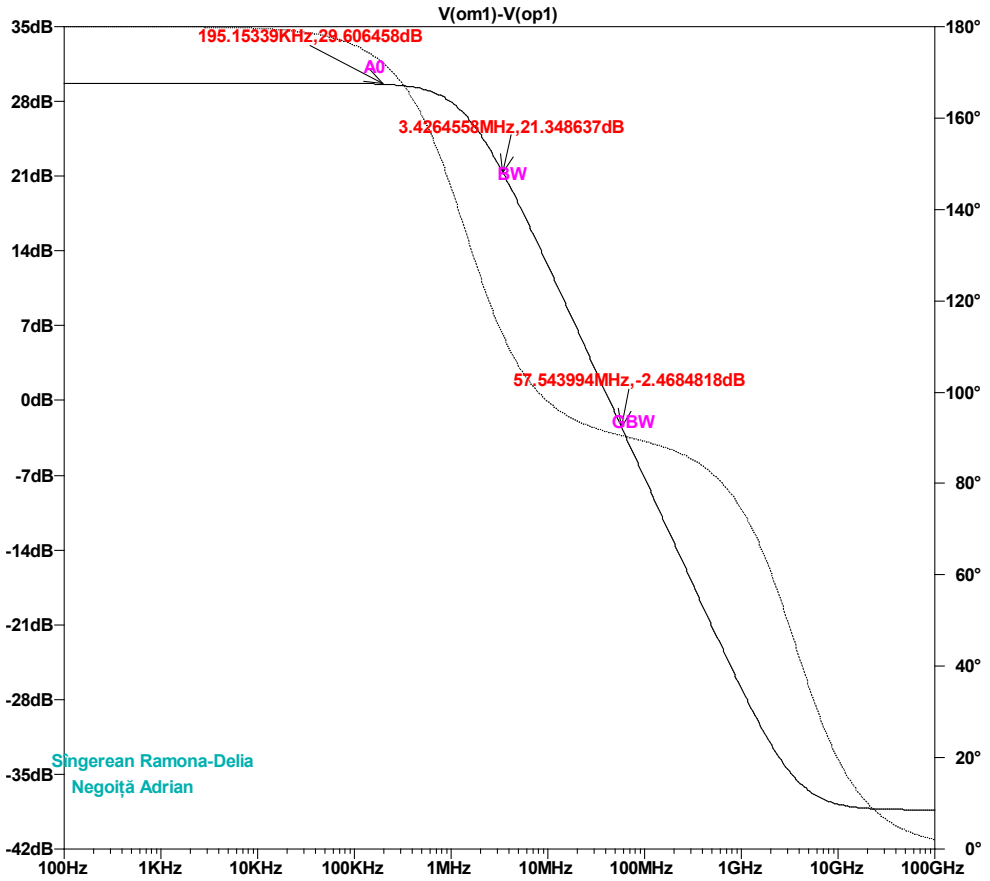

Figura 11. Caracteristica de modul și fază

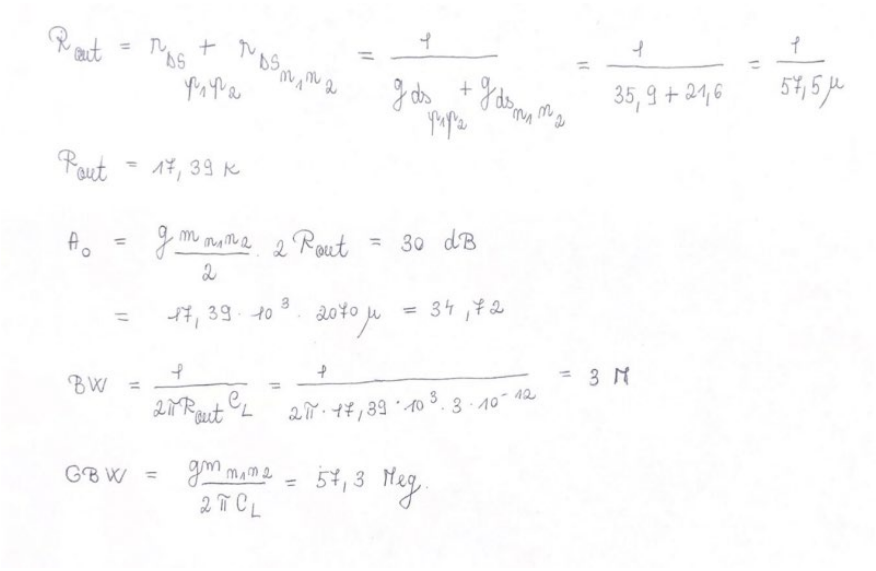

Figura 12. Calculul parametrilor A0, GBW, fpol

Parametru	Calculat	Măsurat
A0 [dB]	34.72	29.6
fpol [KHz]	3000	3426
GBW [MHz]	57.3	57.54

