Proiect Cia

Componenta: Suciu Vlad

Tasca Andrei-Antonio

Cerinte de proiectare:

|		
Amplificator diferential	**Topologie**	Amplificator diferential de tip N cu sarcina oglinda
	Produs amplificare-banda [MHz]	30
	Capacitate de sarcina [pF]	6
Sursa de curent	**Topologie**	Sursa de curent cu tranzistor PMOS cu degenerare rezistiva
	Curent de iesire [uA]	15
	Tensiune de iesire minima [mV]	400
Oglinda de curent	**Topologie**	Oglinda/oglinzi de curent cascoda

Circuite:

- Sursa de curent
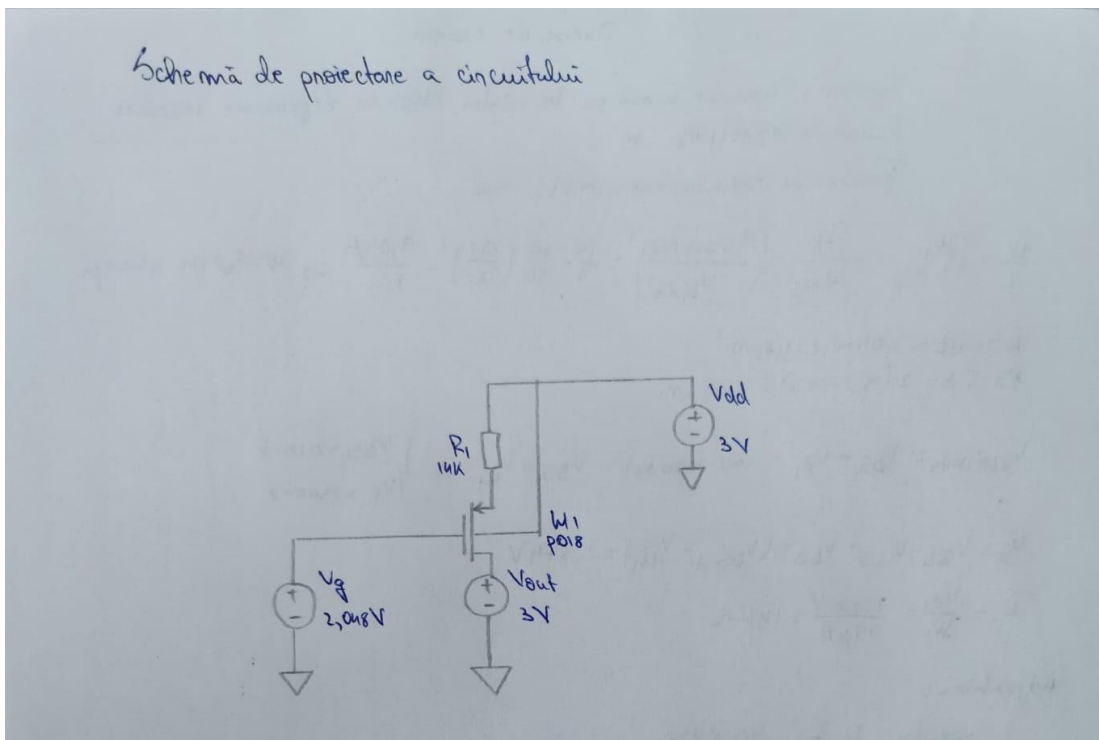
- Amplificator diferential
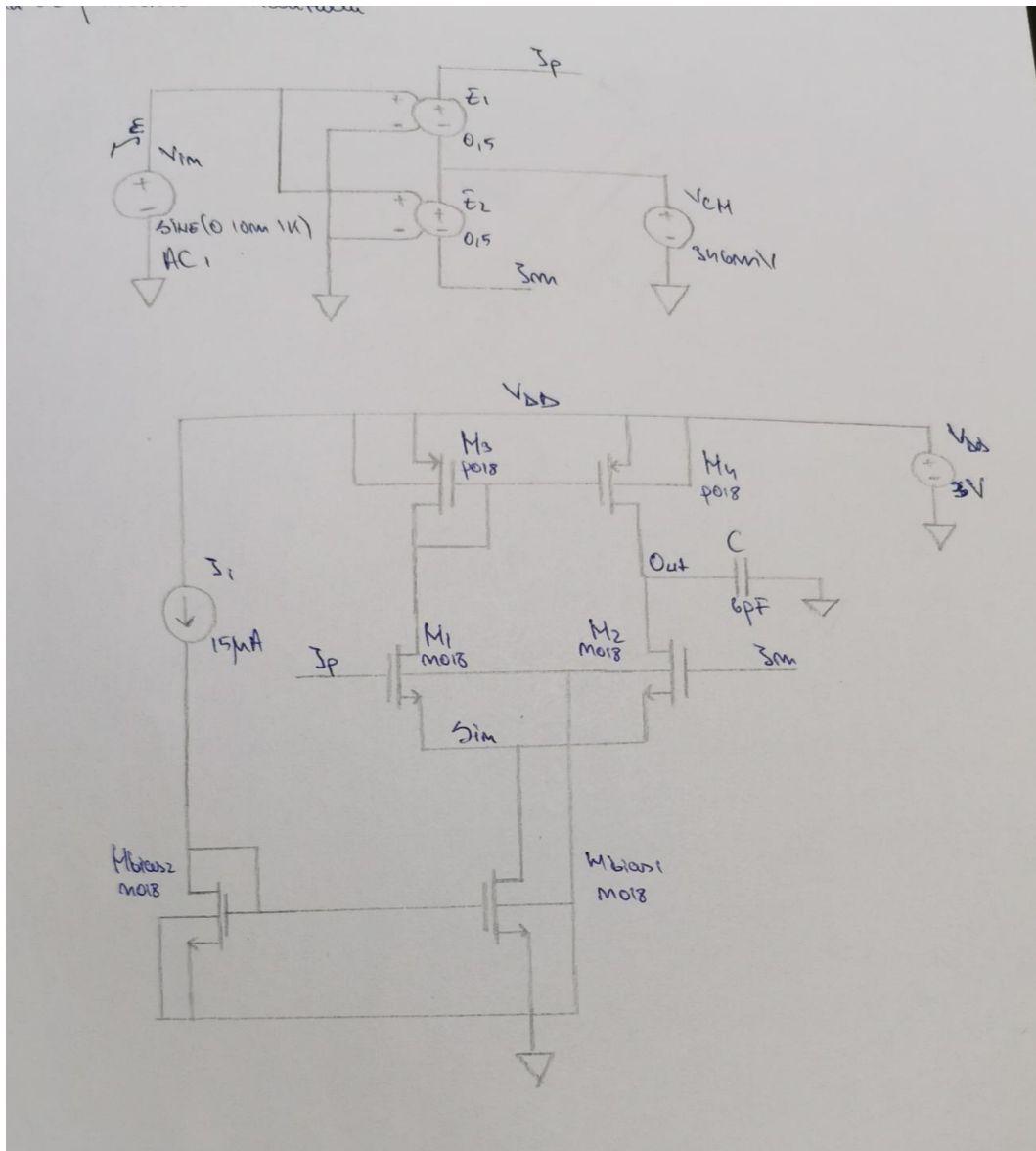
- Oglinzi cascoda
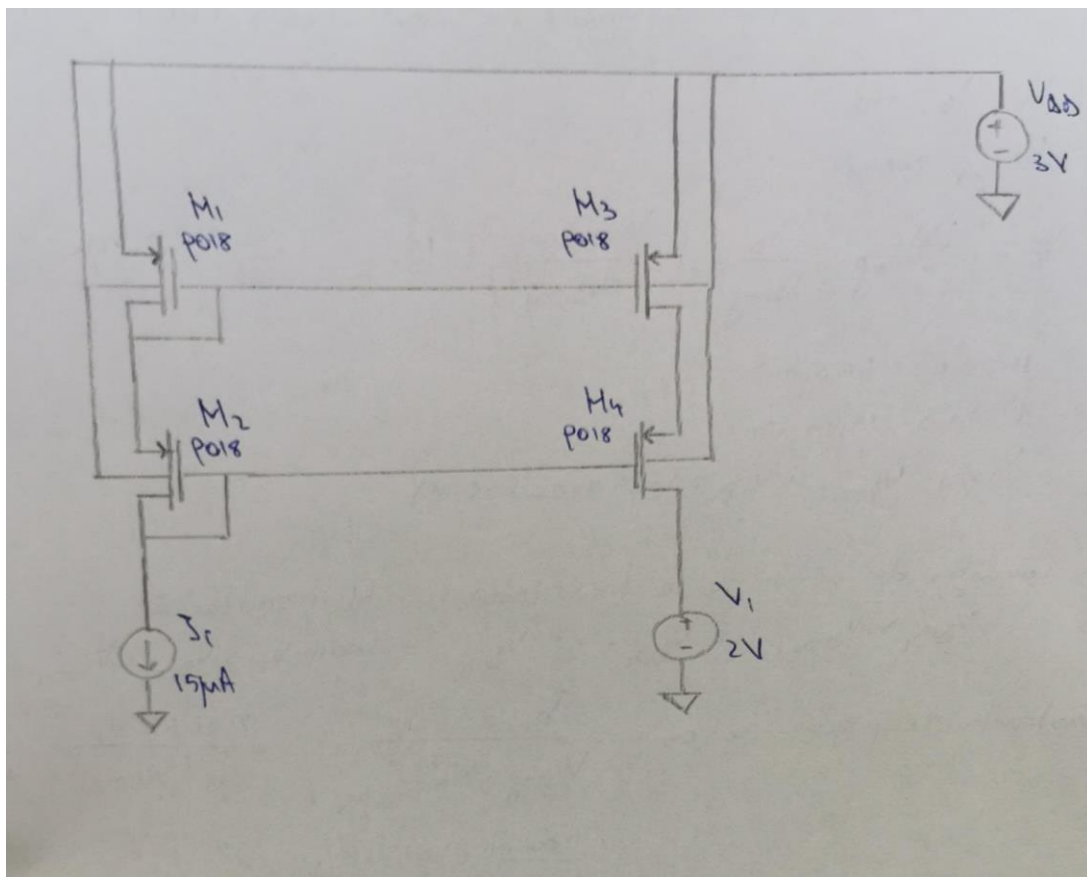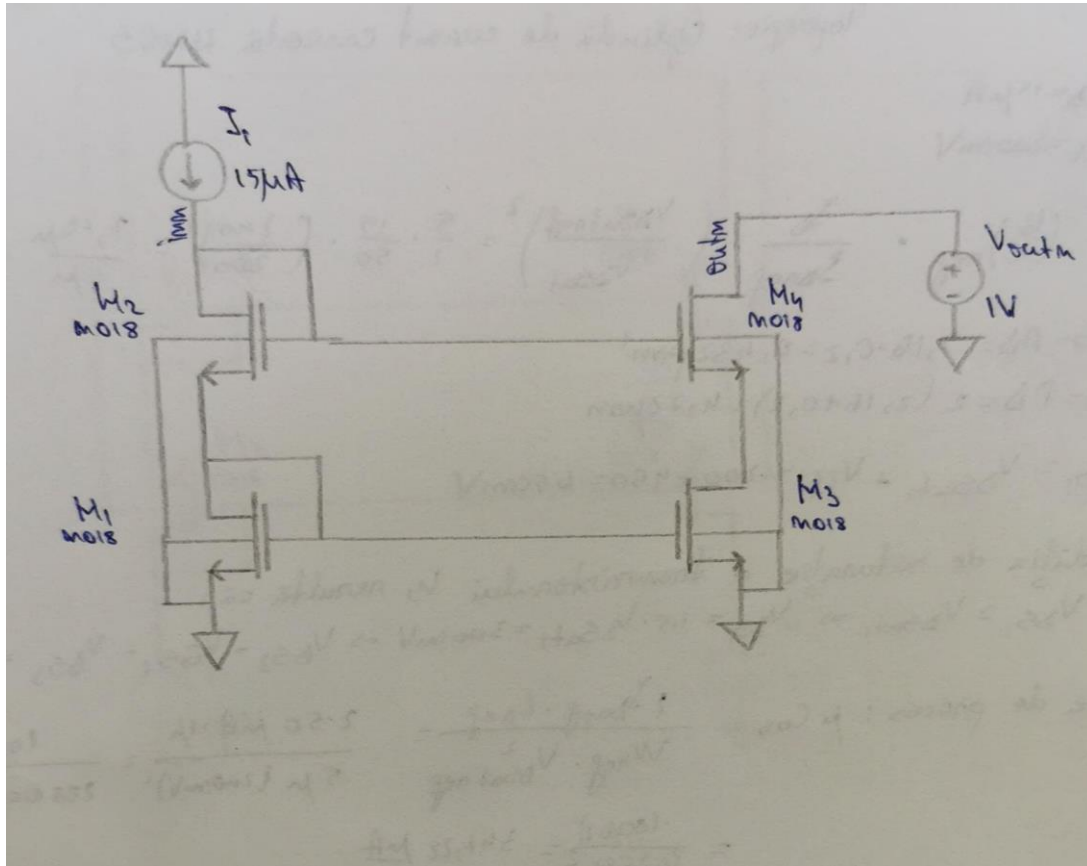
Raport sursa de curent

