LAB REPORT-5

MOS differential amplifier

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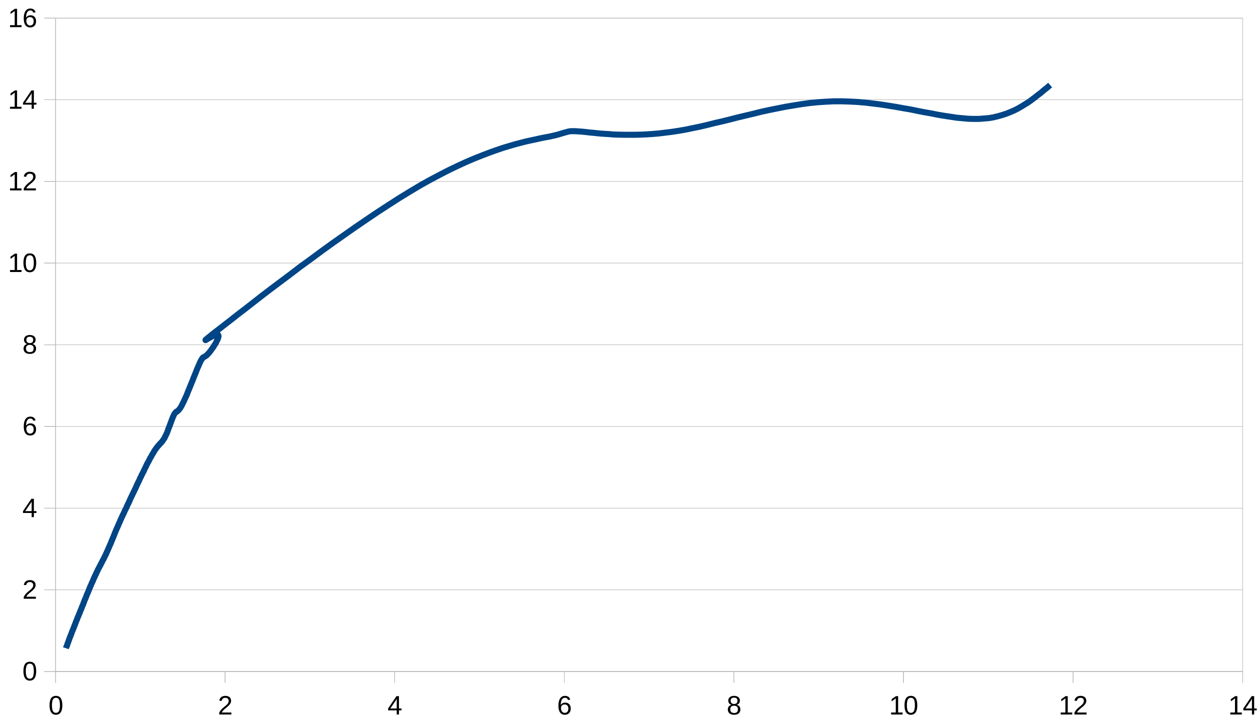
NMOS current mirror

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

$$\mathbf{R_o = 1/(ƛ\ x\ I_{DS})}$$

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,

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

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-p} in mV)**	**V_o (V_{p-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 the characteristics of NMOS current mirror circuit by using a CD4007 IC.
2. The circuit is named as current mirror because, the same current which flows through Drain and source of left side MOSFET, will also flow through right side MOSFET in upward direction, like a mirror structure with respect to the current.
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 100 Hz to 1 MHz, initially, the gain increases becomes almost constant in the mid-band frequency range and after that starts decreasing.
5. The MOSFET operates in the triode region, thereby acting like a resistor whose resistance value we can get from the slope of the plot. However, as V_{DS} is increased above V_{GS}-V_{Th} , MOSFET enters the saturation region, wherein I_{DS} gets saturated thus, making MOSFET acting like a current source whose saturated current depends on V_{GS}.
6. Because of a phenomenon called channel length modulation, IDS increases linearly with VDS with output resistance of **2.4 kΩ** in our case. In ideal case, in absence of channel length modulation, it should be infinity as I_{DS} will be constant
7. All our Simulation and Hardware Results are Similar, so we have successfully understood how to use MOS based amplifiers, especially current mirrors and differential amplifiers.