Tabel 4. Valorile calculate și măsurate ale parametrilor

3.OGLINZI DE CURENR WILSON ASIMETRICA

-> folosim 2 oglinzi, una Nmos si una Pmos

OGLINDA WILSON ASIMETRICA PMOS

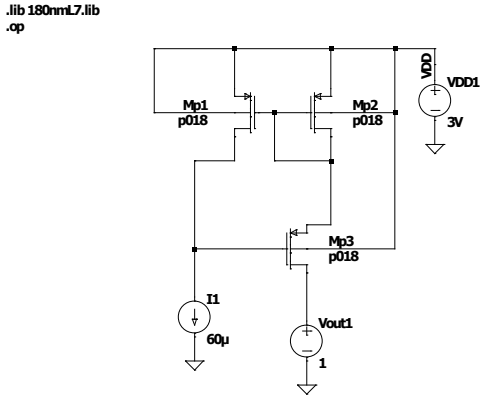

Figura 13. Schema electrică a oglinzii Wilson de tip PMOS

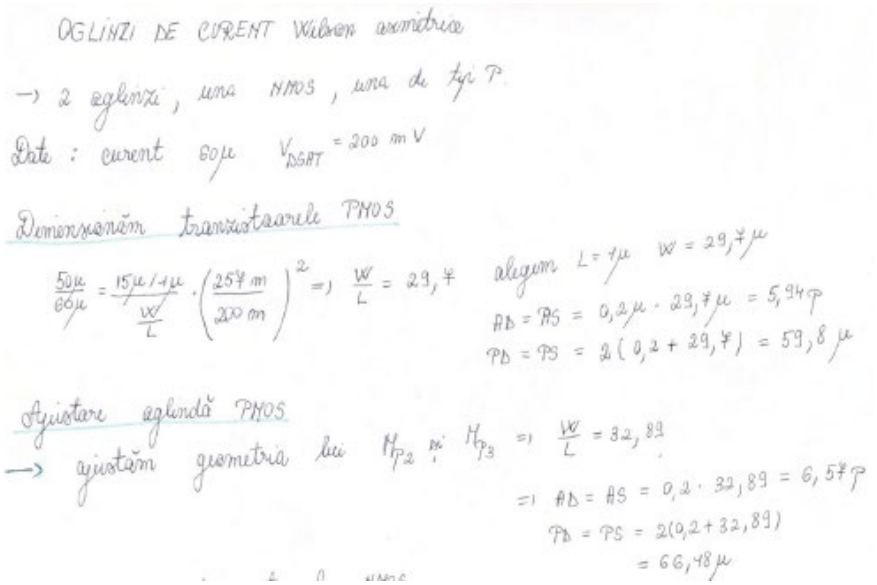

Figura 14. Proiectarea circuitului după valorile alese

SPICE Error Log: C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_OGLINDA_PMOS_OP.log

```
Circuit: * C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_OGLINDA_PMOS_OP.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                         --- BSIM3 MOSFETS ---
Name:         mp3          mp2          mp1
Model:      p018         p018         p018
Id:      -6.00e-05    -6.00e-05    -6.00e-05
Vgs:     -8.81e-01    -7.16e-01    -7.16e-01
Vds:     -1.28e+00    -7.16e-01    -1.60e+00
Vbs:      7.16e-01     0.00e+00     0.00e+00
Vth:     -6.25e-01    -4.46e-01    -4.46e-01
Vdsat:   -2.02e-01    -1.95e-01    -1.95e-01
Gm:       4.45e-04     4.37e-04     4.33e-04
Gds:      6.51e-06     7.45e-06     6.61e-06
Gmb       9.75e-05     1.19e-04     1.18e-04
Cbd:      5.40e-14     7.11e-14     5.79e-14
Cbs:      7.11e-14     9.43e-14     9.43e-14
Cgsov:    1.79e-14     1.79e-14     1.62e-14
Cgdov:    1.69e-14     1.77e-14     1.46e-14
Cgbov:    0.00e+00     0.00e+00     0.00e+00
dQgdVgb:  2.41e-13     2.47e-13     2.21e-13
dQgdVdb: -1.69e-14    -1.78e-14    -1.46e-14
dQgdVsb: -2.14e-13    -2.17e-13    -1.96e-13
dQddVgb: -1.70e-14    -1.81e-14    -1.47e-14
dQddVdb:  7.10e-14     8.91e-14     7.26e-14
dQddVsb:  7.77e-17     2.56e-16     4.74e-17
dQbdVgb: -3.83e-14    -4.24e-14    -3.83e-14
dQbdVdb: -5.40e-14    -7.12e-14    -5.79e-14
dQbdVsb: -7.98e-14    -1.13e-13    -1.11e-13


Date: Wed May 11 01:18:22 2022
Total elapsed time: 0.116 seconds.
```

Figura 15. Fișierul de ieșire după ajustare

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mv]	Vgs [mv]	gm [uS]	gds [uS]
Mp3	32.89	60	202	1280	625	881	445	6.51
Mp2	32.89	60	195	716	446	716	437	7.45
Mp1	29.7	60	195	1600	446	716	433	6.61

Tabelul 5. Parametrii tranzistoarelor după ajustare

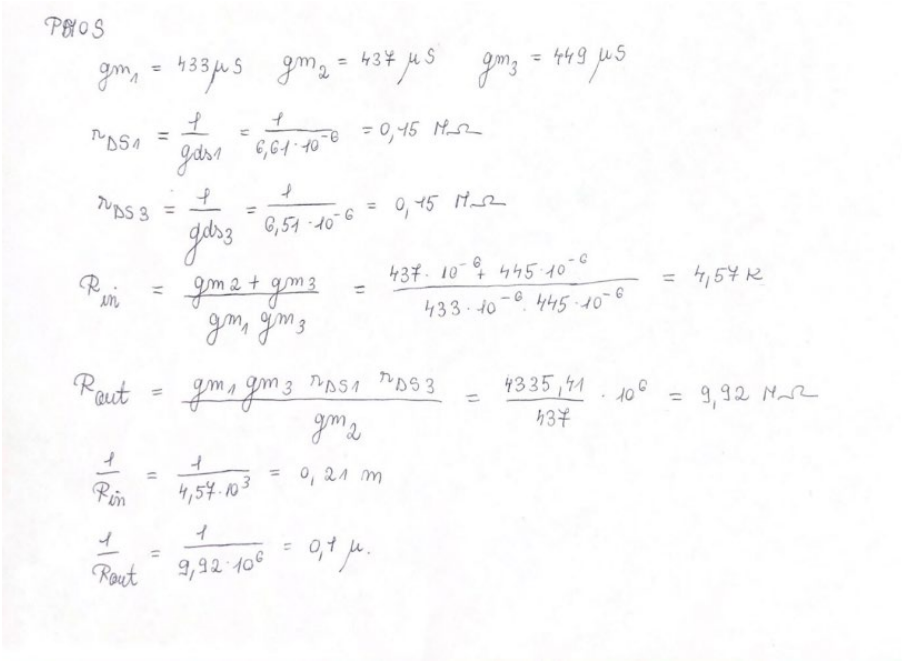

Figura 16. Calculul rezistenței de intrare (Rin) și de ieșire (Rout);