- Schema electrica la nivel de transistor a sursei de curent

.lib 180nmL7.lib

R1
14k

Vdd

3V

M1
p018

Vg

Vout

2.048V

3V

;op

.dc Vout 0 3v 1mv
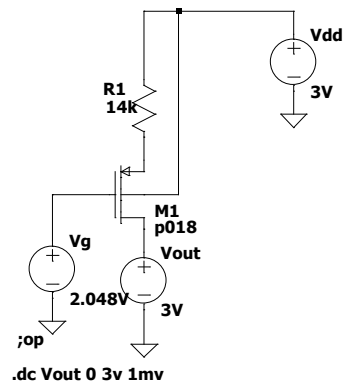
- Proiectarea circuitului dupa specificatii (Iout si Vout)

Sursa de curent

Topologie: Sursa de curent cu tranzistor PMOS cu degenerare rezistivă

Curent de iesire [μA]: 15

Tensiune de iesire minimă [mV]: 400

$$\frac{W}{L} = \left(\frac{W}{L}\right)_{neg} \cdot \frac{I_D}{I_{Dneg}} \left(\frac{V_{Dsat\,neg}}{V_{Dsat}}\right)^2 = \frac{15}{1} \cdot \frac{15}{50} \left(\frac{257}{180}\right)^2 = \frac{9,04\mu}{1\mu} \Rightarrow W = 9,04\mu, \; L = 1\mu$$

$AS = AD = 9,04 \cdot 0,2 = 1,8\,pm^2$

$PS = PD = 2(9,04 + 0,2) = 18,48\,\mu m$

$V_{out\,min} = V_{DS_1} + V_{R_1} \quad (=) \quad 400\,mV = V_{DS_1} + V_{R_1} \Rightarrow \begin{cases} V_{DS_1} = 210\,mV \\ V_{R_1} = 190\,mV \end{cases}$

$V_G = V_{DD} - V_{GS} = V_{DD} - (V_{Dsat} + V_{Th}) = 2,374\,V$

$R_1 = \frac{V_{R_1}}{I_{R_1}} = \frac{210\,mV}{15\,\mu A} = 14\,K\Omega$

Adjustări:

- pentru $M_1 \rightarrow$ $W = 8,23\mu$

$AS = AD = 1,64\,pm^2$

$PS = PD = 16,86\,\mu m$

- $V_G = 2,048\,V$

Tranzistor	W/L	I_D	V_{Dsat}	V_{DS}	V_{Th}	V_{GS}	g_m	g_{DS}
M_1	8,23μ/1μ	15μA	180mV	2,79 V	504mV	742mV	122μS	1,47μS

Calculat: $R_{out} = r_{DS} + R + (g_m + g_{mb}) r_{DS} R = 680K + 14K + (122\mu + 31\mu) 680K \cdot 14K = 2,084\,M$

$r_{DS} = \frac{1}{g_{DS}} = 0,680 \cdot 10^6 = 680\,K\Omega$

Măsurat: $R_{out} = \frac{1}{5,8} \cdot 10^7 = 0,172 \cdot 10^7 = 1,72\,M\Omega$

Parametru	Calculat	Măsurat
R_{out}	2,084Ω	1,72MΩ

Schemă de proiectare a circuitului

Vdd
3V

R₁
14K

W₁
p018

Vg
2,048V

Vout
3V
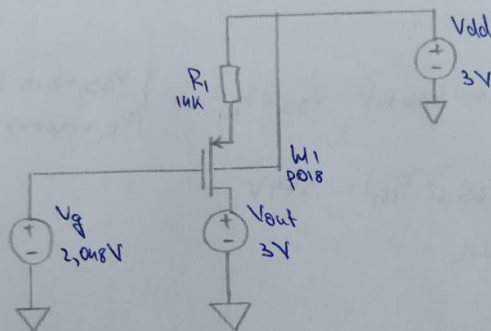
- Error log inainte de ajustare

SPICE Error Log: C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\sursa de curent\srs-cascoda-MOS.log

Circuit: * C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\sursa de curent\srs-cascoda-MOS.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                    --- BSIM3 MOSFETS ---
Name: m1
Model: p018
Id: -1.78e-05
Vgs: -7.61e-01
Vds: -2.75e+00
Vbs: 2.49e-01
Vth: -5.14e-01
Vdsat: -1.87e-01
Gm: 1.38e-04
Gds: 1.73e-06
Gmb   3.45e-05
Cbd: 1.45e-14
Cbs: 2.59e-14
Cgsov: 4.92e-15
Cgdov: 4.23e-15
Cgbov: 0.00e+00
dQgdVgb: 6.65e-14
dQgdVdb: -4.23e-15
dQgdVsb: -5.92e-14
dQddVgb: -4.23e-15
dQddVdb: 1.88e-14
dQddVsb: 4.70e-18
dQbdVgb: -1.12e-14
dQbdVdb: -1.45e-14
dQbdVsb: -2.98e-14

Date: Tue May 10 12:43:15 2022
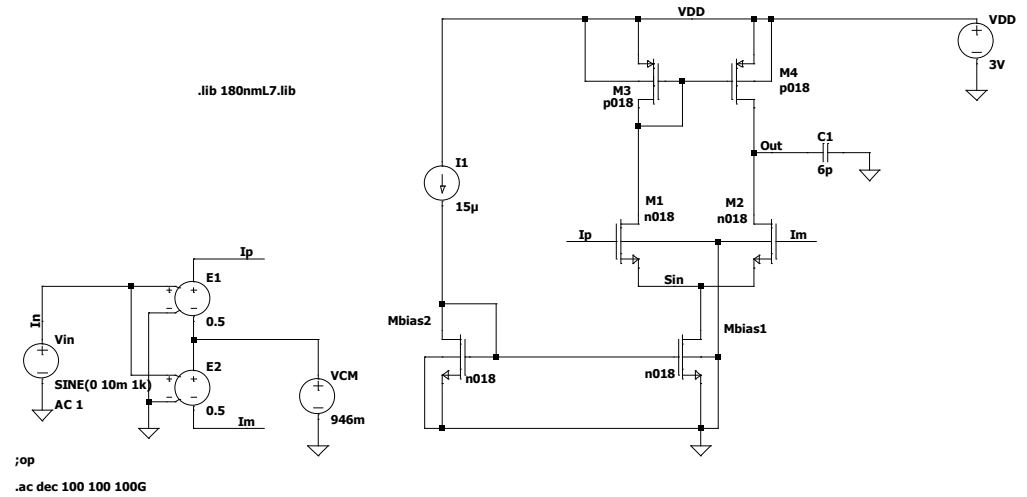Total elapsed time: 0.075 seconds.

tnom = 27
temp = 27
method = trap
totiter = 5
traniter = 0
tranpoints = 0
accept = 0
rejected = 0
matrix size = 5
fillins = 0
solver = Normal
Matrix Compiler1: 150 bytes object code size
Matrix Compiler2: 329 bytes object code size

- Caracteristica de iesire
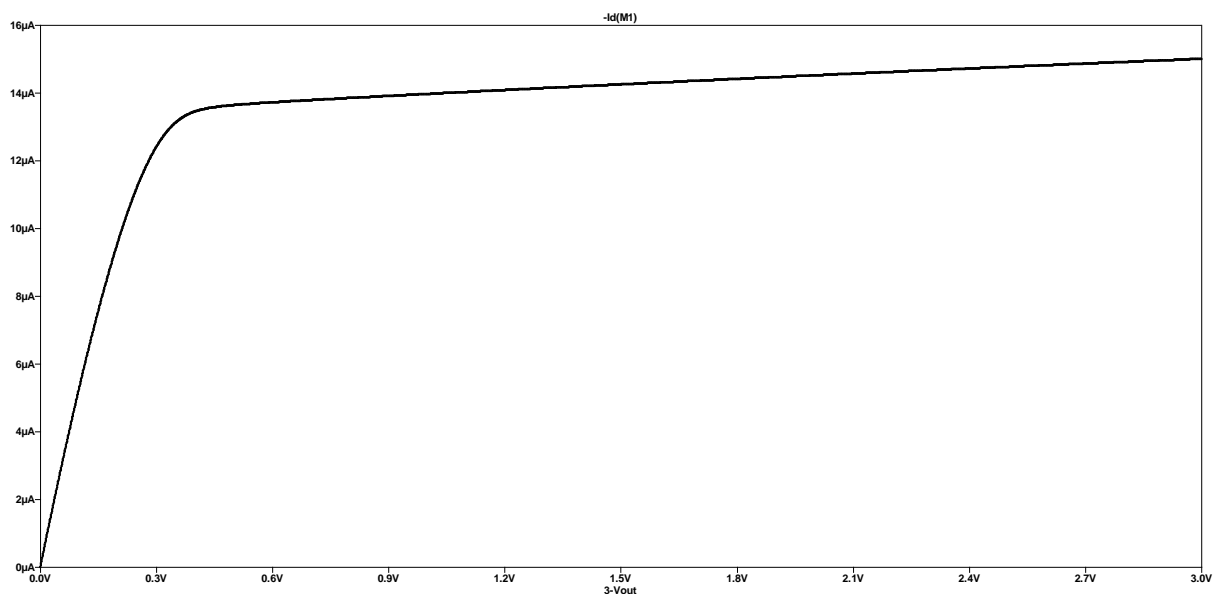
Raport amplificator diferential

- Schema electrica la nivel de transistor al amp. diferential

- Proiectarea circuitului dupa specificatii(GBW si CL)

Amplificator diferențial

Topologie: Amplificator diferențial de tip N cu sarcină oglindă

Produs amplificare-bandă [MHz]: 30

Capacitate de sarcină [pf]: 6

$GBW > 30 \Rightarrow GBW = 50 MHz$, $C_L = 6pf$, $I_{out} = 15 \mu A$

$G_m = 2\pi \, GBW \, C_L = 2\pi \cdot 50 \cdot 10^6 \cdot 6 \cdot 10^{-12} = 1884 \mu S = 1,8 \, mS$

$V_{DSat} = 200 mV$

$g_{m_1} = \dfrac{2 I_D}{V_{DSat}}$, $g_m = 2 \, GBW = 2 \cdot 1,88 \, mS = 3,76 \, mS$

$I_{D_{1,2}} = \dfrac{g_{m_1} \, V_{DSat}}{2} = \dfrac{3,76 \, mS \cdot 200 mV}{2} = 376 \mu A$

$\left(\dfrac{W}{L}\right)_{1,2} = \left(\dfrac{W}{L}\right)_{ref} \cdot \dfrac{I_D}{I_{Dref}} \left(\dfrac{V_{DSat\,ref}}{V_{DSat}}\right)^2 = \dfrac{5}{1} \cdot \dfrac{37,6}{50} \cdot \left(\dfrac{240}{200}\right)^2 = \dfrac{54,14\mu}{1\mu} \Rightarrow \begin{cases} W = 54,14\mu \\ L = 1\mu \end{cases}$

$AS = Ab = 10,82 \, pm^2$

$PS = Pb = 108,68 \, \mu m$

$\left(\dfrac{W}{L}\right)_{3,4} = \left(\dfrac{W}{L}\right)_{ref} \cdot \dfrac{I_D}{I_{Dref}} \left(\dfrac{V_{DSat\,ref}}{V_{DSat}}\right)^2 = \dfrac{5}{1} \cdot \dfrac{37,6}{50} \cdot \left(\dfrac{254}{200}\right)^2 = \dfrac{183,86\mu}{1\mu} \Rightarrow \begin{cases} W = 183,86\mu \\ L = 1\mu \end{cases}$

