LAB REPORT-5

MOS differential amplifier

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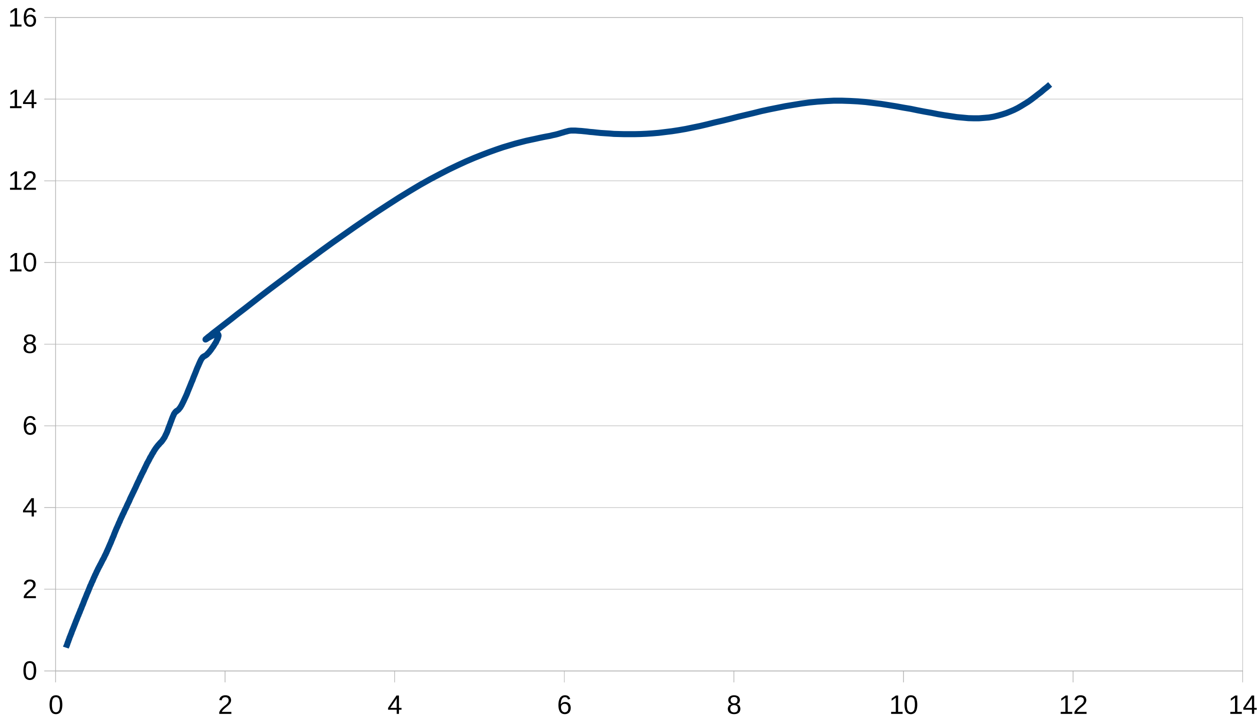
NMOS current mirror

Q4. I_{DS} for different values of V_{DS}:

NMOS current mirror

V_{ds}	I_{ds}
0.122	0.57
0.2	1
0.3	1.52
0.4	2.03
0.5	2.49
0.6	2.9
0.7	3.39
0.8	3.86
1	4.74
1.1	5.16
1.2	5.5
1.3	5.78
1.4	6.3
1.5	6.56
1.7	7.55
1.8	7.78
1.9	8.25
2	8.5
4.3	11.9
5.83	13.1
6.2	13.22
7.35	13.24
9.18	13.96
10.83	13.53
11.73	14.36



For smaller values of V_{DS}, the MOSFET will be in triode region, whereas as V_{DS} increases, I_{DS} begins to saturate and operates in saturation region.

Q5.The output impedance of the current mirror is simply found from the slope of I_{DS} vs V_{DS} in the saturation region.

$$\mathbf{R_o} = \frac{1}{Slope} = \frac{7.35-6.2}{13.24-13.22} \times 10^{3} = \mathbf{57.5\ k\Omega}$$

We know that, channel length modulation parameter (ƛ) and R_o are related by

$$\mathbf{R_o = 1/(\lambda \times I_{DS})}$$

Here, I_{DS} is the saturated value of current in the absence of channel length modulation, which from the plot is 13.56 mA.

So, channel length modulation parameter (ƛ) will be,

$$\lambda = \frac{1}{(Ro * Ids)} = \frac{1}{57.5\, k\Omega\, x\, 13.56\, mA} = \mathbf{0.0128\ V^{-1}}$$

CMOS differential amplifier

Q2.Values of R_1 and C_i for a lower cut-off frequency <30 Hz are:

R_1 = 2.4 kΩ

C_i = 2.2 μF

Q3.The Frequency response of the amplifier by varying the frequency from 10 Hz to 100 MHz

Frequency(in Hz)	V_i (V_{p-p} in mV)	V_o (V_{p-p} in V)	Phase difference
100	100	2.1	50
500	100	2.1	15
1000	100	2.1	15
2000	100	2.2	10
5000	100	2.2	5
7000	100	2.2	0
10000	100	2.2	0
15000	100	2.2	-5
25000	100	2.1	-10
35000	100	1.8	-30
40000	100	1.7	-45
50000	100	1.6	-45
100000	100	1	-60
500000	100	0.8	-85
1000000	100	0.5	-100
10000000	100	0.5	-100

Q7.The Frequency response of the amplifier by varying the frequency from 10 Hz to 100 MHz for the modified circuit:

Frequency(in Hz)	**V_i ($V_{p\text{-}p}$ in mV)**	**V_o ($V_{p\text{-}p}$ in V)**	**Phase difference**
100	30	1	30
500	30	1	20
1000	30	1	0
2000	30	1	0
5000	30	1	-5
7000	30	1	-10
10000	30	1	-15
15000	30	1	-20
25000	30	1	-30
35000	30	0.9	-50
40000	30	0.8	-60
50000	30	0.7	-85
100000	30	0.4	-100
500000	30	0.3	-100
1000000	30	0.2	-100
10000000	30	0.2	-100

Discussion:

1. I understood how to implement a NMOS Common Source Amplifier and found out the required resistances R_2 and R_D that need to be implemented in the circuit for the CMOS to work in amplifier mode.
2. Understood the frequency dependent amplification nature of the NMOS Common Source Amplifier.
3. Operation of Arbitrary Function Generator (AFG) and Digital Oscilloscope for generation and analysis of Periodic signals at different frequencies and finding out the gain of the signal for various frequencies and various input voltages.
4. As the frequency of the input sinusoid increases from 30 Hz to 100 MHz, initially, the gain increases becomes almost constant in the mid-band frequency range and after that starts decreasing.
5. Since The active region in I_{ds} vs V_{gs} curve of MOSFET resemble a line for small values of V_{gs}, It will not Be linear but approximately parabolic for large values of V_{gs} and that is why we are having distortions for large amplitude input waves while increasing amplitude of Input sine wave.
6. All our Simulation and Hardware Results are Similar, so we have successfully understood how to use MOS based amplifiers.