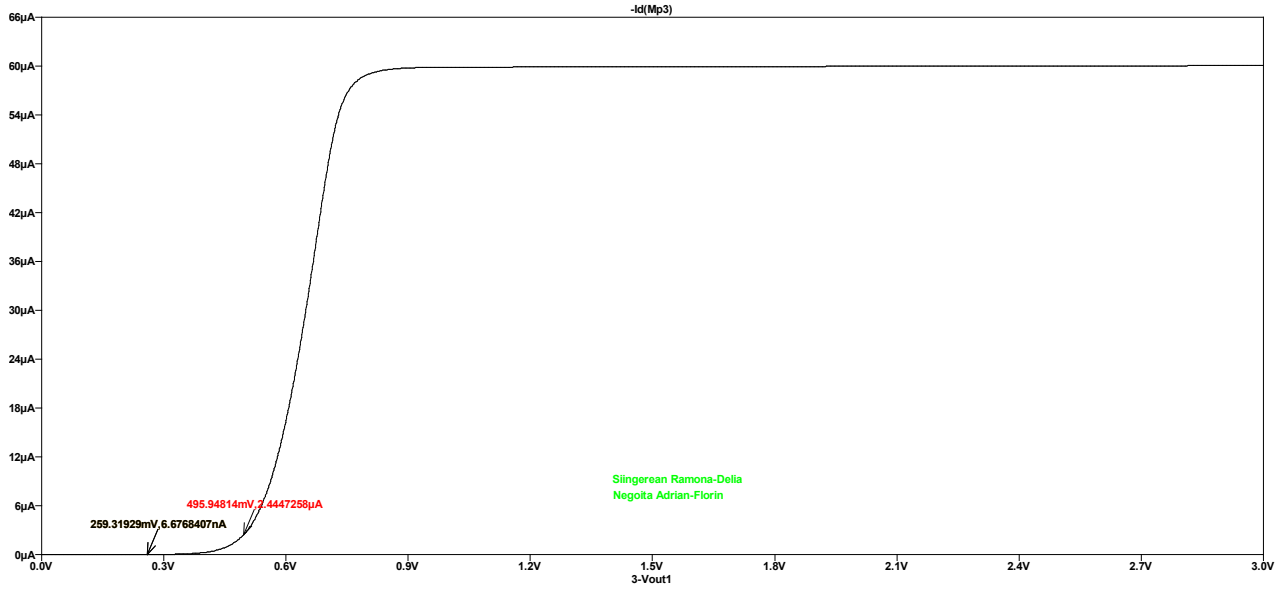

Figura 17. Caracteristica rezistenței de ieșire

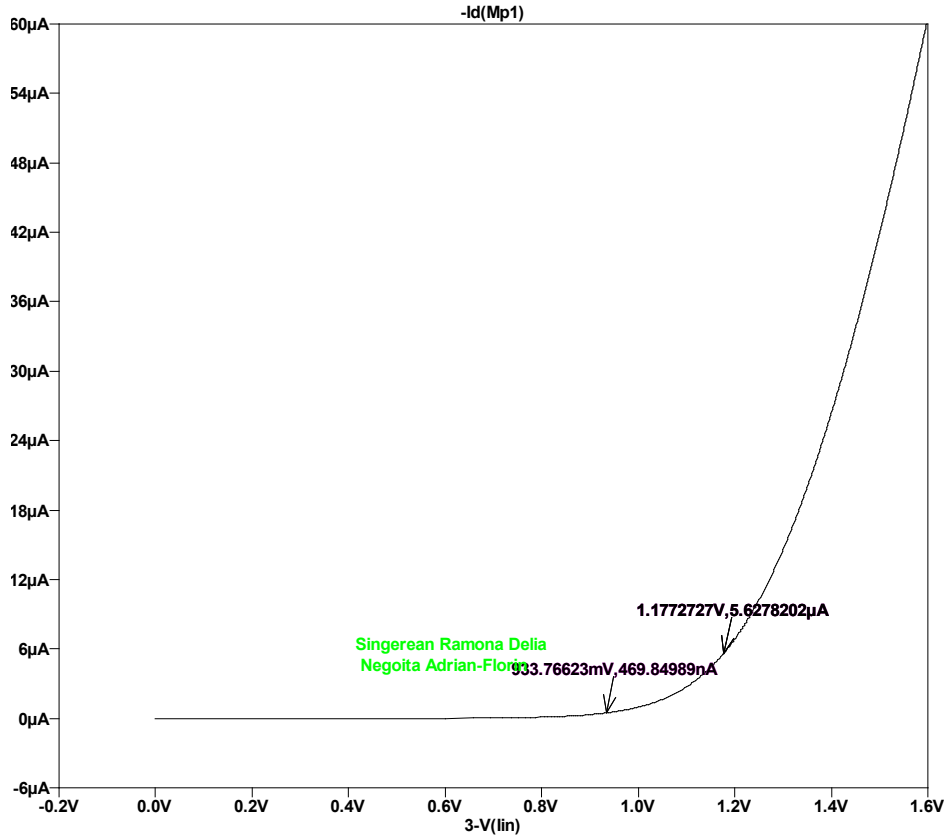

Figura 18. Caracteristica rezistenței de intrare

Parametru	Calculat	Măsurat
Rin [K Ω]	4.57	4.749
Rout [MΩ]	9.92	9.7

Tabel 6. Valorile calculate și măsurate ale rezistenței de ieșire și intrare

OGLINDA WILSON ASIMETRICA NMOS

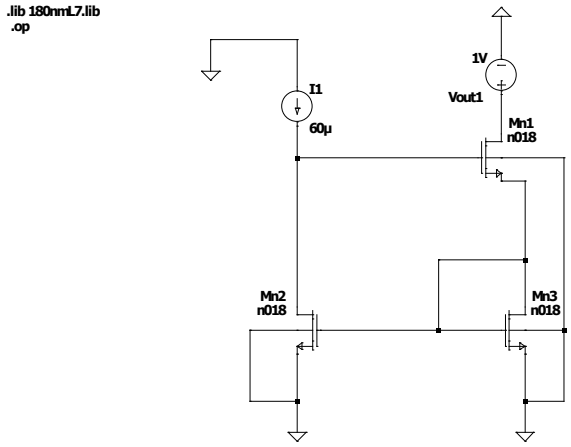

Figura 19 .Schema electrica la nivel de tranzistor a oglinzii Wilson asimetrică de tip NMOS