$AS = Ab = 36,77 pm^2$

$PS = Pb = 368,12 \mu m$

$\left(\dfrac{W}{L}\right)_{Bias2} = \left(\dfrac{W}{L}\right)_{ref} \cdot \dfrac{I_D}{I_{Dref}} \left(\dfrac{V_{DSat\,ref}}{V_{DSat}}\right)^2 = \dfrac{5}{1} \cdot \dfrac{15}{50} \cdot \left(\dfrac{240}{200}\right)^2 = \dfrac{3,16\mu}{1\mu} \Rightarrow \begin{cases} W = 3,16\mu \\ L = 1\mu \end{cases}$

$AS = Ab = 0,43 \, pm^2$

$PS = Pb = 4,72 \mu m$

$I_{DBias_1} = I_{DM_1M_2} + I_{DM_3M_4} = 752 \mu A$

$\left(\dfrac{W}{L}\right)_{Bias_1} = \left(\dfrac{W}{L}\right)_{ref} \cdot \dfrac{I_D}{I_{Dref}} \left(\dfrac{V_{DSat\,ref}}{V_{DSat}}\right)^2 = \dfrac{5}{1} \cdot \dfrac{752}{50} \cdot \left(\dfrac{240}{200}\right)^2 = \dfrac{108,28\mu}{1\mu} \Rightarrow \begin{cases} W = 108,28\mu \\ L = 1\mu \end{cases}$

$AS = Ab = 21,65 \, pm^2$

$PS = Pb = 216,56 \mu m$

$V_{CM} = V_{GSM_1} + V_{DSBias_1} = V_{DSat M_1} + V_{Th} + V_{DSBias_1} = 200 + 446 + 300 = 946 mV$

$V_{DSBias_1} = V_{DSat} + \Delta V = 200 + 100 = 300 mV$

Modifi:

Ajustări:

- pentru Mbias1 → W = 115,5 μ

  AS = AD = 23,1 pm²

  PS = PD = 231,4 μm

Tranzistor	W/L	I_D	V_{Dsat}	V_{DS}	V_{th}	V_{GS}	g_m	g_{DS}
M_1	54,14μ/1μ	376μA	138mV	2,04V	511mV	713mV	2,30mS	29,9μS
M_2	54,14μ/1μ	376μA	138mV	2,04V	511mV	713mV	2,30mS	29,9μS
M_3	183,86μ/1μ	376μA	205mV	732mV	446mV	732mV	2,56mS	46μS
M_4	183,86μ/1μ	376μA	205mV	732mV	446mV	732mV	2,56mS	46μS
Mbias1	115,5μ/1μ	752μA	203mV	227mV	446mV	665mV	5,52mS	448μS
Mbias2	2,16μ/1μ	15μA	203mV	665mV	446mV	665mV	114μS	1,38μS

$A_0 = g_{m_1} (r_{DS_2} \| r_{DS_4}) = g_{m_1} \dfrac{r_{DS_2} \cdot r_{DS_4}}{r_{DS_2} + r_{DS_4}} = 2,30 \cdot 10^{-3} \cdot 13,15 \cdot 10^3 = 38,13$

$r_{DS_2} = \dfrac{1}{g_{DS_2}} = \dfrac{1}{29,9} \cdot 10^6 = 0,0334 \cdot 10^6 = 33,4 \ K\Omega$

$r_{DS_4} = \dfrac{1}{g_{DS_4}} = \dfrac{1}{46} \cdot 10^6 = 0,0217 \cdot 10^6 = 21,7 \ K\Omega$

În decibeli: $20 \log A_0 = 20 \log 38,13 = 20 \cdot 1,58 = 31,6 dB$

$R_{out} = r_{DS_2} \| r_{DS_4} = 13,15 K\Omega$

$GBW = \dfrac{g_{m_1}}{2\pi C_L} = \dfrac{2,30 \cdot 10^{-3}}{2 \cdot 3,14 \cdot 6 \cdot 10^{-12}} = 0,0769 \cdot 10^9 = 76,9 MHz$

$BW = \dfrac{1}{2\pi R_{out} C_L} = \dfrac{1}{2\pi \cdot 13,15 \cdot 10^3 \cdot 6 \cdot 10^{-12}} = \dfrac{1}{495,5 \cdot 10^{-9}} = 0,00201 \cdot 10^9 = 2,01 MHz$
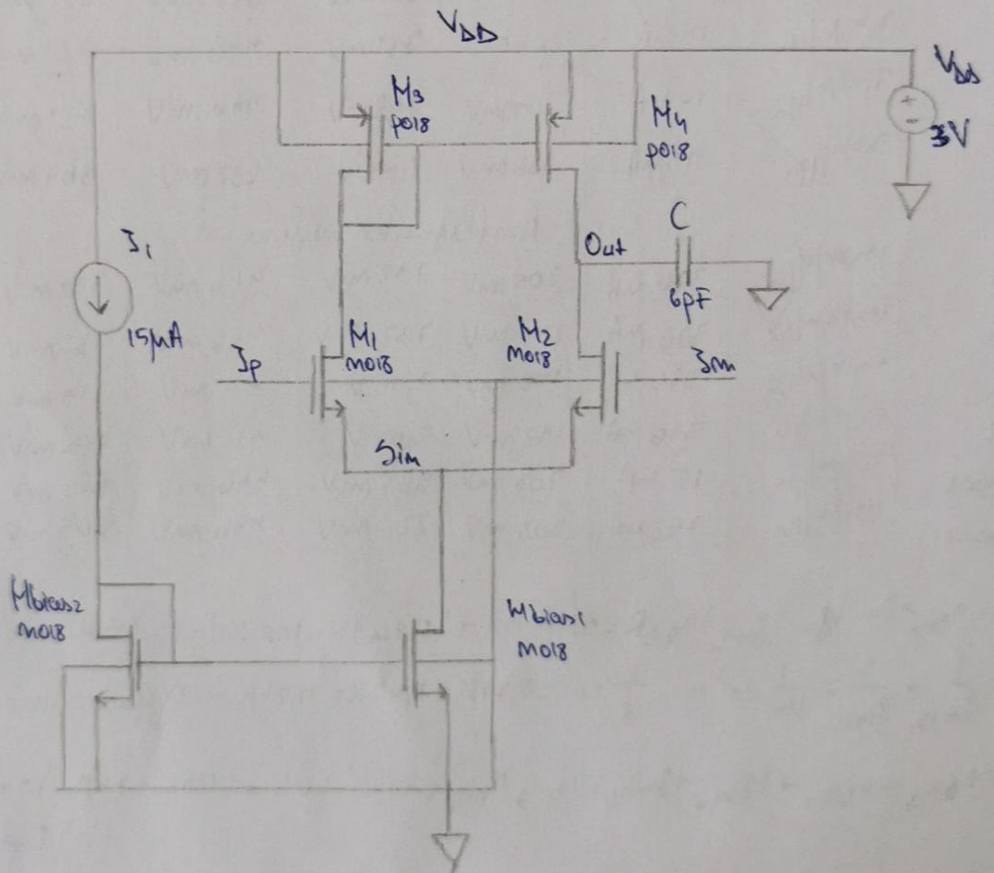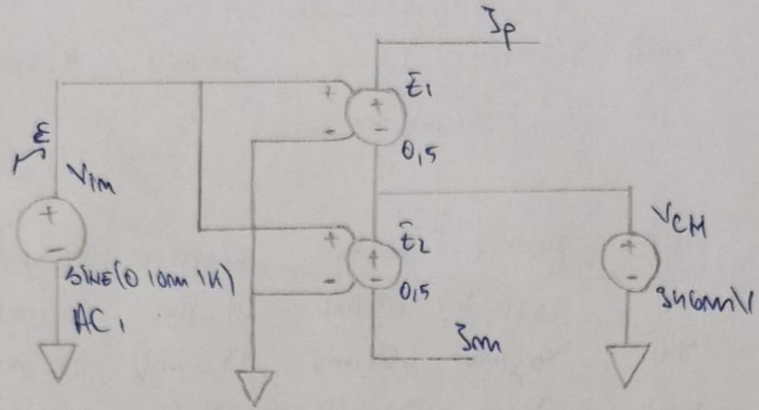
$f_{p_1} = BW = 2,01 MHz$

$f_{p_2} = \dfrac{g_{m_3}}{2\pi C_L} = \dfrac{2,56 \cdot 10^{-3}}{2 \cdot 3,14 \cdot 6 \cdot 10^{-12}} = 0,0679 \cdot 10^9 = 67,9 MHz$

Parametru	Calculat	Măsurat
A_0	31,6dB	31,57dB
f_{pol}	2,01 MHz	1,70 MHz
GBW	76,9 MHz	62,65 MHz

Amplificator diferenţial

Schemă de proiectare a circuitului

- # Error log inainte de ajustare

SPICE Error Log: C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\amplificator\ampdif-sarcsrs.log

Circuit: * C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\amplificator\ampdif-sarcsrs.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                    --- BSIM3 MOSFETS ---
Name: m3   m4   mbias2   m2   mbias1
Model: p018   p018   n018   n018   n018
Id: -3.54e-04   -3.54e-04   1.50e-05   3.54e-04   7.08e-04
Vgs: -7.24e-01   -7.24e-01   6.65e-01   7.13e-01   6.65e-01
Vds: -7.24e-01   -7.24e-01   6.65e-01   2.04e+00   2.33e-01
Vbs: 0.00e+00   0.00e+00   0.00e+00   -2.33e-01   0.00e+00
Vth: -4.46e-01   -4.46e-01   4.46e-01   5.13e-01   4.46e-01
Vdsat: -1.99e-01   -1.99e-01   2.03e-01   1.92e-01   2.03e-01
Gm: 2.50e-03   2.50e-03   1.14e-04   2.82e-03   5.22e-03
Gds: 4.37e-05   4.37e-05   1.38e-06   2.84e-05   3.73e-04
Gmb   6.77e-04   6.77e-04   3.64e-05   8.28e-04   1.67e-03
Cbd: 4.37e-13   4.37e-13   4.30e-15   7.79e-14   2.29e-13
Cbs: 5.81e-13   5.81e-13   5.30e-15   1.15e-13   2.50e-13
Cgsov: 1.00e-13   1.00e-13   1.18e-15   2.95e-14   5.91e-14
Cgdov: 9.90e-14   9.90e-14   1.17e-15   2.61e-14   5.90e-14
Cgbov: 0.00e+00   0.00e+00   0.00e+00   0.00e+00   0.00e+00
dQgdVgb: 1.38e-12   1.38e-12   1.60e-14   3.95e-13   8.17e-13
dQgdVdb: -9.94e-14   -9.94e-14 -1.17e-15   -2.61e-14   -7.52e-14
dQgdVsb: -1.21e-12   -1.21e-12 -1.39e-14   -3.48e-13   -6.98e-13
dQddVgb: -1.01e-13   -1.01e-13 -1.20e-15   -2.61e-14   -9.51e-14
dQddVdb: 5.38e-13   5.38e-13   5.48e-15   1.04e-13   3.28e-13
dQddVsb: 1.40e-15   1.40e-15   2.37e-17   5.50e-17   6.99e-15
dQbdVgb: -2.37e-13   -2.37e-13 -2.29e-15   -5.55e-14   -1.06e-13
dQbdVdb: -4.38e-13   -4.38e-13 -4.30e-15   -7.79e-14   -2.40e-13
dQbdVsb: -6.85e-13   -6.85e-13 -7.43e-15   -1.59e-13   -3.59e-13

Name: m1
Model: n018
Id: 3.54e-04
Vgs: 7.13e-01
Vds: 2.04e+00
Vbs: -2.33e-01
Vth: 5.13e-01
Vdsat: 1.92e-01
Gm: 2.82e-03
Gds: 2.84e-05
Gmb   8.28e-04
Cbd: 7.79e-14
Cbs: 1.15e-13
Cgsov: 2.95e-14
Cgdov: 2.61e-14
Cgbov: 0.00e+00
dQgdVgb: 3.95e-13
dQgdVdb: -2.61e-14
dQgdVsb: -3.48e-13
dQddVgb: -2.61e-14

