Experiment - 5

NMOS Output Characteristics, Common Source Amplifier, and Current Mirror

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1. NMOS Characteristics

(Changed w from 10 μm to 15 μm to get roughly 1 mA current when Vgs = 2V)

a.   ngspice code:

```
Prasann Viswanathan 190070047 NMOS Characteristics

.model NXYAA5U nmos Level=1 Vto=0.7 KP=80u w=10u L=1u
+ Gamma=0 Phi=0.65 Lambda=0.0

vgs 2 0 0
v2 1 0 0
rd 1 3 2.2k
m1 3 2 0 0 NXYAA5U

*analysis commands
.dc v2 0 50 0.02 Vgs 2 5 1
.control
run

*display commands
plot -i(v2)
.endc
.end
```
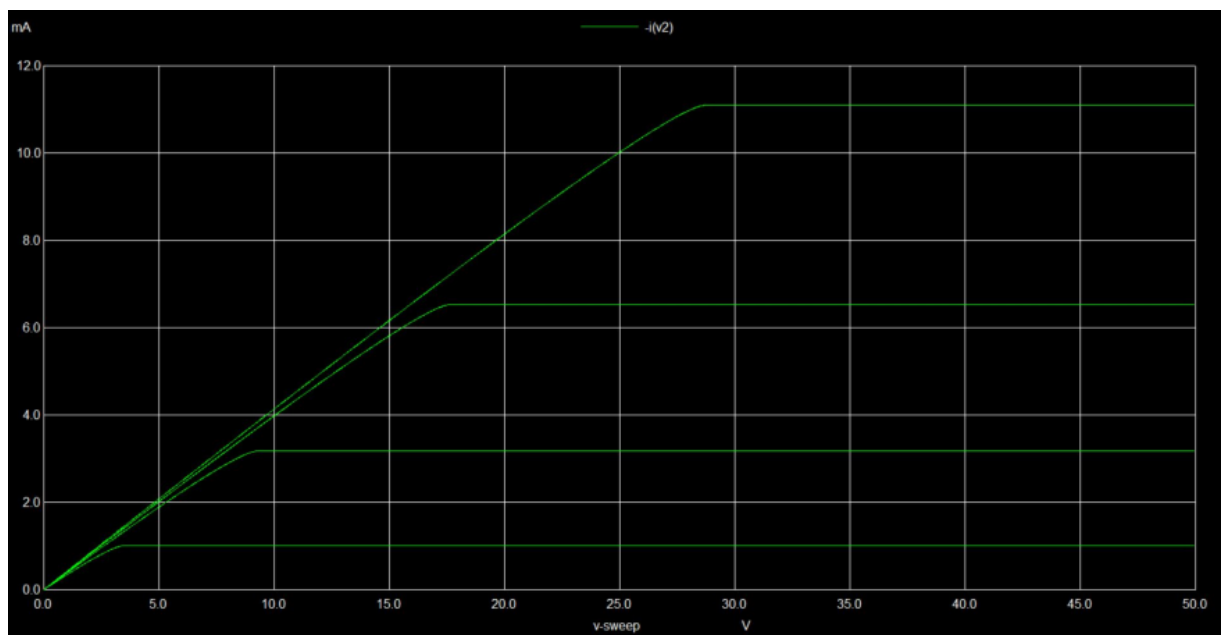
b.   Results

c.   Learning Outcomes

Output characteristics of an NMOS transistor and how they vary according to different Vgs values.

2. NMOS Common-Source Amplifier (Bias Circuit)

a. ngspice code:

```
Prasann Viswanathan 190070047 NMOS Common Source Amp

.model mos_model nmos Level=1 Vto=1 KP=100u w=10u L=1u
+ Gamma=0 Phi=0.65 Lambda=0.0

vdd 1 0 12
v_t 1 2 0
r1 1 g 8.2k
r2 g 0 3.3k
rd 2 d 3.3k
rs s 0 1k
m1 d g s 0 mos_model

*analysis commands
.op
.control
run

*display commands
print v(d) v(g) v(s) i(v_t)
.endc
.end
```

b. Results

```
v(d)      = 8.643329e+00
v(g)      = 3.443478e+00
v(s)      = 1.017173e+00
i(v_test) = 1.017173e-03
```

c. Learning outcomes

Analysis and simulation of the biasing circuit of an NMOS Common Source Amplifier.