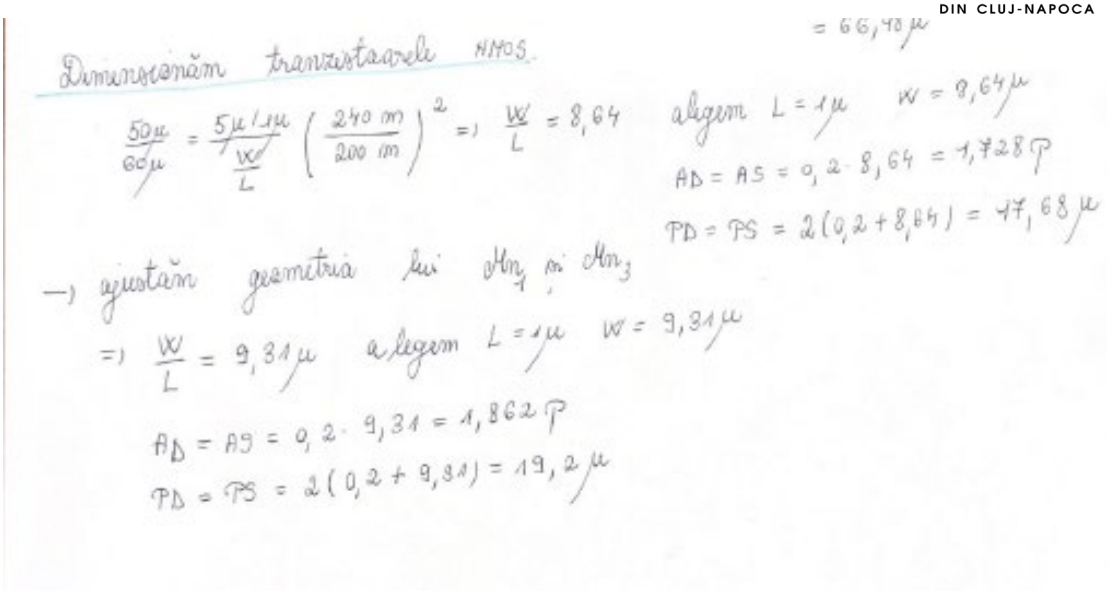

Figura 20. Proiectare circuitului după valorile alese

SPICE Error Log: C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_OGLINDA_NMOS_OP.log

```
Circuit: * C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_OGLINDA_NMOS_OP.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                          --- BSIM3 MOSFETS ---
Name:         mn3          mn2          mn1
Model:       n018         n018         n018
Id:       5.57e-05     6.00e-05     5.57e-05
Vgs:      6.55e-01     6.55e-01     8.47e-01
Vds:      6.55e-01     1.50e+00     3.45e-01
Vbs:      0.00e+00     0.00e+00    -6.55e-01
Vth:      4.46e-01     4.46e-01     6.19e-01
Vdsat:    1.96e-01     1.96e-01     2.15e-01
Gm:       4.39e-04     4.66e-04     4.06e-04
Gds:      5.20e-06     5.08e-06     7.69e-06
Gmb       1.40e-04     1.49e-04     1.06e-04
Cbd:      1.65e-14     1.40e-14     1.53e-14
Cbs:      2.03e-14     2.03e-14     1.65e-14
Cgsov:    4.71e-15     4.71e-15     4.71e-15
Cgdov:    4.66e-15     4.28e-15     4.71e-15
Cgbov:    0.00e+00     0.00e+00     0.00e+00
iQgdVgb:  6.40e-14     6.35e-14     6.37e-14
iQgdVdb: -4.69e-15    -4.28e-15    -5.04e-15
iQgdVsb: -5.55e-14    -5.55e-14    -5.58e-14
iQddVgb: -4.78e-15    -4.30e-15    -5.62e-15
iQddVdb:  2.12e-14     1.83e-14     2.08e-14
iQddVsb:  9.67e-17     1.70e-17     3.26e-16
iQbdVgb: -9.15e-15    -9.18e-15    -8.30e-15
iQbdVdb: -1.65e-14    -1.40e-14    -1.55e-14
iQbdVsb: -2.88e-14    -2.88e-14    -2.16e-14


Date: Wed May 11 01:27:07 2022
Total elapsed time: 0.163 seconds.
```

Figura 21.Fișierul de ieșire înainte de ajustare

SPICE Error Log: C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_OGLINDA_NMOS_OP.log

```
Circuit: * C:\Users\Asus\Desktop\PROEICT_CIA\Lab2-Sursecrt\PROIECT_CIA_OGLINDA_NMOS_OP.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                          --- BSIM3 MOSFETS ---
Name:         mn3          mn2          mn1
Model:       n018         n018         n018
Id:       6.00e-05     6.00e-05     6.00e-05
Vgs:      6.55e-01     6.55e-01     8.47e-01
Vds:      6.55e-01     1.50e+00     3.45e-01
Vbs:      0.00e+00     0.00e+00    -6.55e-01
Vth:      4.46e-01     4.46e-01     6.19e-01
Vdsat:    1.96e-01     1.96e-01     2.15e-01
Gm:       4.73e-04     4.66e-04     4.38e-04
Gds:      5.60e-06     5.08e-06     8.29e-06
Gmb       1.51e-04     1.49e-04     1.14e-04
Cbd:      1.65e-14     1.40e-14     1.53e-14
Cbs:      2.03e-14     2.03e-14     1.65e-14
Cgsov:    5.08e-15     4.71e-15     5.08e-15
Cgdov:    5.03e-15     4.28e-15     5.08e-15
Cgbov:    0.00e+00     0.00e+00     0.00e+00
dQgdVgb:  6.90e-14     6.35e-14     6.86e-14
dQgdVdb: -5.05e-15    -4.28e-15    -5.44e-15
dQgdVsb: -5.99e-14    -5.55e-14    -6.02e-14
dQddVgb: -5.16e-15    -4.30e-15    -6.05e-15
dQddVdb:  2.16e-14     1.83e-14     2.12e-14
dQddVsb:  1.04e-16     1.70e-17     3.52e-16
dQbdVgb: -9.87e-15    -9.18e-15    -8.95e-15
dQbdVdb: -1.65e-14    -1.40e-14    -1.55e-14
dQbdVsb: -2.95e-14    -2.88e-14    -2.21e-14


Date: Wed May 11 01:33:22 2022
Total elapsed time: 0.138 seconds.
```

Figura 22. Fișierul de ieșire după ajustare

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mv]	Vgs [mv]	gm [uS]	gds [uS]
Mn3	9.315	60	196	655	446	655	473	5.60
Mn2	8.64	60	196	1500	446	655	466	5.08
Mn1	9.315	60	201	345	619	847	438	8.29

