Analog Circuits, Sensor Readout and Conversion

Design of a 2-stage OPAMP

Design bias voltages, currents and W/L values of the 2-stage OPAMP depicted in Fig. 1 in order to satisfy the provided specifications.

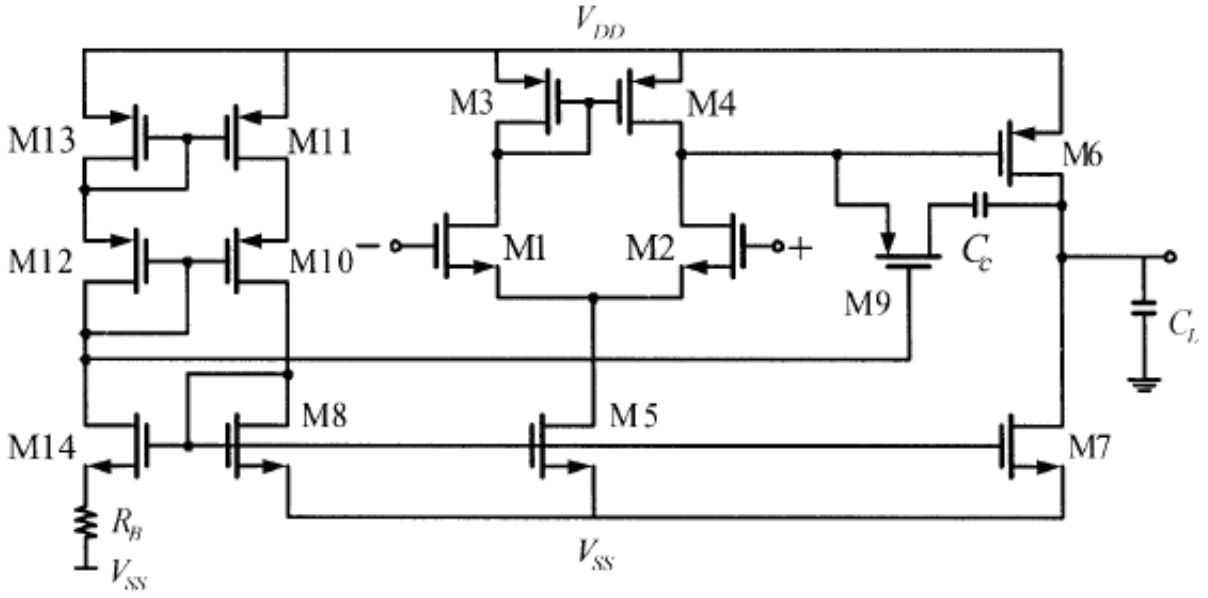

Figure 1: Op-Amp CMOS 2 stadi

- Use the following MOSFET models:

```
.model NMOD1CAP  NMOS  LEVEL=1
+ vto = 0.71     gamma = 0.01
+ phi = 0.6     kp= 182e-6
+ lambda = 0.01
+ tox = 9.6e-9
+ cj = 350e-6 cjsw = 120e-12
+ pb = 0.8 mj=0.33 mjsw = 0.33
+ cgso = 0.046e-9 cgdo = 0.046e-9
```

```
.model PMOD1CAP  PMOS  LEVEL=1
+ vto = -0.901    gamma = 0.01
+ phi = 0.6      kp= 41.5e-6
+ lambda = 0.01
+ tox = 9.6e-9
+ cj = 350e-6 cjsw = 120e-12
+ pb = 0.8 mj=0.33 mjsw = 0.33
+ cgso = 0.046e-9 cgdo = 0.046e-9
```

- **SPECS**

V_{DD}/V_{SS}	2.5/-2.5 V
Slew Rate	$+5$/-5 V/μs
Load Capacitor C_L	5pF
max Vin Common Mode	2.1V
min Vin Common Mode	-1.3V
max Vout	2.2V
min Vout	-2.2V
Gain Bandwidth	5MHz
Differential Gain	$>$80dB
Phase Margin	$>60^{\circ}$

- The specification related to Noise is student-dependent. Find the value of the input-referred noise voltage ($Sn(f)$) specification by looking at the following table, where N is the last digit of the student badge number
  E.g. Mr. James Bond (badge number 007) will select $\sqrt{Sn(f)} = \sqrt{\overline{v_{iN}^2}/\Delta f} < 36$ nV/$\sqrt{Hz}$.

- **Noise**

N	0	1	2	3	4
$\sqrt{Sn(f)}$ [nV/$\sqrt{Hz}$]	22	24	26	28	30
N	5	6	7	8	9
$\sqrt{Sn(f)}$ [nV/$\sqrt{Hz}$]	32	34	36	38	40

- in addition, try to minimize power consumption.

Additional instructions and report template

- The report should be prepared with the following template:
  1. Page 1: Name, badge number, related specs, circuit schematic and table with with the transistors' sizing defined in the design process by the student.
  2. Pages 2 and 3: description of the design procedure.
  3. Page 4 and following: SPICE plots (Bode plots, transient analysis, etc. . .).
  4. Last page: table which compares the requested specs with the achieved circuit performance.
- Drop an email to: "l.demarchi@unibo.it" attaching the report (pdf), and all the SPICE files (schematics, netlists, libraries) which have been used in the simulations.
- The project task should be done autonomously.
- The project report should be delivered to the instructor one week before the scheduled oral examination.