Name: m1
Model: n018
Id: 3.54e-04
Vgs: 7.13e-01
Vds: 2.04e+00
Vbs: -2.33e-01
Vth: 5.13e-01
Vdsat: 1.92e-01
Gm: 2.82e-03
Gds: 2.84e-05
Gmb   8.28e-04
Cbd: 7.79e-14
Cbs: 1.15e-13
Cgsov: 2.95e-14
Cgdov: 2.61e-14
Cgbov: 0.00e+00
dQgdVgb: 3.95e-13
dQgdVdb: -2.61e-14
dQgdVsb: -3.48e-13
dQddVgb: -2.61e-14
dQddVdb: 1.04e-13
dQddVsb: 5.50e-17
dQbdVgb: -5.55e-14
dQbdVdb: -7.79e-14
dQbdVsb: -1.59e-13

Date: Tue May 10 13:41:43 2022
Total elapsed time: 0.060 seconds.

tnom = 27
temp = 27
method = trap
totiter = 6
traniter = 0
tranpoints = 0
accept = 0
rejected = 0
matrix size = 14
fillins = 0
solver = Normal
Matrix Compiler1: 518 bytes object code size
Matrix Compiler2: 1.03 KB object code size

• Caracteristica de modul si faza
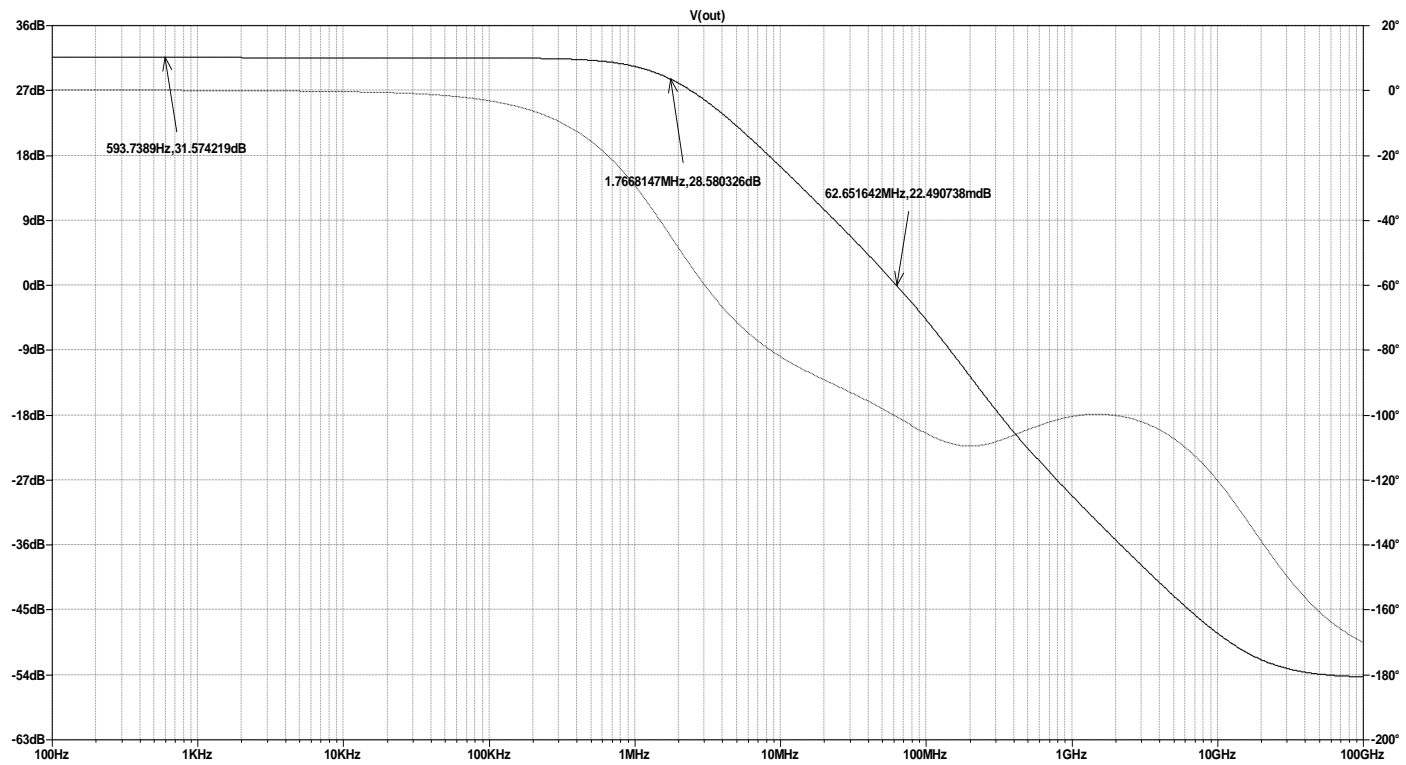
Raport oglinzi de curent

NMOS

- Schema electrica la nivel de transistor a structurii de oglinzi
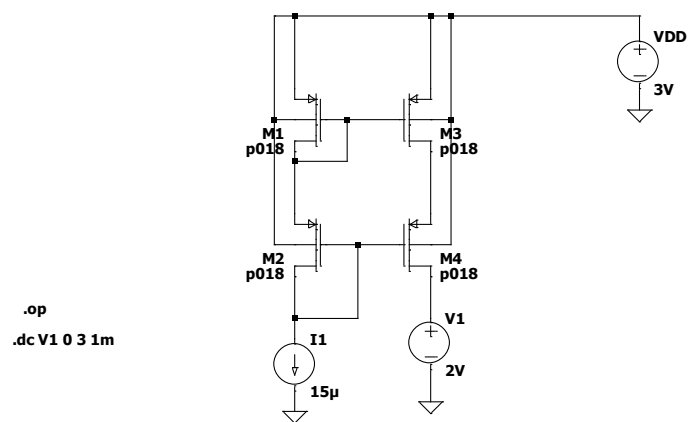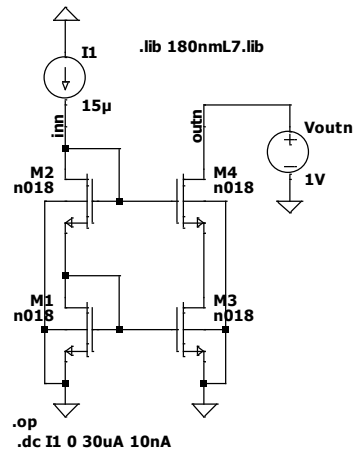
.lib 180nmL7.lib

I1
15µ

M2 n018
M4 n018

Voutn
1V

M1 n018
M3 n018

.op
.dc I1 0 30uA 10nA

VDD
3V

M1 p018
M3 p018

M2 p018
M4 p018

V1
2V

.op
.dc V1 0 3 1m

I1
15µ

- Proiectarea circuitului dupa specificatii(Iin, Iout, Vdsat)

Schema de proiectare a circuitului

I_1

15µA

iin

M_2 MOI8

M_1 MOI8

outm

M_4 MOI8

M_3 MOI8

V_{outm}

1V
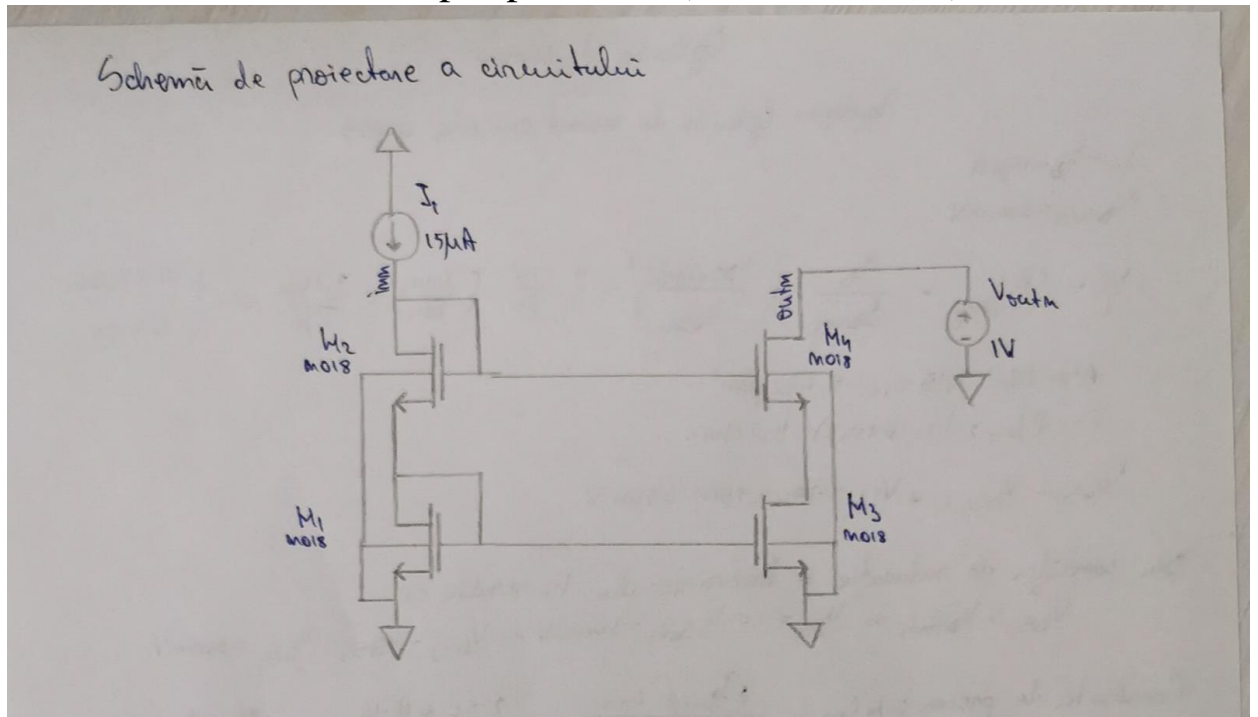
Oglindă de curent

Topologie: Oglindă de curent cascodă NMOS

$I_{in} = I_D = 15\mu A$

$V_{DSat} = 200mV$

$$\frac{W}{L} = \left(\frac{W}{L}\right)_{ref} \cdot \frac{I_D}{I_{Dref}} \cdot \left(\frac{V_{DSat\,ref}}{V_{DSat}}\right)^2 = \frac{5}{1} \cdot \frac{15}{50} \cdot \left(\frac{240}{200}\right)^2 = \frac{2,16\mu}{1\mu} \Rightarrow \begin{cases} W = 2,16\mu \\ L = 1\mu \end{cases}$$

$AS = AD = 2,16 \cdot 0,2 = 0,432\,\mu m^2$

$PS = PD = 2\,(2,16 + 0,2) = 4,72\,\mu m$

$V_{GS_1} = V_{DSat_1} + V_{Th} = 200 + 450 = 650mV$

Din condiția de saturație a tranzistorului M_1 rezultă că:

$V_{DS_1} > V_{DSat_1} \Rightarrow V_{B_3} = 1,5 \cdot V_{DSat_1} = 300mV \Rightarrow V_{DS_3} = V_{GS_1} - V_{B_3} = 350mV$

Constanta de proces: $\mu C_{ox} = \frac{2 \cdot I_{Dref} \cdot L_{ref}}{W_{ref} \cdot V^2_{DSat\,ref}} = \frac{2 \cdot 50\mu A \cdot 1\mu}{5\mu \,(200mV)^2} = \frac{100\mu A}{288\,000 \cdot 10^{-6}V^2} =$

$$= \frac{100\mu A}{0,288V^2} = 347,22\,\frac{\mu A}{V^2}$$

Tranzistor	W/L	I_D	V_{DSat}	V_{DS}	V_{Th}	V_{GS}	g_m	g_{DS}
M_1	$2,16\mu/1\mu$	$15\mu A$	$203mV$	$665mV$	$446mV$	$665mV$	$114\mu S$	$1,38\mu S$
M_2	$2,6\mu/1\mu$	$15\mu A$	$200mV$	$853mV$	$622mV$	$853mV$	$117\mu S$	$1,28\mu S$
M_3	$3,16\mu/1\mu$	$15\mu A$	$203mV$	$660mV$	$446mV$	$665mV$	$114\mu S$	$1,38\mu S$
M_4	$2,72\mu/1\mu$	$15\mu A$	$200mV$	$340mV$	$620mV$	$858mV$	$119\mu S$	$2,06\mu S$

