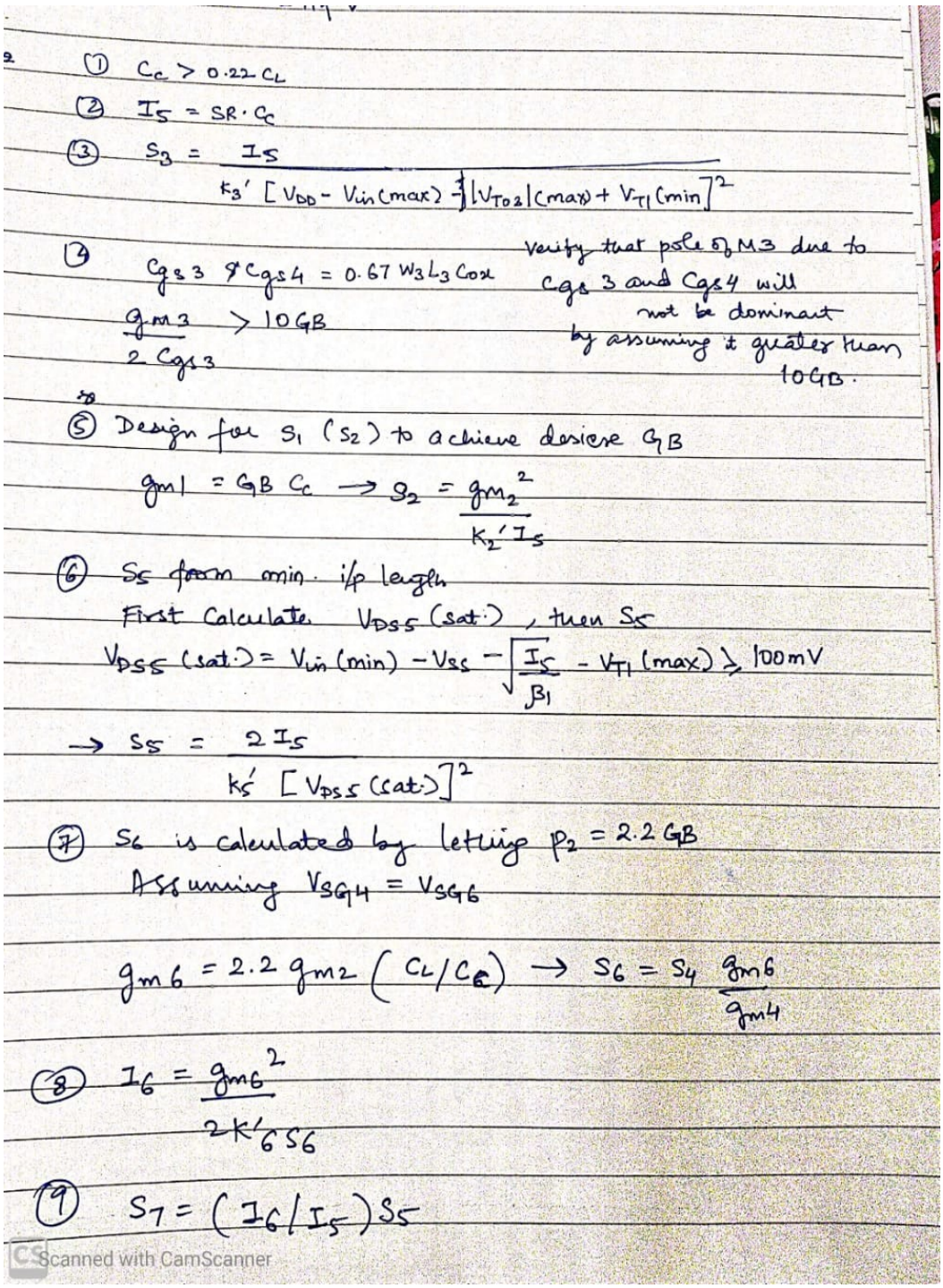
Lab

Submitted By: 2019PSP3023 Gargi Trivedi

Write a Tcl script to design a two-stage Op-Amp. Assume channel lenght= 1um.
Op-Amp Specifications are:
Av= 5000 V/V, VDD= 2.5V, VSS= -2.5V, GB= 5Mhz, Phase Margin= 60 degree, CL=10pF, SR> 10V/uS, Vout range =plus minus 2V , ICMR =-1 to 2V, Pdissipation< 2mW

Note: Design means to find the design parameter (aspect ratio) of all transistors to meet the specifications.



