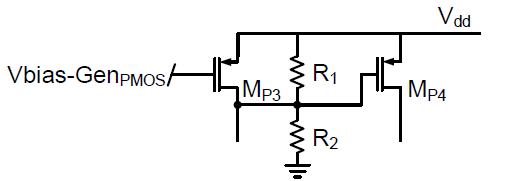
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Node | Time Constant | Assumptions/Simplifications |  | Simplified Time Constant |
| 1 - Input |  | * Cin >> Cgs2 | 20% |  |
| 2 - Vx |  | * R2/R1 < 4 |  |  |
| 3 - Vy |  | * R3/R4 < 4 |  |  |
| 4 - Vz |  |  |  |  |
| 5 - Vout |  | Cgs = 10, >> 1 => tau = | 100% |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Stage | Gain | R in terms of gain | Equals | Simplified Time Constant |
| 1 - CG |  | R2 = 4R1  = gain  => = = gain  => R1 = 5/4\* gain | 5000 |  |
| 2 – Cascode |  | R3 = 4R4  = 5  => = 5  => = 5  => R4 = | 5 |  |
| 3 – CS |  |  | 1.2 |  |
| 4 – CD |  |  | 1 |  |
|  |  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Assumptions | Independent Variables | Derived quantities | Performance Characteristics |
| * Length[1..10] | * I\_branch[1...4]   Random for now   * Gain\_stage[1..4]   CG, cascade  CS,CD ~ 1 always   * $R3 = x\*$R2;   10-10k, increment of 1k   * All gm’s except (4, 7, 8, 10):   0.0000005-0.003 | * Width[1..10] * Cgs[1..10] * Miller Gain (Mn10) * Gm[1..10] * Vov[1..10] | * DC Gain * 3db Bandwidth * Power |

# First resistive divider

Calculating bounds on the ratio of R2/R1:



Assume that the current through Mp3 is matched with the current through Mn2, such that no current flows between the R1/R2 resistive divider and into the transistor stack. Assume that there is no body effect on Vt. In order to keep Mp4 in saturation, we must have the following condition:

In other words

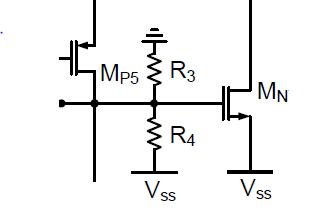
Then R1||R2 = <ratio>/(<1+ratio>R1) = Gain\_CG

R1 = 5/4 Gain\_CG

# First Cgs4

# Second resistor divider

Similarly for R3/R4:



In other words

Use same values as first divider, since GBW product will be less affected by gain since there is a gm factor in this stage.

# third xtor stack

Gain = gm7/gm8

# fourth xtor stack

Script overview

Choose current allocations -> Calculate gm’s -> Calculate Vov’s -> Calculate sizings

1. Find gain equation at each of the 4 stages
   1. Ignore ro, assume ro >> R1-4
2. Find RC time constant at each node
   1. Ignore Cgd b/c Cgd = Cov << Cgs = 2/3WLCox + Cov
   2. Ignore bulk terminal caps b/c hard to estimate
3. Power ≤ 2mW, Vdd - Vss = 5V→ Itot ≤ = 400uA
4. Allocate gain per stage
5. Find R1/R2 ratio = 4
6. Assume R3/R4 = 3
7. Calculate gm from gain and R’s
8. Find power dissipated by the R’s to figure out how much left for xtor stacks
9. Allocate current through 4 stacks based on #5
10. For each xtor,
    1. calculate Vov from its Ids and gm
    2. calculate W from Ids, Vov
    3. calculate Cgs
11. Calculate time constants at each stage. 1/sum must meet our target bandwidth

Gm/id design methodology

1. Start with output stage, MN10. Pick gm/id of 10. Time constant ~ gm10/Cl = allocated 110% of target 90MHz -> solve for gm10. From gm10 and gm/id of 10, solve for id10. From gm and Id, solve for Vov10. Pick min L of 1u for MN10 (CD gain stage). From L, Vov, and id, get W10.
2. MN9 has same Id as MN10 (b/c within same branch). Since MN9 is a bias xtor, pick min L (1u) and min W (2u). Calculate Vov10 from Id, L, and W.
3. Next tackle input stage, MN2. Pick gm/id of 10. Time constant on the input node ~ Cin/gm2 = allocated 20% of total 110Mhz -> solve for gm2. From gm2 and gm/id of 10, solve for id2. From id and gm, solve for Vov2. Pick min L of 1 us for MN2 (CG gain stage). From L, Vov, and id, get W2.
4. Id2 = Id1 = Id3 (within same branch).
   1. Vov1 = Vov9 -> find W1 from Id1 and Vov1
   2. For MP3, since it’s a bias xtor, pick small w=2u and small L=2u. From Id3, w3, and l3, we can solve for Vov3 (how much voltage needed for pmos biasing)
5. 2nd stack, MN6 is a bias xtor. Pick l6=2u, w6=2u. Vov6 = Vov9. From Vov, l, and w, solve for Id6.
6. Id4 = Id5 = Id6
   1. For MP4, pick Gm/id=10 -> find gm4 from Id4 and gm/id. From Id and gm, find Vov4. Pick l4=1u. From l, Vov, Id, solve for w4.
   2. For MP5, we want gm5 ~ gm4 (both in cascade). From gm and Id, solve for Vov. Pick l5=1u. From l, Vov, and Id, solve for w5.
7. Third stack Id = remaining Id after what the other 3 branches + 4 R’s have already used up = Id8 = id 7
   1. For MP8, we know its Vg8 = Vov10. So Vov8 = Vs8 – Vg8 – Vt = Vov10 – Vdd – Vt. Pick l=1u. From l, Id and Vov, solve for w8.
   2. For MN7, pick gm/id = 10. With Id know, solve for gm7. From gm and Id, solve for Vov7. Pick l=1u. From l, Vov, Id, solve for w7.