Tabel 7. Parametrii tranzistoarelor după ajustare

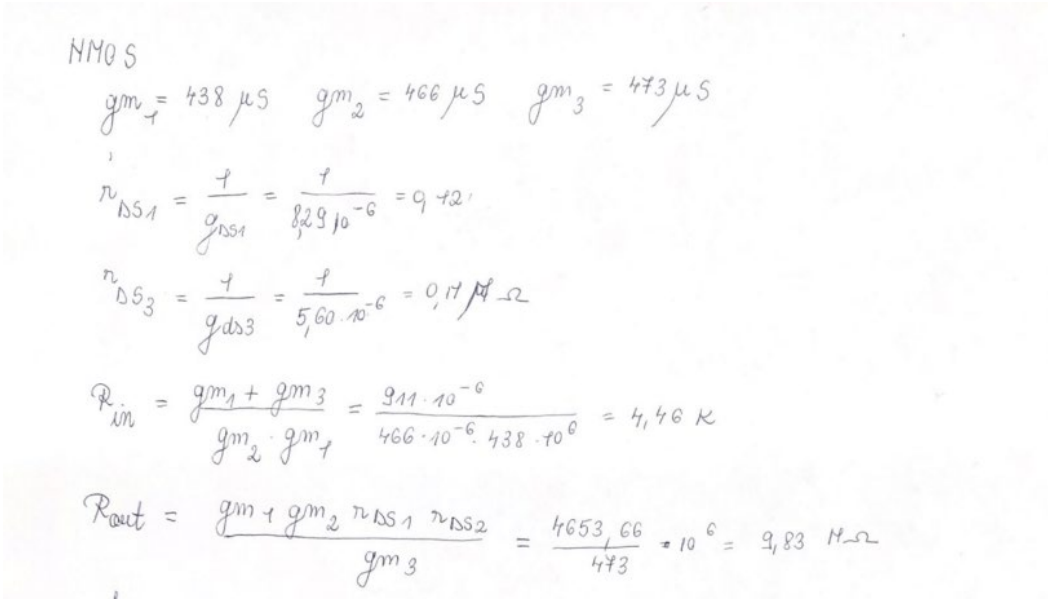

Figura 23. Calculul rezistențelor de intrare și ieșire

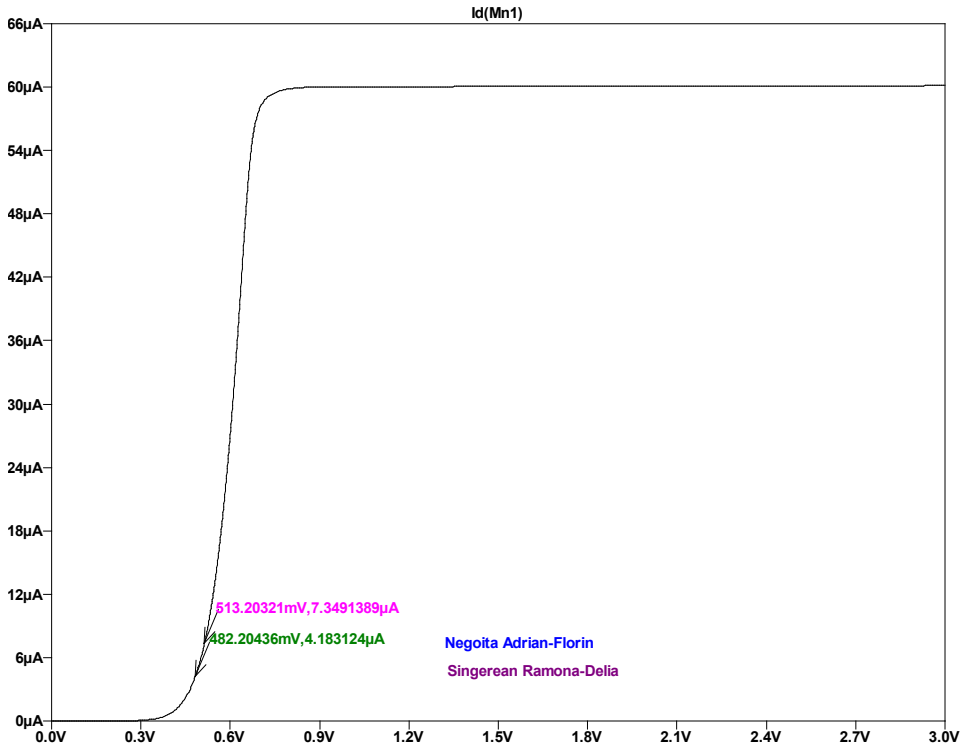

Figura 24. Caracteristica rezistenței de ieșire

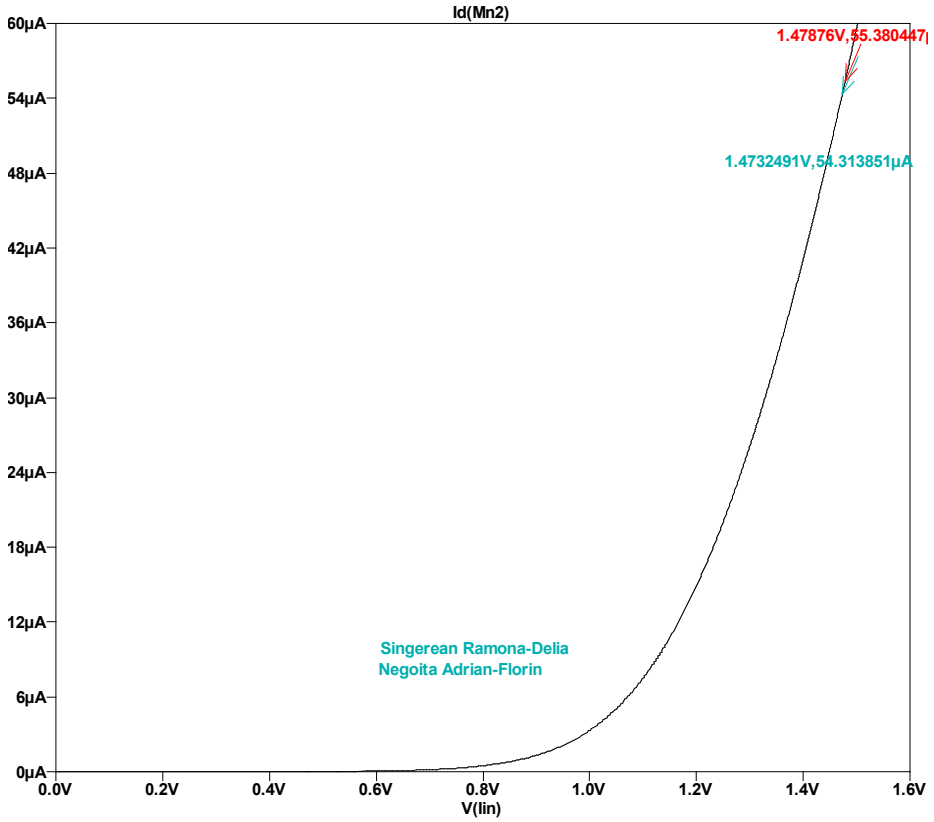

Figura 25. Caracteristica rezistenței de intrare

Parametru	Calculat	Măsurat
Rin [K Ω]	4.46	5.16
Rout [MΩ]	9.83	

Tabelul 8:Valorile calculate și măsurate ale rezistenței de ieșire și intrare

4.CIRCUITUL COMPLET

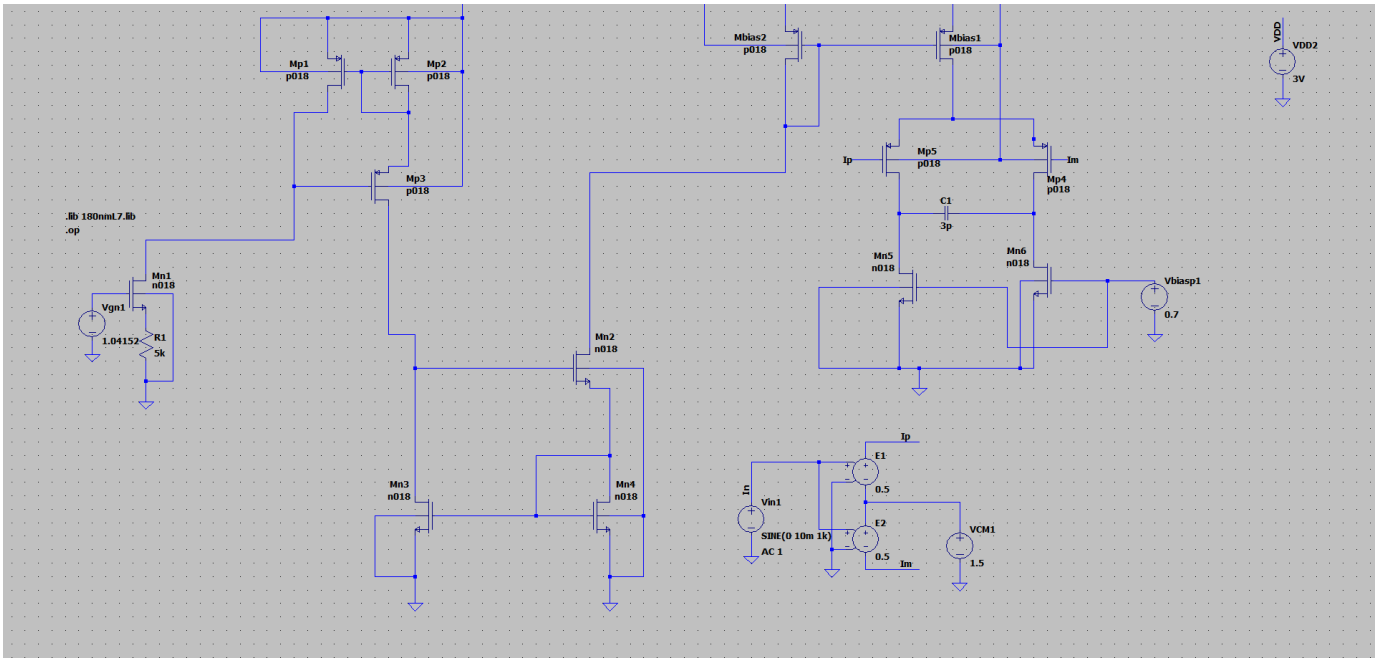

Figura 26 :Schema electrică a circuitului complet

```
Circuit: * C:\Users\Adi\Downloads\PROIECT_CIA\Lab2-Sursecrt\PROIECT_CIA_CIRCUIT_COMPLET_VERSIUNEA_2.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                        --- BSIM3 MOSFETS ---
Name:       mbias2      mbias1       mp5         mp4         mp3
Model:       p018        p018        p018        p018        p018
Id:       -5.81e-05   -5.59e-04   -2.79e-04   -2.79e-04   -5.80e-05
Vgs:      -7.53e-01   -7.53e-01   -1.28e+00   -1.28e+00   -8.83e-01
Vds:      -7.53e-01   -2.22e-01   -4.96e-02   -4.96e-02   -8.10e-01
Vbs:       0.00e+00    0.00e+00    2.22e-01    2.22e-01    7.12e-01
Vth:      -4.46e-01   -4.46e-01   -5.07e-01   -5.07e-01   -6.24e-01