① $C_c > 0.22 C_L$

② $I_5 = SR \cdot C_c$

③ $S_3 = \dfrac{I_5}{K_3' \left[V_{DD} - V_{in(max)} - |V_{T02}|_{(max)} + V_{T1(min)}\right]^2}$

④ $C_{gs3} \& C_{gs4} = 0.67 W_3 L_3 C_{ox}$

$\dfrac{g_{m3}}{2 C_{gs3}} > 10 GB$

verify that pole of M3 due to C_{gs3} and C_{gs4} will not be dominant by assuming it greater than 10GB.

⑤ Design for S_1 (S_2) to achieve desiere GB

$g_{m1} = GB\, C_c \rightarrow S_2 = \dfrac{g_{m2}^2}{K_2' I_5}$

⑥ S_5 from min. i/p length
First Calculate $V_{DS5(sat.)}$, then S_5

$V_{DS5(sat.)} = V_{in(min)} - V_{SS} - \sqrt{\dfrac{I_5}{\beta_1}} - V_{T1(max)} \geq 100mV$

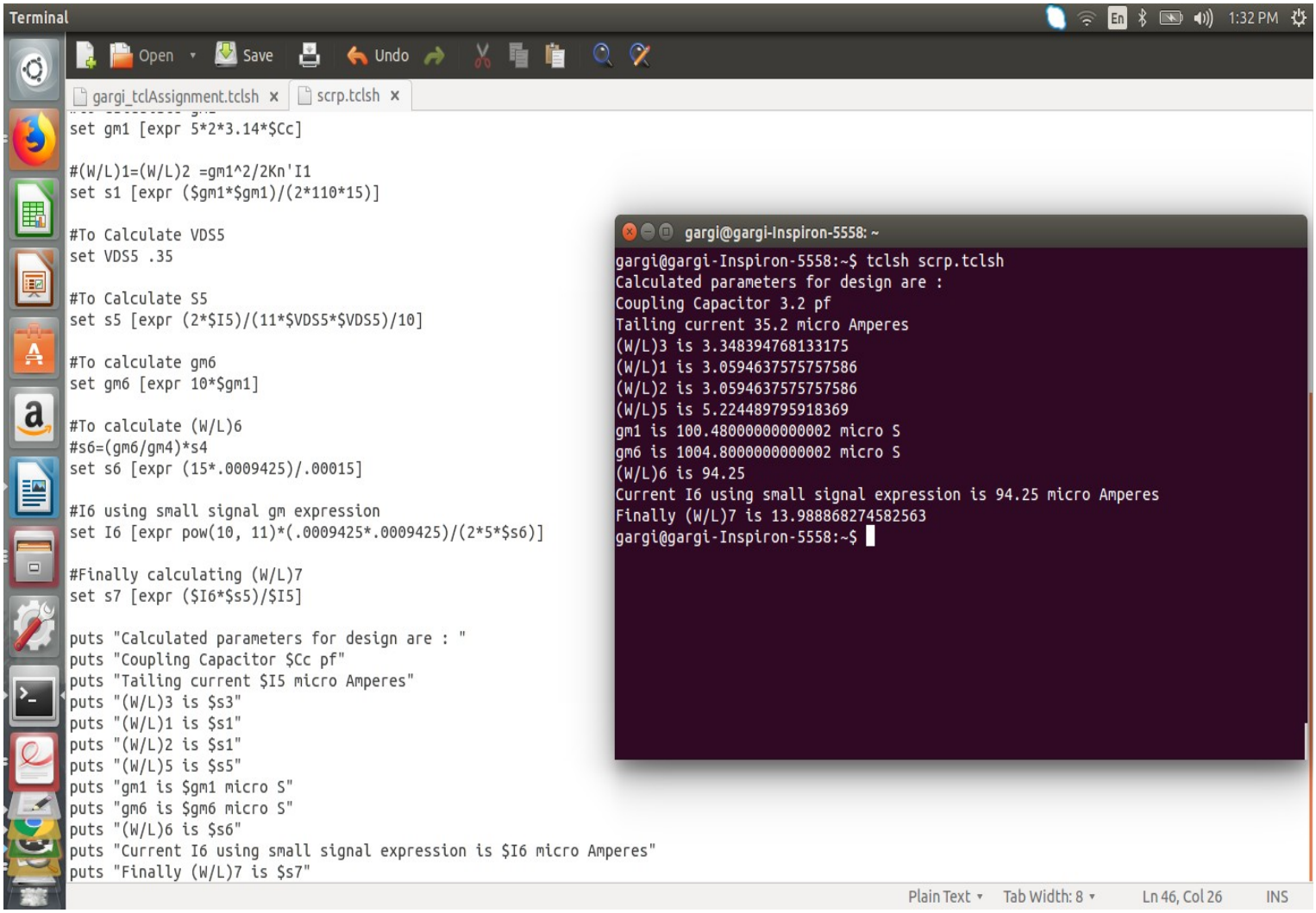
$\rightarrow S_5 = \dfrac{2 I_5}{K_5' \left[V_{DS5(sat.)}\right]^2}$

