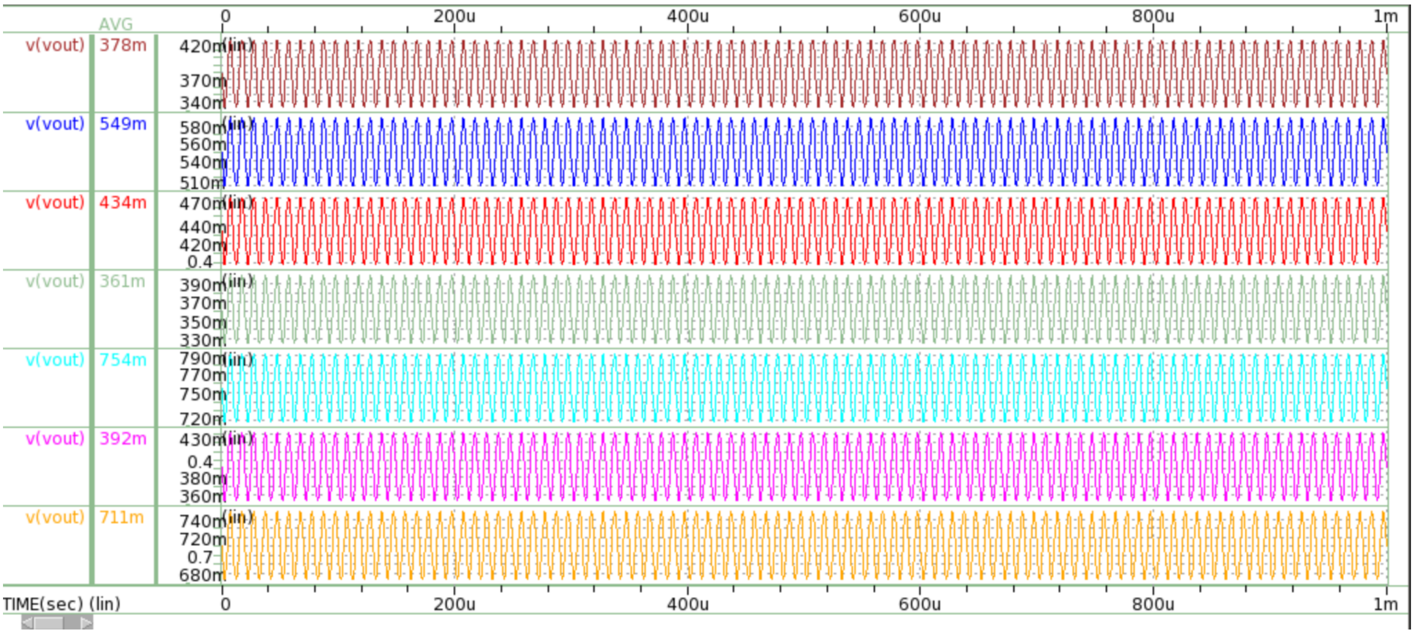
HSPICE Homework #2

Hw2.1

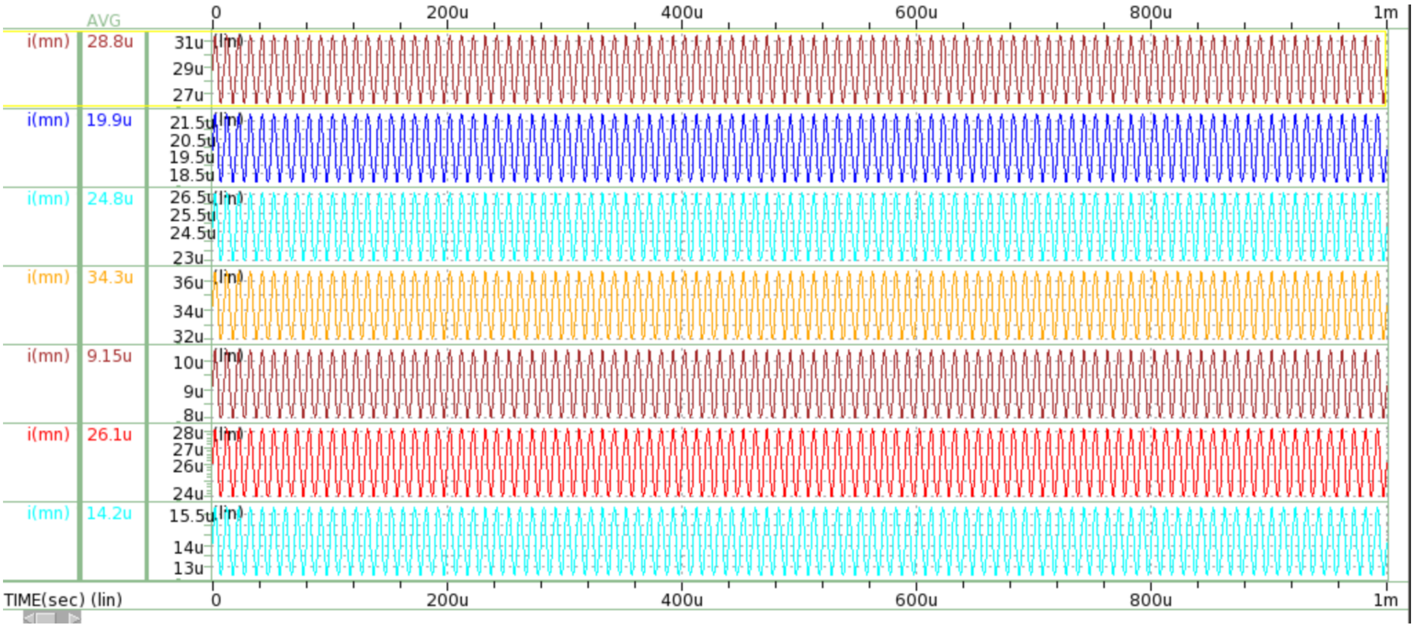
```
Hw2_1
.option post
.temp 25
*source
Vdd vdd gnd 1.8
vss vss gnd 0
vin vin gnd sin(0.6 0.01 100k)
*ckt
mn vout vin gnd gnd n_18_mm w=1.2u l=0.18u
mp vout vout vdd vdd p_18_mm w=1.5u l=1u

*sim
.print LV1(mn)
.tran 10n 1m
.tf V(vout) vin
.print cin=cap(vin) cout= cap(vout)

.lib "/RAID2/COURSE/AICIntro/AICIntro071/U18_model/U18_Spice_model/mm180_reg18_v124.lib" tt

.alter
mn vout vin gnd gnd n_18_mm w=3.6u l=0.54u

.alter
mn vout vin gnd gnd n_18_mm w=1.2u l=0.18u
.temp 75

.alter
.temp 25
.lib "/RAID2/COURSE/AICIntro/AICIntro071/U18_model/U18_Spice_model/mm180_reg18_v124.lib" ff

.alter
.lib "/RAID2/COURSE/AICIntro/AICIntro071/U18_model/U18_Spice_model/mm180_reg18_v124.lib" ss

.alter
.lib "/RAID2/COURSE/AICIntro/AICIntro071/U18_model/U18_Spice_model/mm180_reg18_v124.lib" fnsp

.alter
.lib "/RAID2/COURSE/AICIntro/AICIntro071/U18_model/U18_Spice_model/mm180_reg18_v124.lib" snfp

.end

```

The pictures below are all in the order as the chart.

Vout waveform:



Ids waveform:

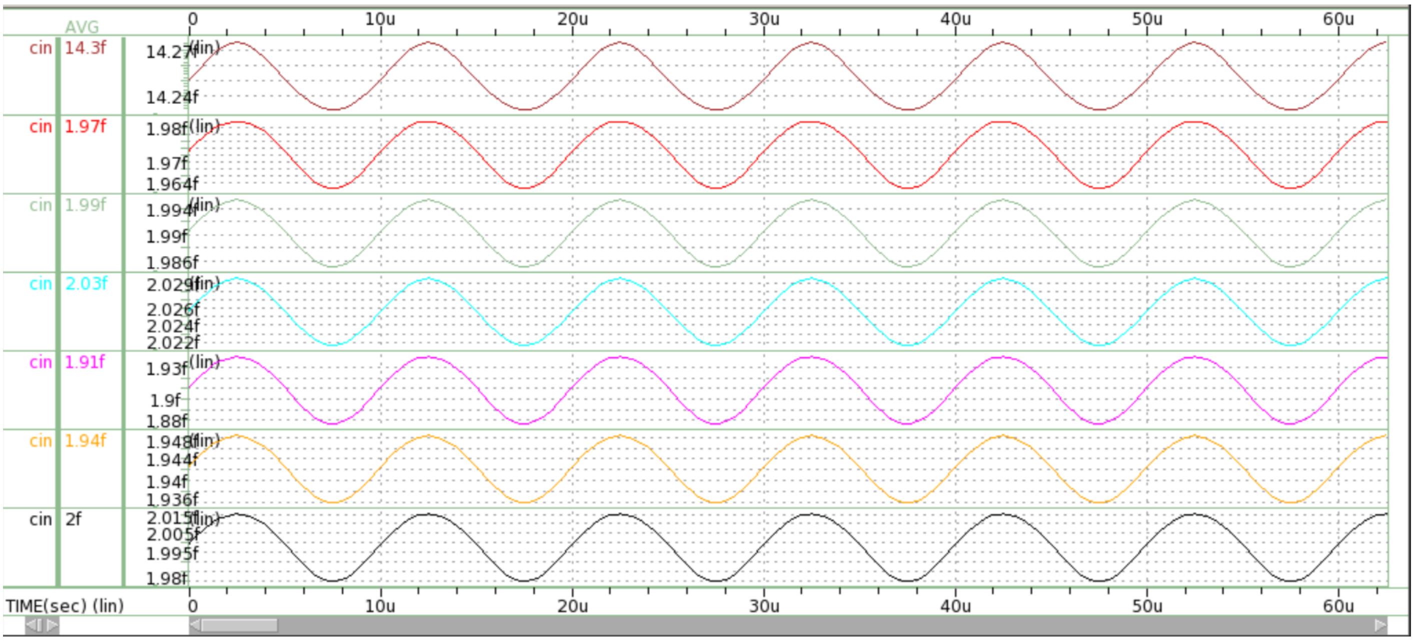


Small signal:

```
v(vout)/vin                          =   -4.6039
input resistance at        vin       =  1.000e+20
output resistance at v(vout)         =   15.8225k

v(vout)/vin                          =   -4.0196
input resistance at        vin       =  1.000e+20
output resistance at v(vout)         =   16.9394k

v(vout)/vin                          =   -3.6654
input resistance at        vin       =  1.000e+20
output resistance at v(vout)         =   15.4508k
```

```
v(vout)/vin                              =   -3.7296
input resistance at            vin       =  1.000e+20
output resistance at v(vout)             =   11.4275k

v(vout)/vin                              =   -3.6566
input resistance at            vin       =  1.000e+20
output resistance at v(vout)             =   26.7409k

v(vout)/vin                              =   -3.9386
input resistance at            vin       =  1.000e+20
output resistance at v(vout)             =   14.1657k

v(vout)/vin                              =   -3.8254
input resistance at            vin       =  1.000e+20
output resistance at v(vout)             =   20.2288k
```

Cin:



Cout:

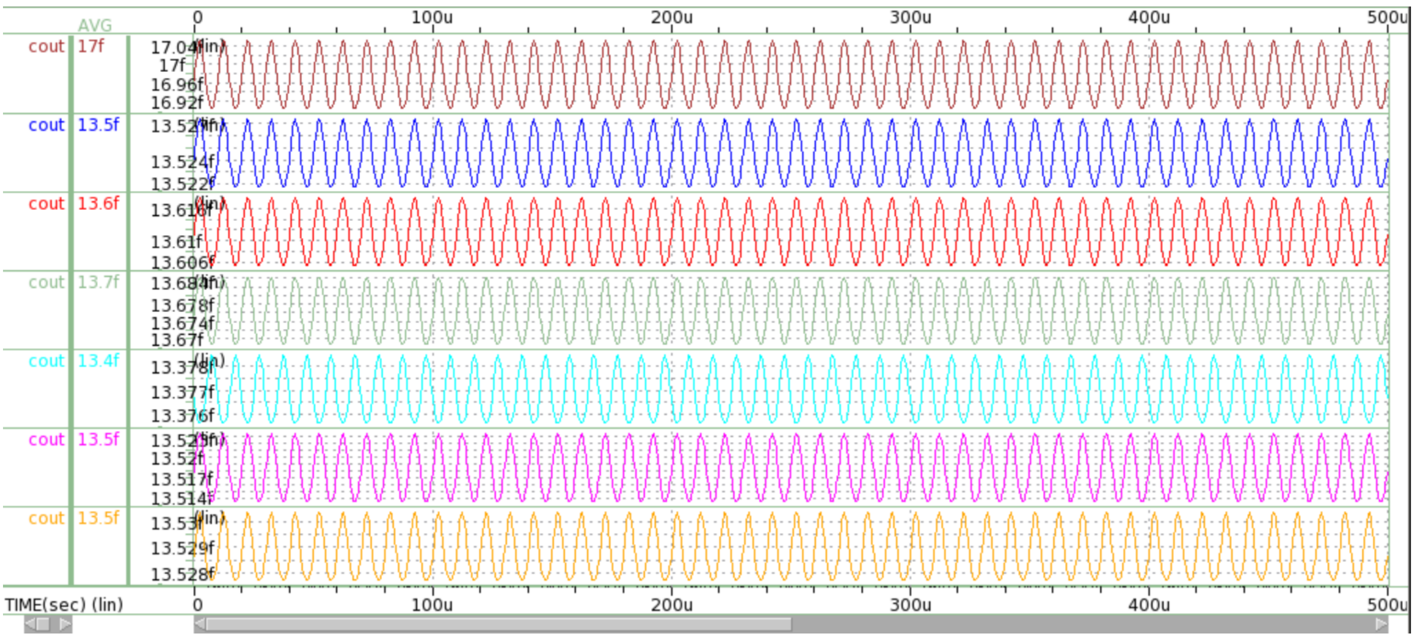


Table: NMOS common-source amplifier

Corner	Temp (°C)	Circuit	Vout (V)	Ids (mA)	DC gain (V/V)	Rout (Ω)	Cin (F)	Cout (F)
TT	25	Fig. 2	378m	0.0288	-4.604	15.823k	14.3f	17f
TT	25	Fig. 1	549m	0.0199	-4.019	16.939k	1.97f	13.5f
TT	75	Fig. 1	434m	0.0248	-3.665	15.451k	1.99f	13.6f
FF	25	Fig. 1	361m	0.0343	-3.73	11.428k	2.03f	13.7f
SS	25	Fig. 1	754m	0.00915	-3.657	26.741k	1.91f	13.4f
FnSp	25	Fig. 1	392m	0.0261	-3.939	14.166k	1.94f	13.5f
SnFp	25	Fig. 1	711m	0.0142	-3.825	20.229k	2f	13.5f

Hw2.2

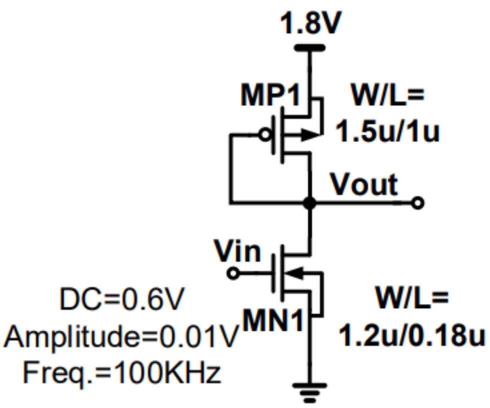


Fig. 1

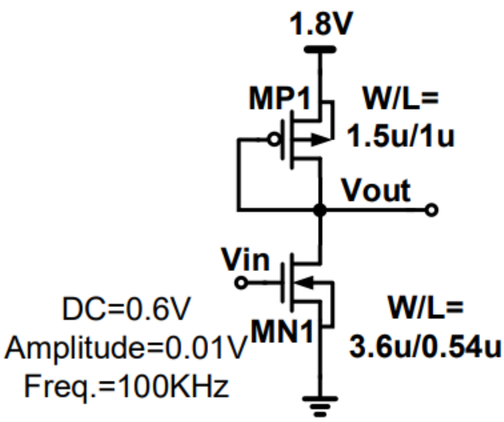


Fig. 2

Figure 1.W/L=1.2u/0.18u=6.6667

```
****     small-signal transfer characteristics

     v(vout)/vin                                =   -4.0196
     input resistance at             vin        =  1.000e+20
     output resistance at v(vout)               =   16.9394k
```

Figure 2.W/L=3.6u/0.54u=6.6667

```
****     small-signal transfer characteristics

     v(vout)/vin                                =   -4.6039
     input resistance at             vin        =  1.000e+20
     output resistance at v(vout)               =   15.8225k
```

Rout analysis:

The picture above shows the output resistance of Figure1 is larger than Figure2. Some reasons determine this result. First, the Rout of both circuits is equal to $\frac{1}{gmp}$//rop//ron.

