NOTE on the Mapping

of Differential to Single-Ended Architecture

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****** Differential Symmetrical Architecture**

```
   .....................................................
   :                                         ___       :
   :                                          |        :
   :              +-----cs----------+         cl       :
   :              |                 |         |        :
---:--ci---offp---+--+         +----+----+----+----+---:-----
   :                 |         |         |         |   :
   :                 |         |         |         |   :
   :     vi    va   ca       gm*va      gds       co   : vo -- Symmetry - VCM
   :                 |         |         |         |   :
   :                 |         |         |         |   :
---:--ci---offm---+--+         +----+----+----+----+---:-----
   :              |                 |         |        :
   :              +-----cs----------+         cl       :
   :                                         _|_       :
   .....................................................
```

```
ceq       = co + cl/2 + 1/ (2/cs + 1/ca + 2/ci)

dc_gain   = gm / gds

wt        = SQRT(gm^2 - gds^2) / ceq

off       = va - vi
                             offp =  off/2
                             offm = -off/2
```

Differential Symmetrical Architecture (rewritten)

```
                   +-----cs----------+
                   |                 |
--ci-------offp----+--+         +----+----+------+------+---------
      vi/2      va/2  |         |         |      |      |        vo/2
                     2*ca    2*gm*va/2   2*gds   cl    2*co
                      |         |         |      |      |
  - - - - - - - - - - : - - - - : - - - - : - - -:- - - : -   Symmetry - VCM
      vi/2      va/2  |         |         |      |      |        vo/2
                     2*ca    2*gm*va/2   2*gds   cl    2*co
                      |         |         |      |      |
--ci-------offm----+--+         +----+----+------+------+---------
                   |                 |
                   +-----cs----------+
```

Taking upper part of the Differential Symmetrical Architecture

```
                  +-----cs----------+
                  |                 |
--ci------offp----+--+         +----+----+------+------+---------
      vi/2     va/2  |         |         |      |      |        vo/2
                    2*ca    2*gm*va/2   2*gds   cl    2*co
                     |         |         |      |      |
---------------------+---------+---------+------+------+------------- VCM
```

```
   ..............................................................
   :                                                            :
   :                  +-----cs----------+                       :
   :                  |                 |                       :
 -:--ci------off'------+--+         +----+----+------+------+----:----
   :      vi'       va'   |         |         |      |      |    :  vo'
   :                     2*ca     2*gm*va'    2*gds   cl    2*co  :
   :                      |         |         |      |      |    :
 -:-----------------------+---------+---------+------+------+----:--+-
   :                                                            :  |
   ..............................................................  |
                                                                   |
                                                                  _|_
```

**** Single-Ended Architecture**

```
 ..............................................................
 :                                                            :
 :                  +-----cs'---------+                       :
 :                  |                 |                       :
-:--ci'-----off'----+--+         +----+----+------+------+----:----
 :       vi'     va'   |         |         |      |      |    :  vo'
 :                    ca'     gm'*va'     gds'   cl'    co'   :
 :                     |         |         |      |      |    :
-:---------------------+---------+---------+------+------+----:--+-
 :                                                            :  |
 :............................................................:  |
                                                                 |
                                                                _|_
```

vi' = vi
va' = va
vo' = vo

WE DEFINE THE CORRESPONDENCE (MAPPING):

off' = off
ci' = ci
ca' = 2*ca
co' = 2*co
cl' = cl
cs' = cs
gm' = 2*gm
gds' = 2*gds

WE DEDUCE:

```
ceq'      =  co'  + cl' + 1 / (1/cs' + 1/ca'   + 1/ci')
          =  2*co + cl  + 1 / (1/cs + 1/(2*ca) + 1/ci )
          =  2*co + cl +  2 / (2/cs + 1/ca     + 2/ci )
          =  2 * ceq

dc_gain' =  gm' / gds'
          =  (2*gm) / (2*gds)
          =  gm / gds
          =  dc_gain

wt'       =  SQRT(gm'^2 - gds'^2) / ceq'
          =  SQRT(4*gm^2 - 4*gds^2) / (2*ceq)
          =  SQRT(gm^2 - gds^2) / ceq
          =  wt

off'      =  va' - vi'
          =  va  - vi
          =  offp
          =  off/2
```

**** **Differential Symmetrical Architecture**

```
   .................................................
   :                                   ___         :
   :                                    |          :
   :          +-----cs----------+       cl         :
   :          |                 |       |          :
---:-ci-------+--+         +----+-------+------+---:-----
   :             |         |                   |   :
   :             |         |                   |   :
   :      va    ca        imax                co   :  vo   -- Symmetry - VCM
   :             |         |                   |   :
   :             |         |                   |   :
---:-ci-------+--+         +----+-------+------+---:-----
   :          |                 |       |          :
   :          +-----cs----------+       cl         :
   :                                   _|_         :
   :...............................................:
```

ceq = co + cl/2 + 1 / (2/cs + 1/ca + 2/ci)

sr = imax / ceq

Differential Symmetrical Architecture (rewritten)

```
            +-----cs----------+
            |                 |
---ci-------+--+         +----+-------+------+---------
       va/2    |         |            |      |     vo/2
              2*ca      imax          cl    2*co
               |         |            |      |
 - - - - - - - : - - - - : - - - - - -:- - - : - - - - - - Symmetry -- VCM
       va/2    |         |            |      |     vo/2
              2*ca      imax          cl    2*co
               |         |            |      |
---ci-------+--+         +----+-------+------+---------
            |                 |
            +-----cs----------+
```

Taking upper part of the Differential Symmetrical Architecture

```
            +-----cs----------+
            |                 |
--ci--------+--+          +----+-------+------+---------
     va/2      |          |            |      |          vo/2
             2*ca       imax          cl    2*co
               |          |            |      |
---------------+----------+------------+------+------------- VCM
```

****** Single-Ended Architecture**

```
  ..................................................
  :                                                :
  :                                                :
  :          +-----cs----------+                   :
  :          |                 |                   :
--:--ci------+--+          +----+-------+------+----:----
  :      va'    |          |            |      |    :  vo'
  :           2*ca      2*imax         cl    2*co   :
  :             |          |            |      |    :
--:-------------+----------+------------+------+----:--+-
  :                                                :   |
  :................................................:   |
                                                       |
                                                      _|_
```

va' = va
vo' = vo

WE DEFINE THE CORRESPONDENCE (MAPPING):

ci' = ci
ca' = 2*ca
co' = 2*co
cl' = cl
cs' = cs
imax' = 2*imax

WE DEDUCE:

```
ceq'     =  co'  + cl' + 1 / (1/cs' + 1/ca'   + 1/ci')
         =  2*co + cl  + 1 / (1/cs + 1/(2*ca) + 1/ci )
         =  2*co + cl +  2 / (2/cs + 1/ca     + 2/ci )
         =  2 * ceq


sr'      =  imax'  / ceq'
         =  2*imax / (2*ceq)
         =  imax / ceq
         =  sr
```

****
SUMMARY: MAPPING
****

SE <----> DIFF

```
 vi'      =  vi
 va'      =  va
 vo'      =  vo

 off'     =  off

 ci'      =  ci
 ca'      =  2*ca      ←
 co'      =  2*co      ←
 cl'      =  cl
 cs'      =  cs
 gm'      =  2*gm      ←
gds'      =  2*gds     ←

imax'     =  2*imax    ←
```

****
THIS MAPPING GUARANTEES THAT
****

SE <----> DIFF

```
 dc_gain' =  dc_gain
 wt'      =  wt
 sr'      =  sr
```