⑦ S_6 is calculated by letting $p_2 = 2.2\, GB$
Assuming $V_{SG4} = V_{SG6}$

$g_{m6} = 2.2\, g_{m2} \left(C_L / C_6\right) \rightarrow S_6 = S_4 \dfrac{g_{m6}}{g_{m4}}$

⑧ $I_6 = \dfrac{g_{m6}^2}{2 K_6' S_6}$

⑨ $S_7 = \left(I_6 / I_5\right) S_5$



Code:

```
set Av 5000
set VDD 2.5
set VSS -2.5
set GB 5
set PhaseMargin 60
set CL 10
set SR 11
set Vout 2
set Pdissipation 1.9
set channel_lenght 1

# Cc >2 CL
set Cc [expr (2.2*$CL)/10 +1]

# I5=SR*Cc
set I5 [expr $SR*$Cc]

# (W/L)3 using ICMR requirements
set s3 [expr $I5/(5*($VDD-2-2.5+.55)*($VDD-2-2.5+.55))]

#to calculate gm1
```

```
set gm1 [expr 5*2*3.14*$Cc]

#(W/L)1=(W/L)2 =gm1^2/2Kn'I1
set s1 [expr ($gm1*$gm1)/(2*110*15)]

#To Calculate VDS5
set VDS5 .35

#To Calculate S5
set s5 [expr (2*$I5)/(11*$VDS5*$VDS5)/10]

#To calculate gm6
set gm6 [expr 10*$gm1]

#To calculate (W/L)6
#s6=(gm6/gm4)*s4
set s6 [expr (15*.0009425)/.00015]

#I6 using small signal gm expression
set I6 [expr pow(10, 11)*(.0009425*.0009425)/(2*5*$s6)]

#Finally calculating (W/L)7
set s7 [expr ($I6*$s5)/$I5]

puts "Calculated parameters for design are : "
puts "Coupling Capacitor $Cc pf"
puts "Tailing current $I5 micro Amperes"
puts "(W/L)3 is $s3"
puts "(W/L)1 is $s1"
puts "(W/L)2 is $s1"
puts "(W/L)5 is $s5"
puts "gm1 is $gm1 micro S"
puts "gm6 is $gm6 micro S"
puts "(W/L)6 is $s6"
puts "Current I6 using small signal expression is $I6 micro Amperes"
puts "Finally (W/L)7 is $s7"
```