Ajustări:

- pentru $M_2 \Rightarrow W = 2,6\mu$

    $AS = AD = 0,52\,\mu m^2$

    $PS = PD = 5,6\,\mu m$

- pentru $M_4 \Rightarrow W = 2,72\mu$

    $AS = AD = 0,54\,\mu m^2$

    $PS = PD = 5,84\,\mu m$

$R_{in} = \frac{1}{g_{m_1}} + \frac{1}{g_{m_2}} = \frac{1}{114} \cdot 10^6 + \frac{1}{117} \cdot 10^6 = 17,1\,K\Omega \rightarrow$ Calculat

$R_{in} = \frac{1}{Slope} = \frac{1}{52} \cdot 10^6 = 0,0192 \cdot 10^6 = 19,2\,K\Omega \rightarrow$ Măsurat

- Error log inainte de ajustare

```
Circuit: * C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\oglinda\ogl-cascodaLV-MOS.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                    --- BSIM3 MOSFETS ---
Name:        m1          m3          m2          m4
Model:       n018        n018        n018        n018
Id:          1.50e-05    1.50e-05    1.50e-05    1.50e-05
Vgs:         6.65e-01    6.65e-01    8.53e-01    8.58e-01
Vds:         6.65e-01    6.60e-01    8.53e-01    3.40e-01
Vbs:         0.00e+00    0.00e+00   -6.65e-01   -6.60e-01
Vth:         4.46e-01    4.46e-01    6.22e-01    6.20e-01
Vdsat:       2.03e-01    2.03e-01    2.18e-01    2.23e-01
Gm:          1.14e-04    1.14e-04    1.07e-04    1.05e-04
Gds:         1.38e-06    1.38e-06    1.23e-06    2.22e-06
Gmb          3.64e-05    3.64e-05    2.80e-05    2.74e-05
Cbd:         4.30e-15    4.31e-15    3.66e-15    4.00e-15
Cbs:         5.30e-15    5.30e-15    4.30e-15    4.31e-15
Cgsov:       1.18e-15    1.18e-15    1.18e-15    1.18e-15
Cgdov:       1.17e-15    1.17e-15    1.17e-15    1.18e-15
Cgbov:       0.00e+00    0.00e+00    0.00e+00    0.00e+00
dQgdVgb:     1.60e-14    1.60e-14    1.58e-14    1.59e-14
dQgdVdb:    -1.17e-15   -1.17e-15   -1.17e-15   -1.28e-15
dQgdVsb:    -1.39e-14   -1.39e-14   -1.39e-14   -1.40e-14
dQddVgb:    -1.20e-15   -1.20e-15   -1.18e-15   -1.43e-15
dQddVdb:     5.48e-15    5.49e-15    4.83e-15    5.41e-15
dQddVsb:     2.37e-17    2.41e-17    1.33e-17    8.26e-17
dQbdVgb:    -2.29e-15   -2.29e-15   -2.13e-15   -2.07e-15
dQbdVdb:    -4.30e-15   -4.31e-15   -3.66e-15   -4.06e-15
dQbdVsb:    -7.43e-15   -7.43e-15   -5.57e-15   -5.60e-15



Date: Sun May 08 15:09:03 2022
Total elapsed time: 0.059 seconds.

tnom = 27
temp = 27
method = trap
totiter = 6
traniter = 0
tranpoints = 0
accept = 0
rejected = 0
matrix size = 5
fillins = 0
solver = Normal
Matrix Compiler1: 248 bytes object code size
Matrix Compiler2: 389 bytes object code size
```
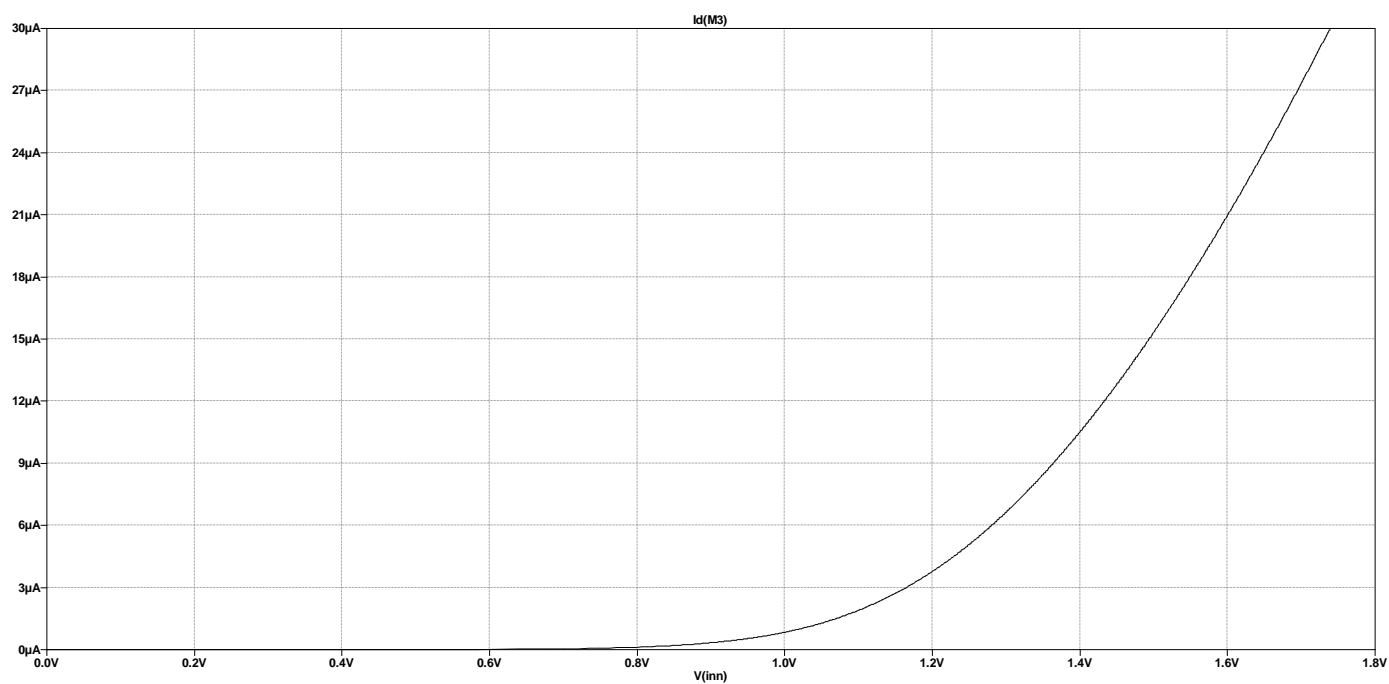
- Caracteristica de intrare

PMOS

- Proiectarea circuitului dupa specificatii(Iin, Iout, Vdsat)

Oglindă de curent

Topologie: Oglindă de curent cascodă PMOS

$I_{in} = I_{\emptyset} = 15 \mu A$

$V_{DSat} = 200 mV$

$$\frac{W}{L} = \left(\frac{W}{L}\right)_{ref} \cdot \frac{I_{\emptyset}}{I_{\emptyset ref}} \cdot \left(\frac{V_{DSat\,ref}}{V_{DSat}}\right)^2 = \frac{15}{1} \cdot \frac{15}{50} \left(\frac{257}{200}\right)^2 = \frac{7,42\mu}{1\mu}$$

$AS = AD = 1,48 pm^2$

$PS = PD = 15,24 \mu m$

$V_{GS_1} = V_{DSat_1} + V_{Th} = 200 + 450 = 650 mV$

Din condiția de saturație a tranzistorului M_1 rezultă că:

$$V_{DS_1} > V_{DSat_1} \Rightarrow V_{DS_1} = 1,5 \cdot V_{DSat_1} = 300 mV \Rightarrow V_{DS_3} = V_{GS_1} - V_{DS_3} = 350 mV$$

Constanta de proces: $\mu C_{ov} = \dfrac{2 I_{\emptyset ref} \cdot L_{ref}}{W_{ref} \cdot V_{DSat\,ref}^2} = \dfrac{2 \cdot 50\mu A \cdot 1\mu}{15\mu \, (257mV)^2} = \dfrac{100\mu A}{930735 \cdot 10^{-6} V^2} =$

$$= \frac{100\mu A}{0,93 V^2} = 101 \mu A/V^2$$

Tranzistor	W/L	$I_{\emptyset}$	V_{DSat}	V_{DS}	V_{Th}	V_{GS}	g_m	g_{DS}
M_1	$7,42\mu/1\mu$	$15\mu A$	$204 mV$	$731 mV$	$446 mV$	$731 mV$	$103\mu S$	$1,84 \mu S$
M_2	$7,42\mu/1\mu$	$15\mu A$	$200 mV$	$881 mV$	$628 mV$	$881 mV$	$113\mu S$	$1,72 \mu S$
M_3	$7,42\mu/1\mu$	$15\mu A$	$204 mV$	$731 mV$	$446 mV$	$731 mV$	$103\mu S$	$1,84 \mu S$
M_4	$7,42\mu/1\mu$	$15\mu A$	$200 mV$	$283 mV$	$628 mV$	$881 mV$	$113\mu S$	$4,58 \mu S$

Ajustări:

- pentru $M_2 \rightarrow W = 8,8\mu$

  $AS = AD = 1,76 pm^2$

  $PS = PD = 18 \mu m$

- pentru $M_4 \rightarrow W = 8,6\mu$

  $AS = AD = 1,92 pm^2$

  $PS = PD = 19,6 \mu m$

$R_{out} = r_{DS_3} + r_{DS_4} + (g_{m_4} + g_{m b_4}) \, r_{DS_3} \, r_{DS_4} = 543K + 218K + (113\mu + 24,5\mu) \, 543K \cdot 218K = 16,3 M\Omega \rightarrow calculat$

$R_{out} = \frac{1}{slope} = \frac{1}{63 \cdot 10^{-9}} = 15,8 M\Omega$

Schema de proiectare a circuitului
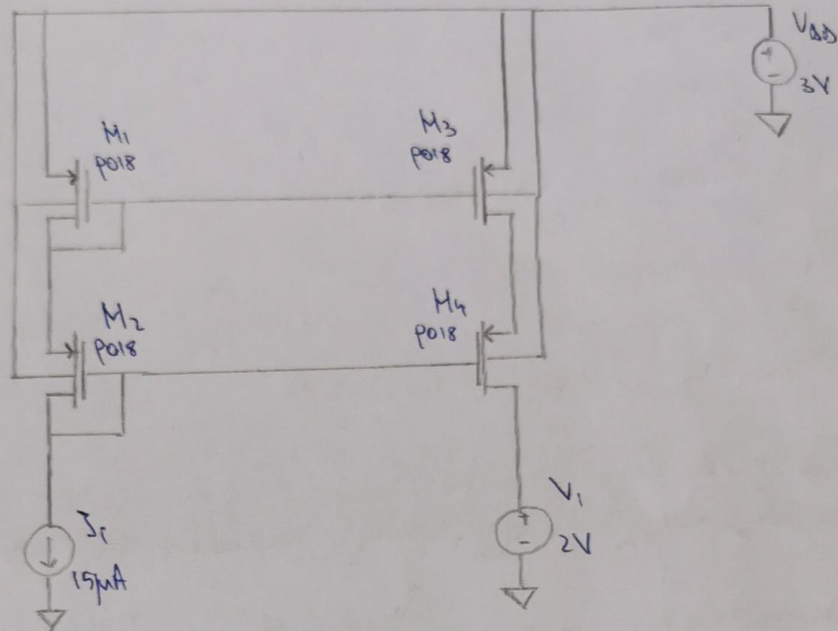
- Error log inainte de ajustare

SPICE Error Log: C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\oglinda\de tip p\ogl-cascodaP-MOS.log

Circuit: * C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\oglinda\de tip p\ogl-cascodaP-MOS.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
--- BSIM3 MOSFETS ---