And we know gmp is proportional to ID. Due to the velocity saturation on short channel devices, ID will prematurely saturate, which causes ID much smaller than expected. Thus, the smaller gmp and ID are, the larger the Rout will be.

Also, the ron is equal to $\frac{1}{\lambda ID}$. Thus, As ID decreases, ron will also get larger. What' s more, λ is proportional to $\frac{1}{L}$, which will cause **a larger Rout when the Length is small**.

Gain analysis:

The two figures show the gain of figure2 is larger than the figure1. Recall that we just mention the velocity saturation above, which will let ID be smaller on the short-channel devices. Once ID gets smaller, gmn will also get smaller. This will **result in a smaller gain**.

Hw2.3

Figure1 temp25 (ID=19.9uA)

```
v(vout)/vin                              =   -4.0196
input resistance at          vin         =  1.000e+20
output resistance at v(vout)             =   16.9394k

gm        47.0712u   237.4156u
gds      677.9233n    11.2949u
```

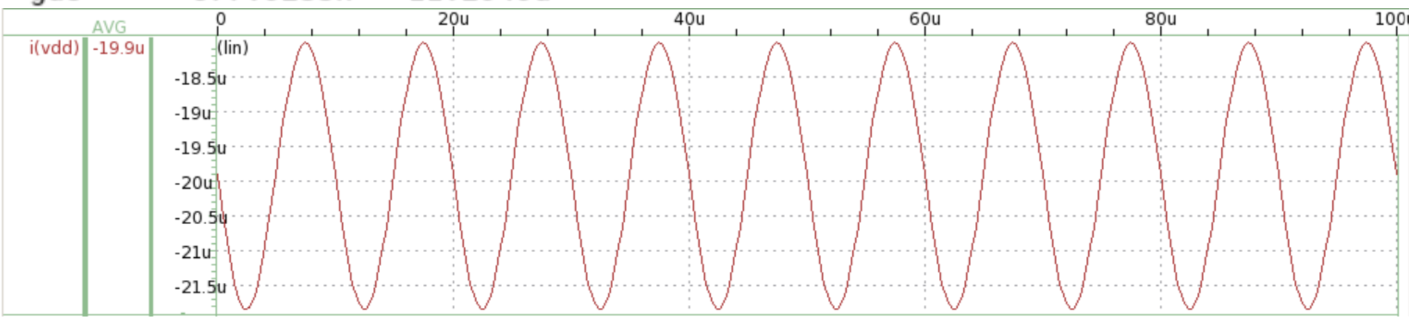
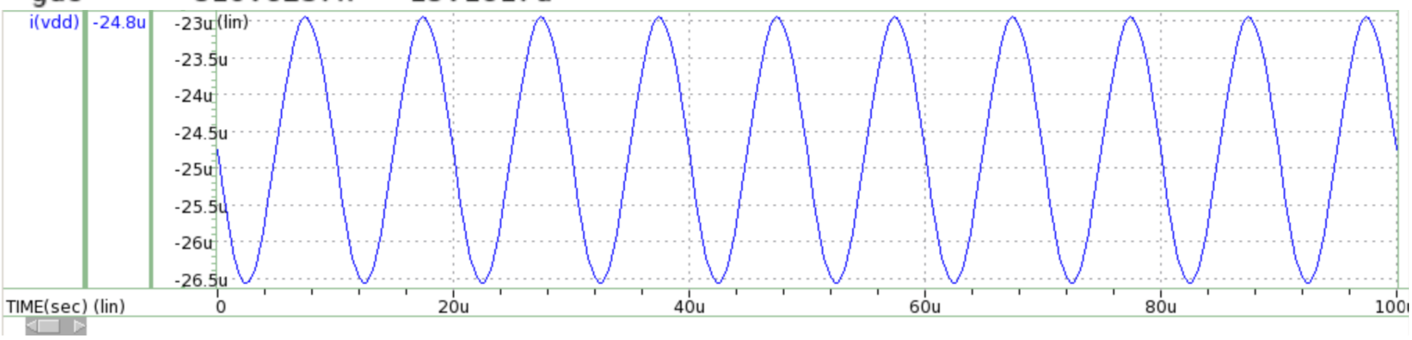
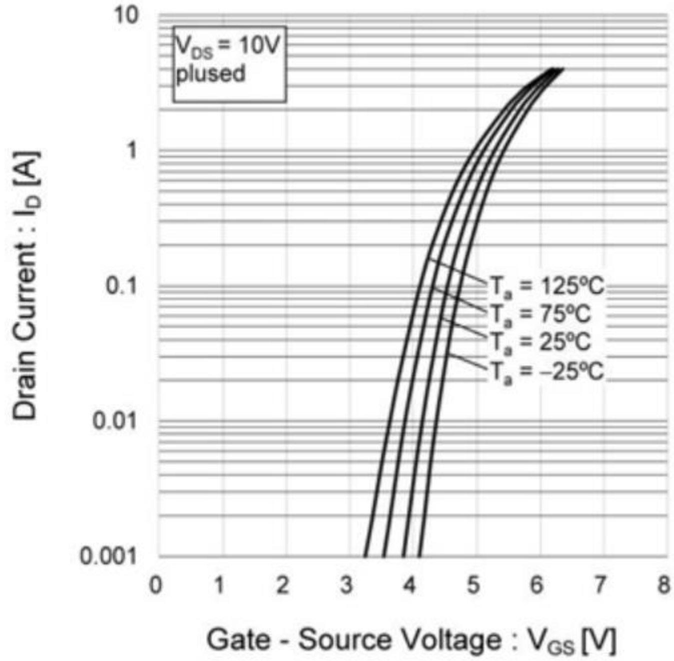
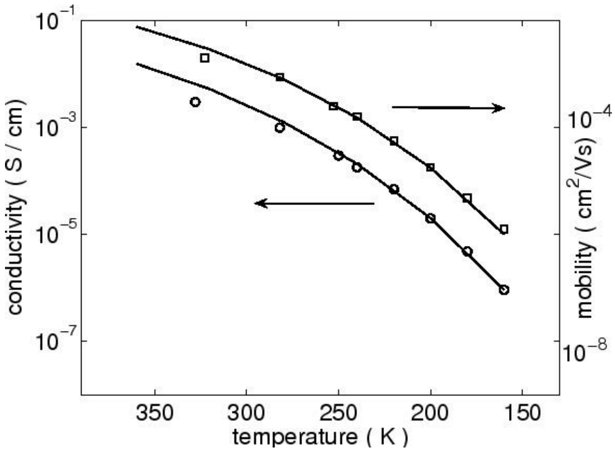


Figure1 temp 75 (ID=24.8uA)

```
v(vout)/vin                              =   -3.6654
input resistance at          vin         =  1.000e+20
output resistance at v(vout)             =   15.4508k

gm        48.7617u   237.3561u
gds      810.6237n    15.1617u
```







Rout analysis:

The left picture shows that if VGS is a constant, ID will increase as temperature increases. The reason is that ID=$\frac{1}{2}UnCox\frac{W}{L}(VGS-VTH)^2$, and the right picture shows that as temperature increases, Un will increase too. Thus, we can know that if temperature increases, ID will increase.

We know that ro=1/gds. The result above shows that gds increase when the temperature increases from 25 degrees to 75 degrees, which implies ro decrease.

It is known that Rout=$\frac{1}{gmp}$//rop//ron, and ron and rop are equal to $\frac{1}{\lambda ID}$. Thus, as ID increase, **Rout will get smaller**. This is totally the same as the result in hspice.

Gain analysis:

It is proved that a higher temperature results in a lower Rout in this circuit. And it is known that the gain formula is Av=-gmn*Rout. From the result above, it shows that gm didn’ t change obviously due to the cancelation of Vth and Un. Therefore, if Rout gets smaller, **Av gain will also get smaller**. This deduction exactly accords with the Hspice result.