Vdsat:    -2.18e-01   -2.18e-01   -5.07e-01   -5.07e-01   -2.04e-01
Gm:        3.63e-04    3.30e-03    3.36e-04    3.36e-04    4.28e-04
Gds:       6.97e-06    4.93e-04    5.35e-03    5.35e-03    6.71e-06
Gmb        9.85e-05    9.01e-04    1.12e-04    1.12e-04    9.36e-05
Cbd:       5.87e-14    7.48e-13    3.63e-13    3.63e-13    6.50e-14
Cbs:       7.87e-14    8.33e-13    3.71e-13    3.71e-13    7.88e-14
Cgsov:     1.35e-14    1.44e-13    7.11e-14    7.11e-14    1.79e-14
Cgdov:     1.33e-14    1.43e-13    7.11e-14    7.11e-14    1.78e-14
Cgbov:     0.00e+00    0.00e+00    0.00e+00    0.00e+00    0.00e+00
dQgdVgb:   1.85e-13    2.02e-12    1.14e-12    1.14e-12    2.42e-13
dQgdVdb:  -1.34e-14   -2.16e-13   -5.25e-13   -5.25e-13   -1.78e-14
dQgdVsb:  -1.64e-13   -1.73e-12   -6.13e-13   -6.13e-13   -2.14e-13
dQddVgb:  -1.36e-14   -2.85e-13   -5.63e-13   -5.63e-13   -1.81e-14
dQddVdb:   7.22e-14    1.10e-12    1.72e-12    1.72e-12    8.30e-14
dQddVsb:   1.74e-16   -3.36e-14   -6.76e-13   -6.76e-13    1.95e-16
dQbdVgb:  -3.18e-14   -2.94e-13   -4.66e-15   -4.66e-15   -3.82e-14
dQbdVdb:  -5.88e-14   -8.17e-13   -7.69e-13   -7.69e-13   -6.51e-14
dQbdVsb:  -9.25e-14   -9.70e-13   -2.20e-13   -2.20e-13   -8.76e-14
```