3. NMOS Common-Source Amplifier

    a. ngspice code:

```
Prasann Viswanathan 190070047 NMOS Common Source Amp Experiment

.model mos_model nmos Level=1 Vto=1 KP=100u w=10u L=1u
+ Gamma=0 Phi=0.65 Lambda=0.0

vin 3 0 sin(0 50m 1k 0 0)
vdd 1 0 12
v_t 1 2 0
r1 1 g 8.2k
r2 g 0 3.3k
rd 2 d 3.3k
rs s 0 1k
m1 d g s 0 mos_model
c1 g 3 10u
c2 s 0 100u

*analysis commands
.tran 10u 20ms
.control
run

*display commands
plot v(3)
plot v(d)
.endc
.end
```
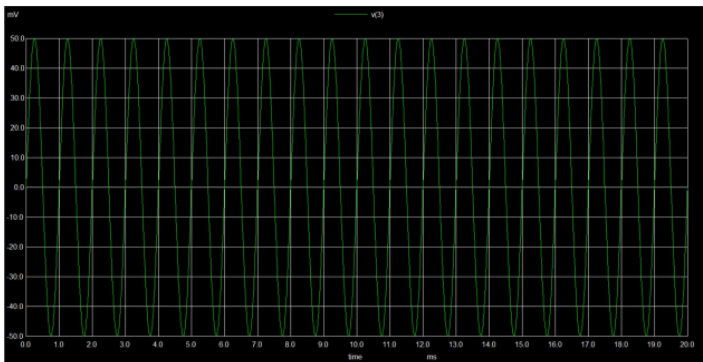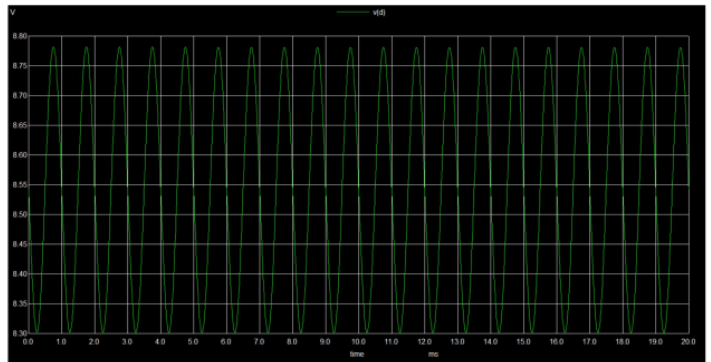
    b. Results (Vo1 and Vo2 vs time)

V_{in}

V_{Out}

    c. Learning outcomes

Calculating the voltage gain in an NMOS amplifier using its small circuit model. Verifying the results using simulation.

4. NMOS Current Mirror based Current Source

a. ngspice code:

```
Prasann Viswanathan 190070047 NMOS Current Mirror Current Source

.model mos_model nmos Level=1 Vto=1 KP=100u w=10u L=1u
+ Gamma=0 Phi=0.65 Lambda=0.0

vdd 1 0 12
m1 2 2 0 0 mos_model
m2 3 2 0 0 mos_model
v0 3 0 0
r 1 2 8.2k

*analysis commands
.dc v0 1 5 0.2
.control
run

*display commands
plot -i(v0)
plot -i(vdd)
print -i(v0)
print -i(vdd)
.endc
.end
```
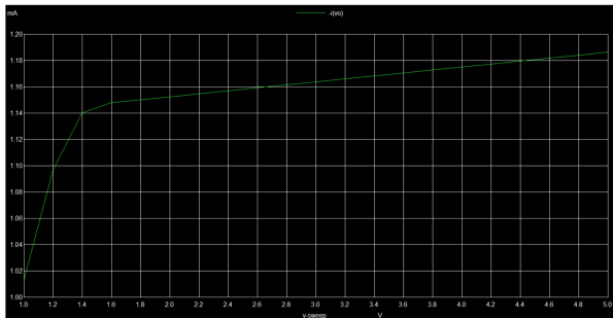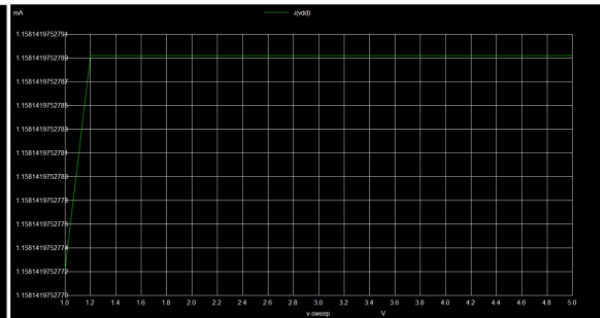
b. Results

I_0 v/s V_0

I_{REF} v/s V_0

Index	v-sweep	-i(v0)
0	1.000000e+00	3.601811e-04
1	1.200000e+00	4.202173e-04
2	1.400000e+00	4.762535e-04
3	1.600000e+00	5.282897e-04
4	1.800000e+00	5.763259e-04
5	2.000000e+00	6.203622e-04
6	2.200000e+00	6.603984e-04
7	2.400000e+00	6.964346e-04
8	2.600000e+00	7.284708e-04
9	2.800000e+00	7.565070e-04
10	3.000000e+00	7.805432e-04
11	3.200000e+00	8.005795e-04
12	3.400000e+00	8.166157e-04
13	3.600000e+00	8.286519e-04
14	3.800000e+00	8.366881e-04
15	4.000000e+00	8.407243e-04
16	4.200000e+00	8.412426e-04
17	4.400000e+00	8.412426e-04
18	4.600000e+00	8.412426e-04
19	4.800000e+00	8.412426e-04
20	5.000000e+00	8.412426e-04

Index	v-sweep	-i(vdd)
0	1.000000e+00	8.412426e-04
1	1.200000e+00	8.412426e-04
2	1.400000e+00	8.412426e-04
3	1.600000e+00	8.412426e-04
4	1.800000e+00	8.412426e-04
5	2.000000e+00	8.412426e-04
6	2.200000e+00	8.412426e-04
7	2.400000e+00	8.412426e-04
8	2.600000e+00	8.412426e-04
9	2.800000e+00	8.412426e-04
10	3.000000e+00	8.412426e-04
11	3.200000e+00	8.412426e-04
12	3.400000e+00	8.412426e-04
13	3.600000e+00	8.412426e-04
14	3.800000e+00	8.412426e-04
15	4.000000e+00	8.412426e-04
16	4.200000e+00	8.412426e-04
17	4.400000e+00	8.412426e-04
18	4.600000e+00	8.412426e-04
19	4.800000e+00	8.412426e-04
20	5.000000e+00	8.412426e-04

c. Learning outcomes

The output current was fairly equal to the reference current over the range. Also learnt hand analysis of NMOS current source.