Name:	m1	m2	m4	m3
Model:	p018	p018	p018	p018
Id:	-1.50e-05	-1.50e-05	-1.50e-05	-1.50e-05
Vgs:	-7.31e-01	-9.04e-01	-9.15e-01	-7.31e-01
Vds:	-7.31e-01	-9.04e-01	-2.80e-01	-7.20e-01
Vbs:	0.00e+00	7.31e-01	7.20e-01	0.00e+00
Vth:	-4.46e-01	-6.28e-01	-6.26e-01	-4.46e-01
Vdsat:	-2.04e-01	-2.16e-01	-2.25e-01	-2.04e-01
Gm:	1.03e-04	1.02e-04	9.58e-05	1.03e-04
Gds:	1.84e-06	1.68e-06	5.25e-06	1.84e-06
Gmb:	2.79e-05	2.24e-05	2.10e-05	2.78e-05
Cbd:	1.80e-14	1.46e-14	1.68e-14	1.81e-14
Cbs:	2.40e-14	1.80e-14	1.81e-14	2.40e-14
Cgsov:	4.04e-15	4.04e-15	4.04e-15	4.04e-15
Cgdov:	4.00e-15	4.00e-15	4.00e-15	4.00e-15
Cgbov:	0.00e+00	0.00e+00	0.00e+00	0.00e+00
dQgdVgb:	5.56e-14	5.46e-14	5.53e-14	5.56e-14
dQgdVdb:	-4.01e-15	-4.00e-15	-4.89e-15	-4.02e-15
dQgdVsb:	-4.90e-14	-4.84e-14	-4.83e-14	-4.90e-14
dQddVgb:	-4.08e-15	-4.05e-15	-5.92e-15	-4.09e-15
dQddVdb:	2.21e-14	1.87e-14	2.31e-14	2.21e-14
dQddVsb:	5.55e-17	3.56e-17	-3.75e-17	5.70e-17
dQbdVgb:	-9.55e-15	-8.61e-15	-8.07e-15	-9.55e-15
dQbdVdb:	-1.80e-14	-1.46e-14	-1.75e-14	-1.81e-14
dQbdVsb:	-2.82e-14	-1.99e-14	-2.00e-14	-2.82e-14

Date: Sun May 08 18:01:10 2022
Total elapsed time: 0.048 seconds.

tnom = 27
temp = 27
method = trap
totiter = 7
traniter = 0
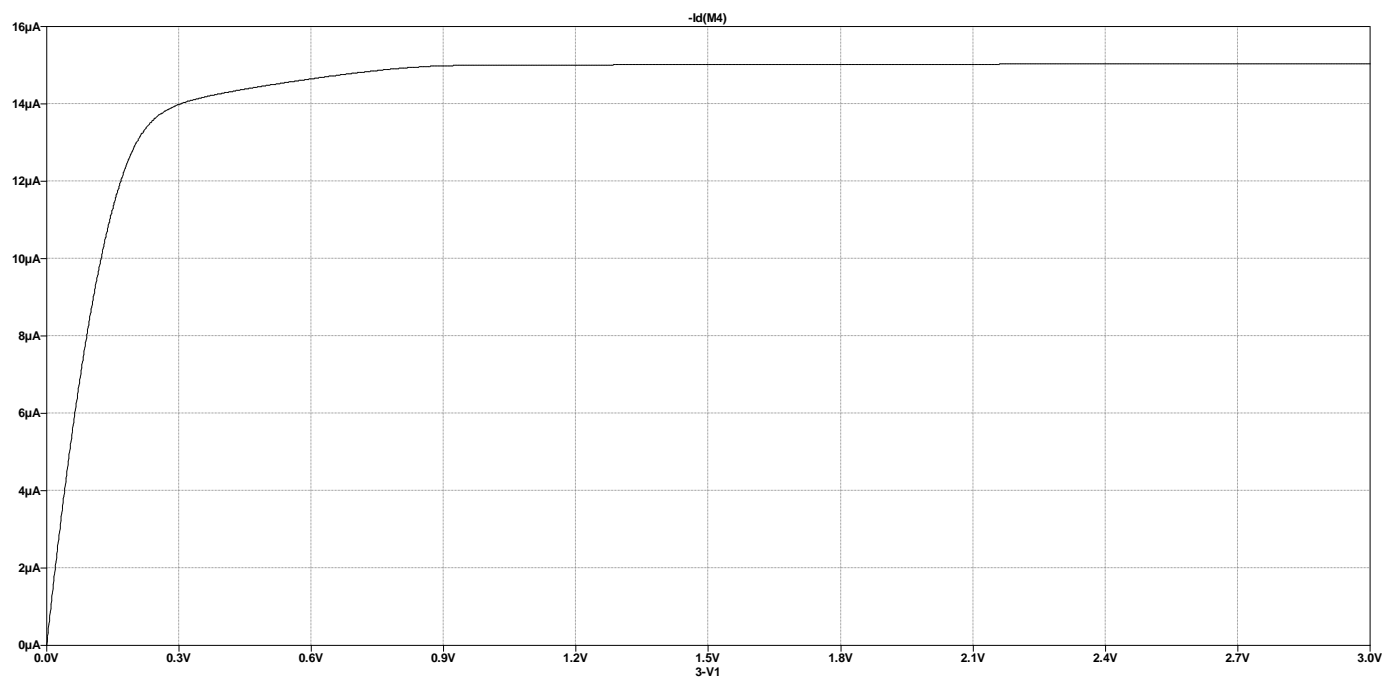tranpoints = 0
accept = 0
rejected = 0
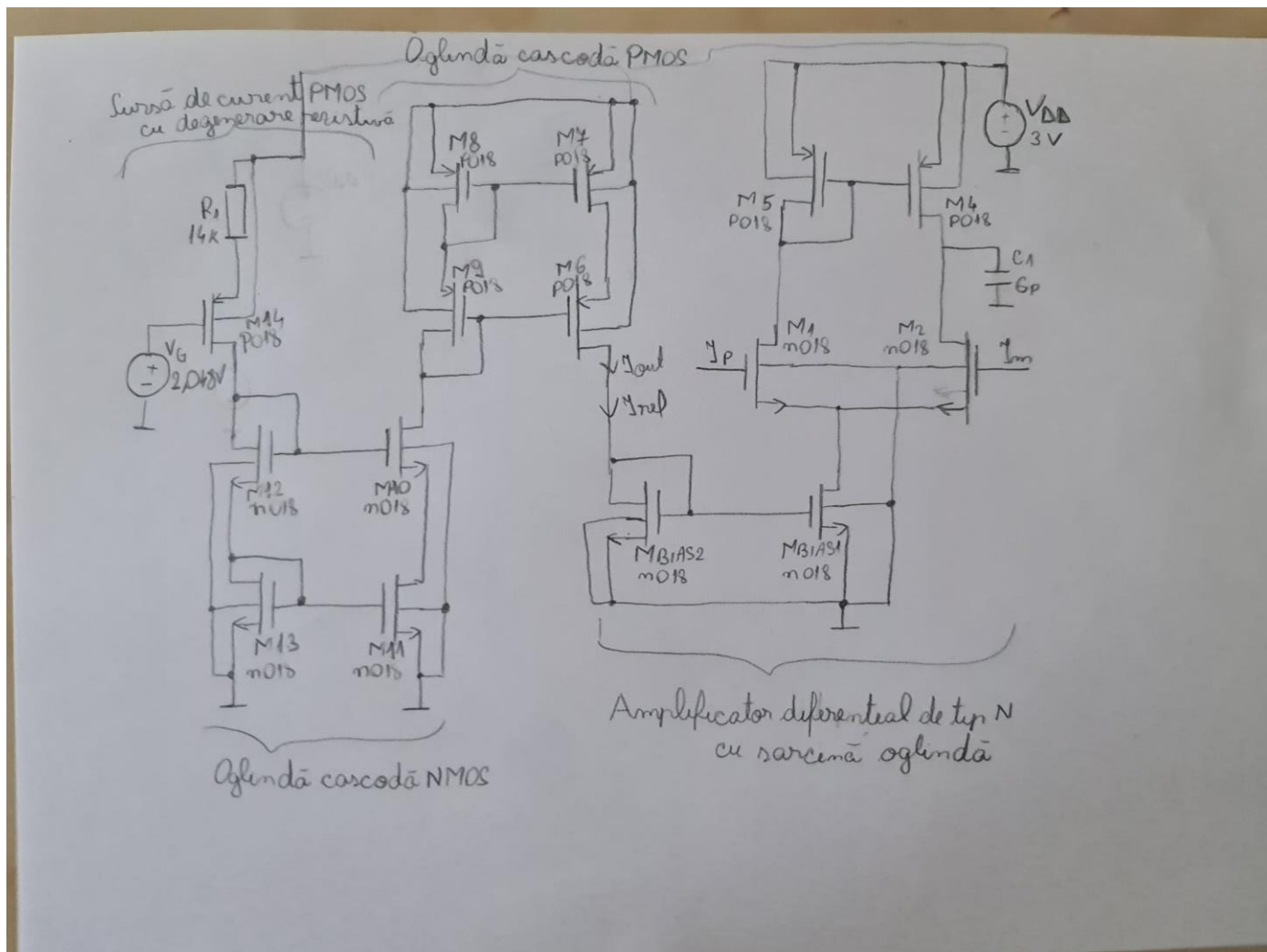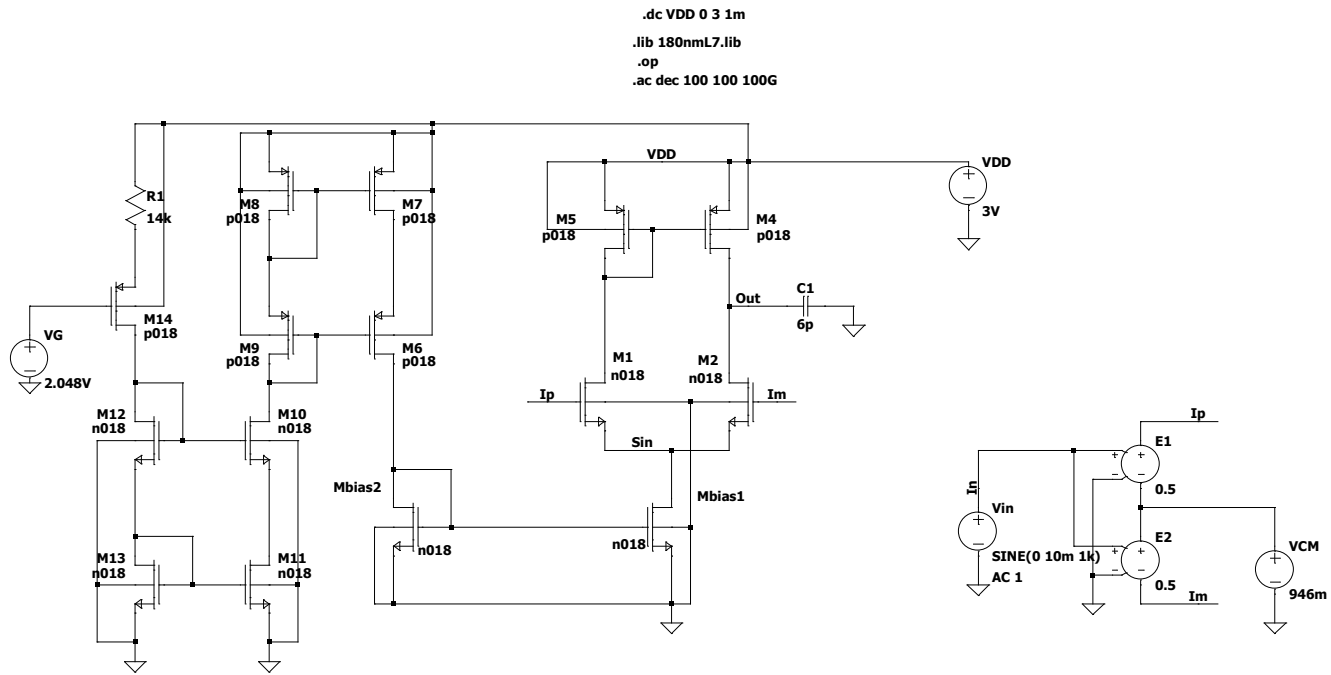matrix size = 7
fillins = 0
solver = Normal
Matrix Compiler1: 348 bytes object code size
Matrix Compiler2: 623 bytes object code size