SPICE Error Log: C:\Users\Adi\Downloads\PROIECT_CIA\Lab2-Sursecrt\PROIECT_CIA_CIRCUIT_COMPLET_VERSIUNEA_2.log

```
dQbdVgb:  -3.18e-14   -2.94e-13   -4.66e-15   -4.66e-15   -3.82e-14
dQbdVdb:  -5.88e-14   -8.17e-13   -7.69e-13   -7.69e-13   -6.51e-14
dQbdVsb:  -9.25e-14   -9.70e-13   -2.20e-13   -2.20e-13   -8.76e-14

Name:         mp2         mp1         mn6         mn5         mn4
Model:       p018        p018        n018        n018        n018
Id:       -5.80e-05   -5.81e-05    2.79e-04    2.79e-04    5.81e-05
Vgs:      -7.12e-01   -7.12e-01    6.50e-01    6.50e-01    6.51e-01
Vds:      -7.12e-01   -1.59e+00    2.73e+00    2.73e+00    6.51e-01
Vbs:       0.00e+00    0.00e+00    0.00e+00    0.00e+00    0.00e+00
Vth:      -4.46e-01   -4.46e-01    4.46e-01    4.46e-01    4.46e-01
Vdsat:    -1.92e-01   -1.92e-01    1.92e-01    1.92e-01    1.93e-01
Gm:        4.31e-04    4.27e-04    2.17e-03    2.17e-03    4.66e-04
Gds:       7.24e-06    6.42e-06    2.16e-05    2.16e-05    5.46e-06
Gmb        1.17e-04    1.16e-04    6.98e-04    6.98e-04    1.48e-04
Cbd:       7.88e-14    5.80e-14    5.20e-14    5.20e-14    1.79e-14
Cbs:       1.04e-13    9.43e-14    8.80e-14    8.80e-14    2.20e-14
Cgsov:     1.79e-14    1.62e-14    2.07e-14    2.07e-14    5.08e-15
Cgdov:     1.77e-14    1.46e-14    1.77e-14    1.77e-14    5.03e-15
Cgbov:     0.00e+00    0.00e+00    0.00e+00    0.00e+00    0.00e+00
dQgdVgb:   2.47e-13    2.21e-13    2.78e-13    2.78e-13    6.90e-14
dQgdVdb:  -1.78e-14   -1.46e-14   -1.77e-14   -1.77e-14   -5.05e-15
dQgdVsb:  -2.17e-13   -1.96e-13   -2.44e-13   -2.44e-13   -5.98e-14
dQddVgb:  -1.81e-14   -1.47e-14   -1.78e-14   -1.78e-14   -5.16e-15
dQddVdb:   9.68e-14    7.26e-14    6.98e-14    6.98e-14    2.30e-14
dQddVsb:   2.59e-16    4.75e-17    2.19e-17    2.19e-17    1.05e-16
dQbdVgb:  -4.24e-14   -3.84e-14   -4.04e-14   -4.04e-14   -9.87e-15
dQbdVdb:  -7.89e-14   -5.80e-14   -5.20e-14   -5.20e-14   -1.79e-14
dQbdVsb:  -1.23e-13   -1.11e-13   -1.25e-13   -1.25e-13   -3.12e-14

Name:         mn3         mn2         mn1
```

SPICE Error Log: C:\Users\Adi\Downloads\PROIECT_CIA\Lab2-Sursecrt\PROIECT_CIA_CIRCUIT_COMPLET_VERSIUNEA_2.log

```
Name:          mn3          mn2          mn1
Model:       n018         n018         n018
Id:       5.80e-05     5.81e-05     5.81e-05
Vgs:      6.51e-01     8.27e-01     7.51e-01
Vds:      1.48e+00     1.60e+00     1.12e+00
Vbs:      0.00e+00    -6.51e-01    -2.90e-01
Vth:      4.46e-01     6.18e-01     5.28e-01
Vdsat:    1.93e-01     2.01e-01     2.09e-01
Gm:       4.58e-04     4.50e-04     4.28e-04
Gds:      4.95e-06     4.60e-06     4.85e-06
Gmb       1.46e-04     1.17e-04     1.24e-04
Cbd:      1.40e-14     1.37e-14     1.42e-14
Cbs:      2.03e-14     1.79e-14     1.82e-14
Cgsov:    4.71e-15     5.08e-15     4.44e-15
Cgdov:    4.29e-15     4.64e-15     4.21e-15
Cgbov:    0.00e+00     0.00e+00     0.00e+00
dQgdVgb:  6.35e-14     6.78e-14     5.97e-14
dQgdVdb: -4.29e-15    -4.64e-15    -4.22e-15
dQgdVsb: -5.55e-14    -6.00e-14    -5.23e-14
dQddVgb: -4.30e-15    -4.66e-15    -4.25e-15
dQddVdb:  1.83e-14     1.84e-14     1.84e-14
dQddVsb:  1.76e-17     1.53e-17     2.92e-17
dQbdVgb: -9.18e-15    -9.19e-15    -8.26e-15
dQbdVdb: -1.40e-14    -1.37e-14    -1.42e-14
dQbdVsb: -2.88e-14    -2.34e-14    -2.46e-14


Date: Sat May 14 10:56:35 2022
Total elapsed time: 0.165 seconds.
```

Figura 27:Fișierul de ieșire înainte de ajustare

Tranzistor	W/L	ID [uA]	Vdsat [mV]	Vds [mV]	Vth [mv]	Vgs [mv]	gm [uS]	gds [uS]
Sursă de curent								
Mn1	8.139	58.1	209	1120	528	751	428	4.85
Oglindă/oglinzi de curent								
Mp3	32.89	58	204	810	624	883	428	6.71
Mp2	32.89	58	192	712	446	712	431	7.24
Mp1	29.7	58.1	192	1590	446	712	427	6.42
Mn2	9.315	58.1	201	1600	618	827	450	4.60
Mn3	8.64	58	193	1480	446	651	458	4.95
Mn4	9.315	58.1	193	651	446	651	466	5.46
Amplificator diferențial								
Mbias2	24.55	58.6	218	753	446	753	363	6.97
Mbias1	264.78	559	218	222	446	753	3300	493
Mp5	130.53	279	507	49.6	507	1280	336	53.5
Mp4	130.53	279	507	49.6	507	1290	336	53.5
Mn6	38	279	192	2730	446	650	2170	21.6
Mn5	38	279	192	2730	446	650	2170	21.6

Tabel 9.Parametrii tranzistoarelor

Calcul circuit final

Rout pentru sursa de curent (Routs)

