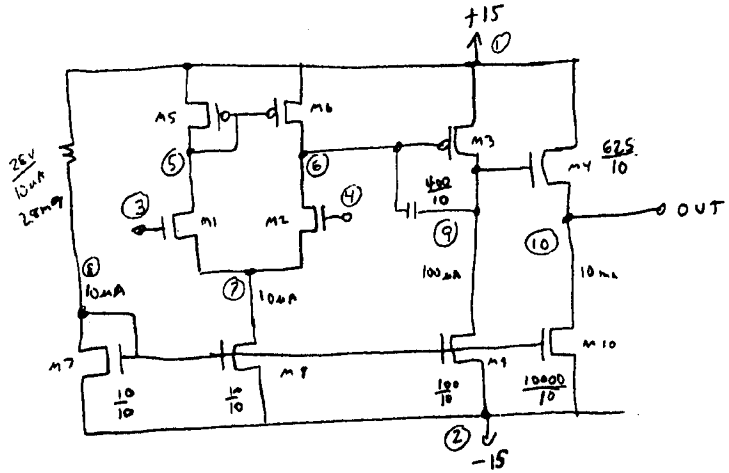
(1)



N
KP = 20u
Lambda = .01
$V_{TO} = 1$

Stage 3:

$R_o = 200\,\Omega = \frac{1}{g_m} \Rightarrow g_m = .005 = \sqrt{2K_p \frac{W}{L} I_{DQ}}$

$= \sqrt{(2)(20\times10^{-6})\frac{W}{L}(10\times10^{-3})}$

$5\times10^{-3} = \sqrt{(400\times10^{-9})\frac{W}{L}}$

$2.5\times10^{-5} = 4\times10^{-7}\frac{W}{L}$

$62.5 = \frac{W}{L}$

$L = 1\mu \quad W = 62.5\mu$

Calculate V_{GS} -

$I_D = K V_{GST}^2$

$2K = K_p \frac{W}{L}$

$= (20\times10^{-6})(62.5)$

$= 1.25\times10^{-3}$

$K = 6.25\times10^{-4}$

$V_{GST}^2 = \frac{I_D}{K} = \frac{1\times10^{-2}}{6.25\times10^{-4}} = 16$

$V_{GST} = 4$

$V_{GS} = 5$

(2)

Stage 2 - Gain = -100

M9.
Mirror - Calculate r_o · $V_{DS} = 20$ $I_D = 100\mu A = 10^{-4}$

$r_o = \frac{1}{\lambda I_D} = \frac{1}{(.01)(100\mu)} = \frac{1}{10^{-2}\,10^{-4}} = \frac{1}{10^{-6}} = 10^6$

M3 - Calculate r_o -- $V_{DS} = 10$ $I_D = 100\mu A$ $r_o = 10^6$

$r_{Load} = 500k$.

$gain = -g_m R_L \rightarrow g_m = \frac{-gain}{R_L}$

$g_m = \frac{+100}{500k} = 2\times10^{-4}$

~~$= \sqrt{2K_p \frac{W}{L} I_{DQ}}$~~

~~$= \sqrt{(2)(20\times10^{-6})\frac{W}{L}(10^{-4})}$~~

~~$= \sqrt{40\times10^{-10}\frac{W}{L}}$~~

~~$= \sqrt{4\times10^{-9}\frac{W}{L}}$~~

~~$4\times10^{-8} = 4\times10^{-9}\frac{W}{L}$~~

~~$\frac{10^{-8}}{10^{-9}} = \frac{W}{L} = 10$~~

$= \sqrt{2K_p \frac{W}{L} I_{DQ}}$

$= \sqrt{2(5\times10^{-6})\frac{W}{L}(10^{-4})}$

$= \sqrt{10\times10^{-10}\frac{W}{L}}$

$= \sqrt{10^{-9}\frac{W}{L}}$

$4\times10^{-8} = 10^{-9}\frac{W}{L}$

$\frac{4\times10^{-8}}{10^{-9}} = \frac{W}{L} = 40$

V_{GS} ...

$I_D = K V_{GST}^2$

$2K = K_p \frac{W}{L}$

$= (5\times10^{-6})(40)$

$= 200\times10^{-6}$

$= 2\times10^{-4}$

$K = 1\times10^{-4}$

$V_{GST}^2 = \frac{I_D}{K} = \frac{10^{-4}}{10^{-4}}$

$= 1$

$V_{GS} = 2$

③

Diff -am,

$I = 10\mu A$

Current mirror - $I = 5\mu A$ each size $= \frac{10}{10}$

M_6: $V_{DS} = 2$

best way -- size so $V_{GS} = 2$
($V_{GST} = 1$)

$I_D = K V_{GST}^2$

$5\mu = K$

$2K = 10\mu = K_p \frac{W}{L}$

$10\mu = 5\mu \frac{W}{L}$

$\frac{10\mu}{5\mu} = \frac{W}{L}$

then need to consider lambda.

M5, M6

$r = \frac{1}{\lambda I_D} = \frac{1}{(.01)(5\mu)} = \frac{1}{10^{-2}\ 5 \times 10^{-6}} = \frac{1}{5 \times 10^{-8}} = 2 \times 10^{7} = 20\,meg$

M8:

$r = \frac{1}{\lambda I_D} = \frac{1}{(.01)(10\mu)} = 10\,meg$

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②

distortion

```
put it back for measurements
10 3 1meg
10 10meg dec
.print four v(10)
.plot tran v(10)
.modify rload=10k
.generator freq=100 ampl=.01
.tran 0 .01 .0005
.fourier 100

.generator freq=1k ampl=.01
.tran 0 .001 .00005
.fourier 1k

.generator freq=10k ampl=.01
.tran 0 .0001 .000005
.fourier 10k

**** higher level
.generator freq=100 ampl=.05
.tran 0 .01 .0005
.fourier 100

.generator freq=1k ampl=.05
.tran 0 .001 .00005
.fourier 1k

.generator freq=10k ampl=.05
.tran 0 .0001 .000005
.fourier 10k

**** even higher level
.plot tran v(10)(-10,10)

.generator freq=100 ampl=.1
.tran 0 .01 .0005
.fourier 100

.generator freq=1k ampl=.1
.tran 0 .001 .00005
.fourier 1k

.generator freq=10k ampl=.1
.tran 0 .0001 .000005
.fourier 10k
```