- Caracteristica de iesire

Raport circuit final

.dc VDD 0 3 1m

.lib 180nmL7.lib
.op
.ac dec 100 100 100G

- Error log inainte de ajustare

SPICE Error Log: C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\Toate\Proiect_final.log

```
Circuit: * C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\Toate\Proiect_final.asc

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                     --- BSIM3 MOSFETS ---
Name:        m14        m9         m8         m7         m6
Model:       p018       p018       p018       p018       p018
Id:         -1.43e-05  -1.43e-05  -1.43e-05  -1.43e-05  -1.43e-05
Vgs:        -7.52e-01  -8.73e-01  -7.24e-01  -7.24e-01  -8.56e-01
Vds:        -1.32e+00  -8.73e-01  -7.24e-01  -7.40e-01  -1.60e+00
Vbs:         2.00e-01   7.24e-01   0.00e+00   0.00e+00   7.40e-01
Vth:        -5.01e-01  -6.27e-01  -4.46e-01  -4.46e-01  -6.30e-01
Vdsat:      -1.88e-01  -1.96e-01  -1.99e-01  -1.99e-01  -1.81e-01
Gm:          1.11e-04   1.11e-04   1.01e-04   1.01e-04   1.22e-04
Gds:         1.62e-06   1.65e-06   1.76e-06   1.76e-06   1.53e-06
Gmb:         2.81e-05   2.42e-05   2.73e-05   2.74e-05   2.64e-05
Cbd:         1.12e-14   1.74e-14   1.81e-14   1.80e-14   1.68e-14
Cbs:         1.63e-14   2.13e-14   2.40e-14   2.40e-14   2.31e-14
Cgsov:       4.48e-15   4.79e-15   4.04e-15   4.04e-15   5.23e-15
Cgdov:       4.16e-15   4.74e-15   4.00e-15   3.99e-15   4.78e-15
Cgbov:       0.00e+00   0.00e+00   0.00e+00   0.00e+00   0.00e+00
dQgdVgb:     6.10e-14   6.48e-14   5.56e-14   5.56e-14   7.02e-14
dQgdVdb:    -4.16e-15  -4.75e-15  -4.01e-15  -4.01e-15  -4.78e-15
dQgdVsb:    -5.40e-14  -5.73e-14  -4.90e-14  -4.90e-14  -6.25e-14
dQddVgb:    -4.18e-15  -4.80e-15  -4.08e-15  -4.07e-15  -4.80e-15
dQddVdb:     1.54e-14   2.22e-14   2.21e-14   2.20e-14   2.16e-14
dQddVsb:     1.89e-17   4.49e-17   5.66e-17   5.42e-17   1.44e-17
dQbdVgb:    -1.02e-14  -1.02e-14  -9.55e-15  -9.56e-15  -1.12e-14
dQbdVdb:    -1.12e-14  -1.74e-14  -1.81e-14  -1.80e-14  -1.68e-14
dQbdVsb:    -2.01e-14  -2.37e-14  -2.82e-14  -2.82e-14  -2.56e-14

Name:        m5         m4         m13        m12        m11
Model:       p018       p018       n018       n018       n018
Id:         -3.60e-04  -3.60e-04   1.43e-05   1.43e-05   1.43e-05
Vgs:        -7.26e-01  -7.26e-01   6.58e-01   8.21e-01   6.58e-01
Vds:        -7.26e-01  -7.26e-01   6.58e-01   8.21e-01   6.62e-01
Vbs:         0.00e+00   0.00e+00   0.00e+00  -6.58e-01   0.00e+00
Vth:        -4.46e-01  -4.46e-01   4.46e-01   6.20e-01   4.46e-01
Vdsat:      -2.01e-01  -2.01e-01   1.98e-01   1.95e-01   1.98e-01
Gm:          2.51e-03   2.51e-03   1.11e-04   1.16e-04   1.11e-04
Gds:         4.43e-05   4.43e-05   1.32e-06   1.23e-06   1.32e-06
Gmb:         6.82e-04   6.82e-04   3.54e-05   2.99e-05   3.55e-05
Cbd:         4.37e-13   4.37e-13   4.31e-15   4.39e-15   4.30e-15
Cbs:         5.81e-13   5.81e-13   5.30e-15   5.14e-15   5.30e-15
Cgsov:       1.00e-13   1.00e-13   1.18e-15   1.42e-15   1.18e-15
Cgdov:       9.90e-14   9.90e-14   1.17e-15   1.40e-15   1.17e-15
Cgbov:       0.00e+00   0.00e+00   0.00e+00   0.00e+00   0.00e+00
dQgdVgb:     1.38e-12   1.38e-12   1.60e-14   1.90e-14   1.60e-14
dQgdVdb:    -9.94e-14  -9.94e-14  -1.17e-15  -1.41e-15  -1.17e-15
dQgdVsb:    -1.21e-12  -1.21e-12  -1.39e-14  -1.67e-14  -1.39e-14
dQddVgb:    -1.01e-13  -1.01e-13  -1.20e-15  -1.42e-15  -1.20e-15
dQddVdb:     5.37e-13   5.37e-13   5.49e-15   5.80e-15   5.48e-15
```

SPICE Error Log: C:\Users\ASUS\OneDrive\Desktop\cia\Proiect_noi\Toate\Proiect_final.log

```
dQddVgb:    -1.01e-13  -1.01e-13  -1.20e-15  -1.42e-15  -1.20e-15
dQddVdb:     5.37e-13   5.37e-13   5.49e-15   5.80e-15   5.48e-15
dQddVsb:     1.39e-15   1.39e-15   2.40e-17   1.69e-17   2.37e-17
dQbdVgb:    -2.37e-13  -2.37e-13  -2.29e-15  -2.56e-15  -2.29e-15
dQbdVdb:    -4.37e-13  -4.37e-13  -4.31e-15  -4.39e-15  -4.31e-15
dQbdVsb:    -6.85e-13  -6.85e-13  -7.43e-15  -6.67e-15  -7.43e-15

Name:        m10        mbias2     m2         mbias1     m1
Model:       n018       n018       n018       n018       n018
Id:          1.43e-05   1.43e-05   3.60e-04   7.20e-04   3.60e-04
Vgs:         8.17e-01   6.59e-01   7.15e-01   6.59e-01   7.15e-01
Vds:         7.41e-01   6.59e-01   2.04e+00   2.31e-01   2.04e+00
Vbs:        -6.62e-01   0.00e+00  -2.31e-01   0.00e+00  -2.31e-01
Vth:         6.21e-01   4.46e-01   5.12e-01   4.46e-01   5.12e-01
Vdsat:       1.92e-01   1.98e-01   1.94e-01   1.98e-01   1.94e-01
Gm:          1.18e-04   1.11e-04   2.84e-03   5.46e-03   2.84e-03
Gds:         1.25e-06   1.33e-06   2.88e-05   3.66e-04   2.88e-05
Gmb:         3.04e-05   3.55e-05   8.36e-04   1.75e-03   8.36e-04
Cbd:         4.62e-15   4.31e-15   7.79e-14   1.70e-07   7.79e-14
Cbs:         5.35e-15   5.30e-15   1.15e-13   2.67e-13   1.15e-13
Cgsov:       1.48e-15   1.18e-15   2.95e-14   6.30e-14   2.95e-14
Cgdov:       1.47e-15   1.17e-15   2.61e-14   6.30e-14   2.61e-14
Cgbov:       0.00e+00   0.00e+00   0.00e+00   0.00e+00   0.00e+00
dQgdVgb:     1.99e-14   1.60e-14   3.95e-13   8.70e-13   3.95e-13
dQgdVdb:    -1.48e-15  -1.17e-15  -2.61e-14  -7.94e-14  -2.61e-14
dQgdVsb:    -1.75e-14  -1.39e-14  -3.48e-13  -7.45e-13  -3.48e-13
dQddVgb:    -1.50e-15  -1.20e-15  -2.61e-14  -1.00e-13  -2.61e-14
dQddVdb:     6.11e-15   5.49e-15   1.04e-13   1.70e-07   1.04e-13
dQddVsb:     2.18e-17   2.40e-17   5.51e-17   7.80e-15   5.51e-17
dQbdVgb:    -2.68e-15  -2.29e-15  -5.55e-14  -1.13e-13  -5.55e-14
dQbdVdb:    -4.63e-15  -4.31e-15  -7.79e-14  -1.70e-07  -7.79e-14
dQbdVsb:    -6.95e-15  -7.43e-15  -1.59e-13  -3.83e-13  -1.59e-13


Date: Tue May 10 19:10:54 2022
Total elapsed time: 0.044 seconds.

tnom = 27
temp = 27
method = trap
totiter = 8
traniter = 0
tranpoints = 0
accept = 0
rejected = 0
matrix size = 23
fillins = 0
solver = Normal
Matrix Compiler1: 1.36 KB object code size
Matrix Compiler2: 2.06 KB object code size
```

- Tabel cu parametrii

Tranzistor	W/L	I_D	V_{Dsat}	V_{DS}	V_{Th}	V_{GS}	g_m	g_{DS}
				Sursa de curent				
M14	3,6μ/1μ	15μA	180mV	1,30V	504mV	742mV	124μS	1,72μS
				Oglinzi de curent				
M12	2,6μ/1μ	15μA	200mV	823mV	622mV	823mV	118μS	1,28μS
M13	3,16μ/1μ	15μA	203mV	665mV	446mV	665mV	114μS	1,33μS
M11	3,16μ/1μ	15μA	203mV	668mV	446mV	665mV	114μS	1,37μS
M10	2,72μ/1μ	15μA	197mV	720mV	622mV	825mV	121μS	1,31μS
M9	8,8μ/1μ	15μA	200mV	881mV	628mV	881mV	163μS	1,72μS
M8	7,42μ/1μ	15μA	204mV	731mV	446mV	731mV	103μS	1,84μS
M7	7,42μ/1μ	15μA	204mV	748mV	446mV	731mV	103μS	1,83μS
M6	3,5μ/1μ	15μA	186mV	1,53V	632mV	864mV	124μS	1,61μS
				Amplificator diferențial				
M5	183,86μ/1μ	376μA	205mV	732mV	446mV	732mV	2,56mS	46μS
M4	183,86μ/1μ	376μA	205mV	732mV	446mV	732mV	2,56mS	46μS
M1	54,14μ/1μ	376μA	138mV	2,04V	511mV	719mV	2,30mS	23,3μS
M2	54,14μ/1μ	376μA	138mV	2,04V	511mV	719mV	2,30mS	23,3μS
M_Bias2	3,16μ/1μ	15μA	203mV	665mV	446mV	665mV	114μS	1,38μS
M_Bias1	115,3μ/1μ	752μA	203mV	227mV	446mV	665mV	5,52mS	443μS

$R_{out} = r_{DS} + R + (g_m + g_{mb})r_{DS}R = 581K + 14K + (124μ+31μ)581K·14K = 1,85MΩ$ → Sursă de curent

$R_{in} = \frac{1}{g_{m13}} + \frac{1}{g_{m12}} = \frac{1}{114}·10^6 + \frac{1}{118}·10^6 = 8,77K + 8,47K = 17,24K$ → Oglindă NMOS

$R_{out} = r_{DS7} + r_{DS6} + (g_{m6} + g_{mb6})r_{DS7}r_{DS6} = 546K + 621K + (124μ+26,3μ)546K·621K = 52,26MΩ$
→ Oglindă PMOS

$A_0 = g_{m1}(r_{DS2} || r_{DS4}) = 38,13$ → 31,6dB
GBW = 76,5MHz
BW = 2,01MHz
$f_{p1} = 2,01MHz$
$f_{p2} = 67,5MHz$
→ Amplificator