$g_m = 428\mu S$

$g_{mb} = 124\mu S$

$r_{ds} = \frac{1}{g_{ds}} = \frac{1}{4,85} \cdot 10^{+6} = 0,2\ M\Omega$

$R_{out} = r_{ds} + R_1 + (g_m + g_{mb}) r_{DS} R_1 =$

$= 0,2 \cdot 10^6 + 5 \cdot 10^3 + (124\mu + 428\mu) \cdot 0,2 \cdot 5 \cdot 10^9$

$= 205 \cdot 10^3 + 552 \cdot 10^{-6} \cdot 10^9 = 205 \cdot 10^3 + 552 \cdot 10^3 =$

$= 0,757\ M\Omega$

Rin, Rout0 (oglinda Pmos)

$g_{m3} = 428\mu S$ $\quad g_{ds3} = 6,42\mu S$

$g_{m2} = 431\mu S$ $\quad g_{ds2} = 7,24\mu S$

$g_{m1} = 427\mu S$ $\quad g_{ds1} = 6,42\mu S$

$r_{DS1} = \frac{1}{g_{ds1}} = \frac{1}{6,42} \cdot 10^6 = 0,15\ M\Omega$

$r_{DS2} = \frac{1}{g_{ds2}} = 0,13\ M\Omega$

$r_{DS3} = \frac{1}{g_{ds3}} = 0,14\ M\Omega$

$R_{in} = \frac{g_{m2} + g_{m3}}{g_{m1} g_{m3}} = \frac{(431 + 428) \cdot 10^{-6}}{427 \cdot 428 \cdot 10^{-12}} = \frac{859}{182756} \cdot 10^6 =$

$= 4,7\ K$

$R_{out} = \frac{g_{m1} g_{m3} r_{DS1} r_{DS3}}{g_{m2}} = \frac{427 \cdot 428 \cdot 0,15 \cdot 0,14}{431 \cdot 10^{-6}} = 8,9\ M\Omega$

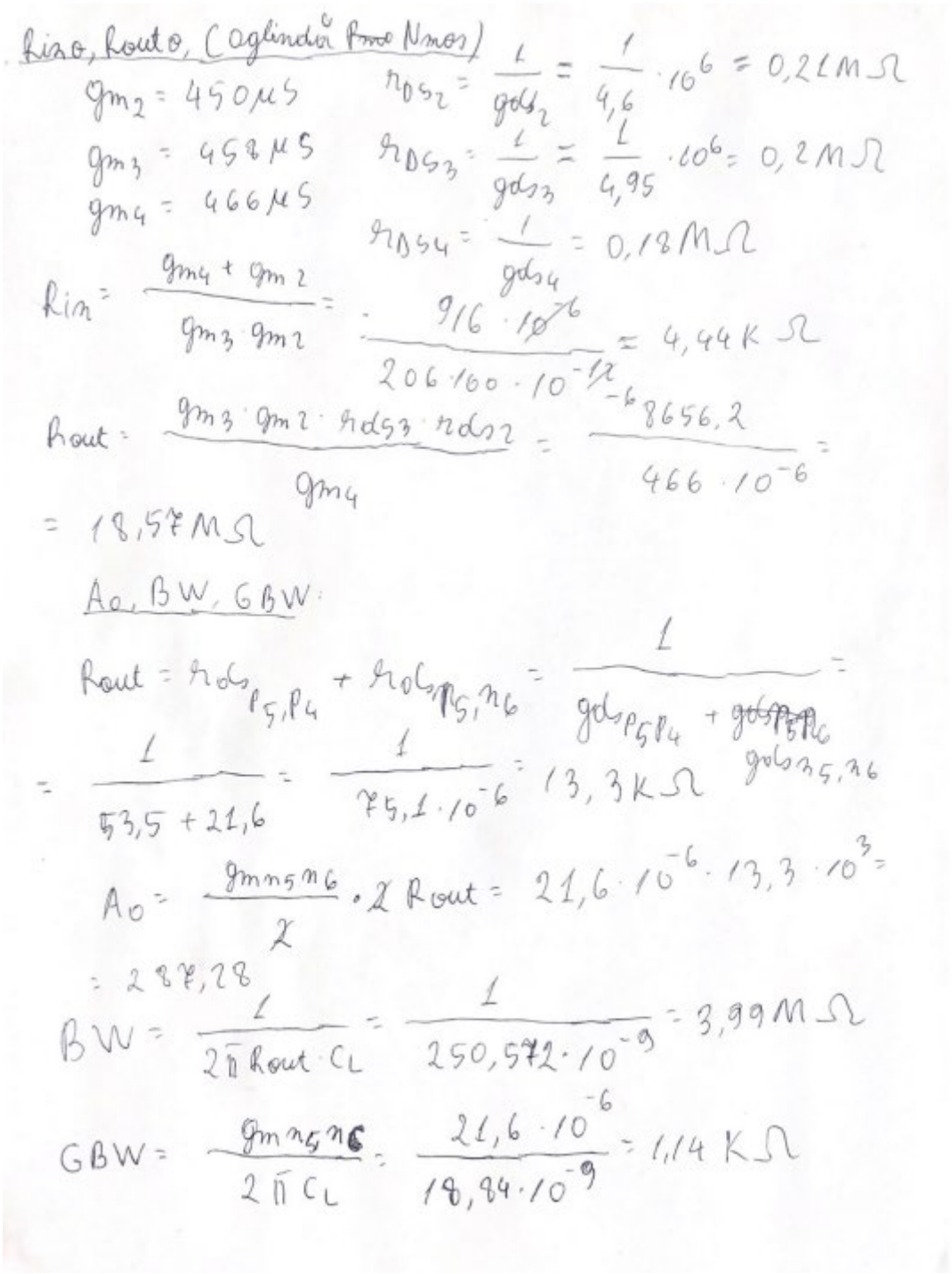

Figura 28 :Calculul parametrilor

Parametru	Calculat	Masurat
Sursa de curent		
Rout [Mohm]	0.757	
Oglinda NMOS		
Rin [Kohm]	4.44	
Rout [Mohm]	18.57	
Oglinda PMOS		
Rin [Kohm]	4.7	
Rout [Mohm]	8.9	
Amplificator diferential		
A0 [db]	50	
F_{pol} [kHz]	3.99	
GBW [MHz]	1	

Tabel 10. Valorile calculate și măsurate ale parametrilor sursei de curent, oglinzilor și amplificatorului