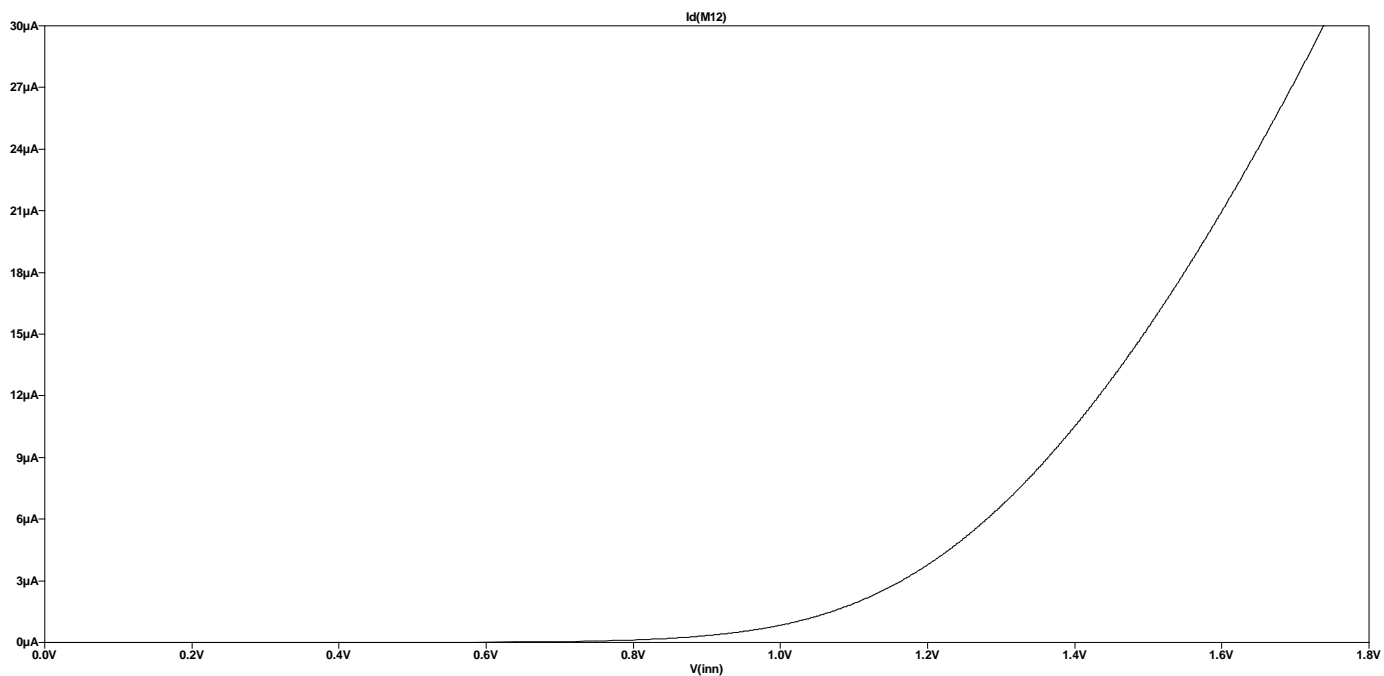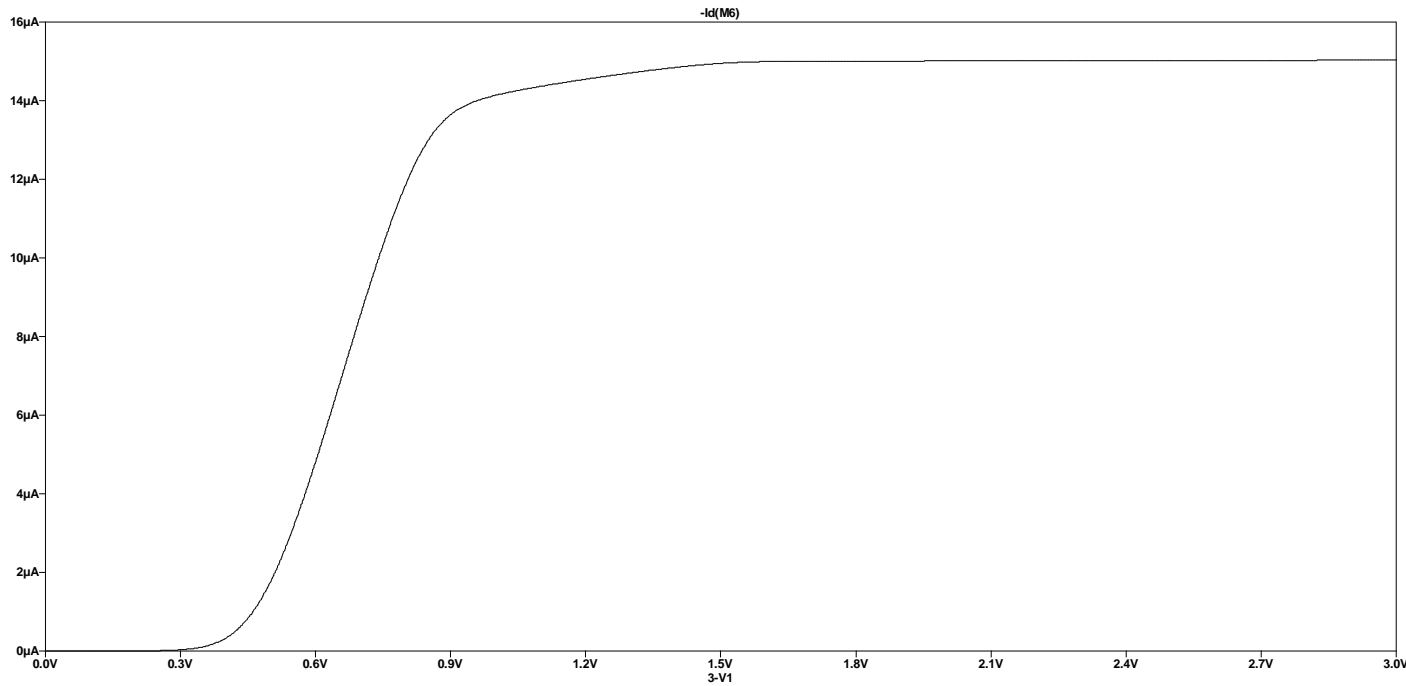| Parametru	Calculat	Măsurat
	Sursa de curent	
Routs	1,85MΩ	1,13MΩ
	Oglinzi de curent	
Rino	17,24KΩ	13,6KΩ
Routo	52,26MΩ	42,5MΩ
	Amplificator diferențial	
A0	31,6dB	31,75dB
fpol	2,01MHz	1,73MHz
GBW	76,5MHz	61,28MHz

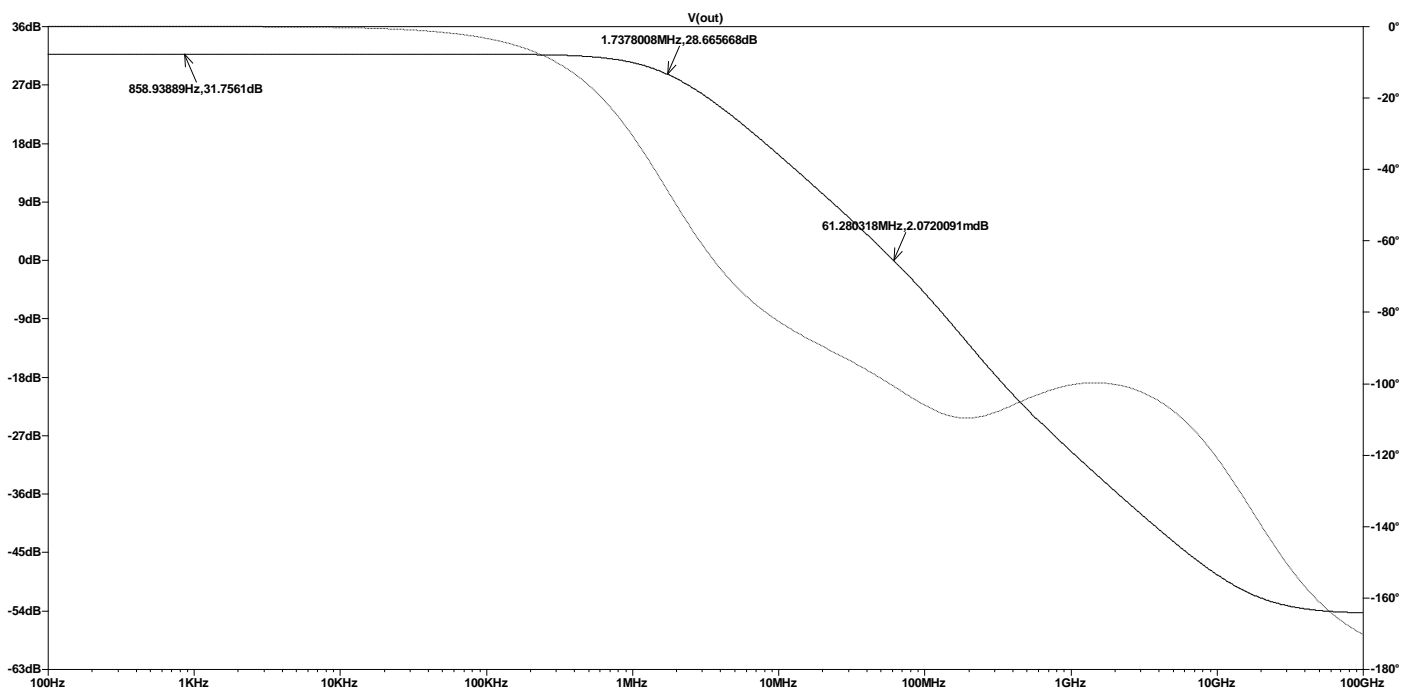## • Caracteristica de iesire a sursei de current

-Id(M14)
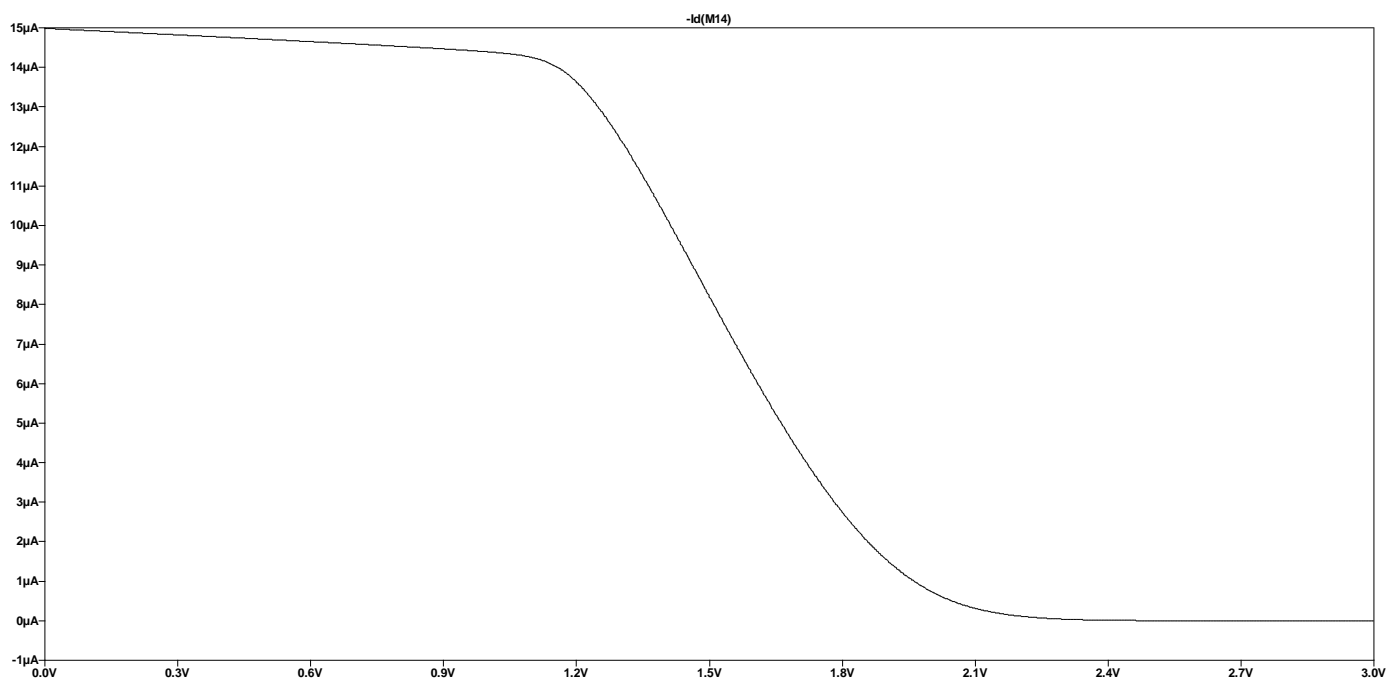
• Caracteristica de intrare a oglinzii de current

Id(M12)

- **Caracteristica de iesire a oglinzii de current**

-Id(M6)

- **Caracteristica de modul si faza**

V(out)

858.93889Hz,31.7561dB

1.7378008MHz,28.665668dB

61.280318MHz,2.0720091mdB

- Raspuns in timp al circuitului final