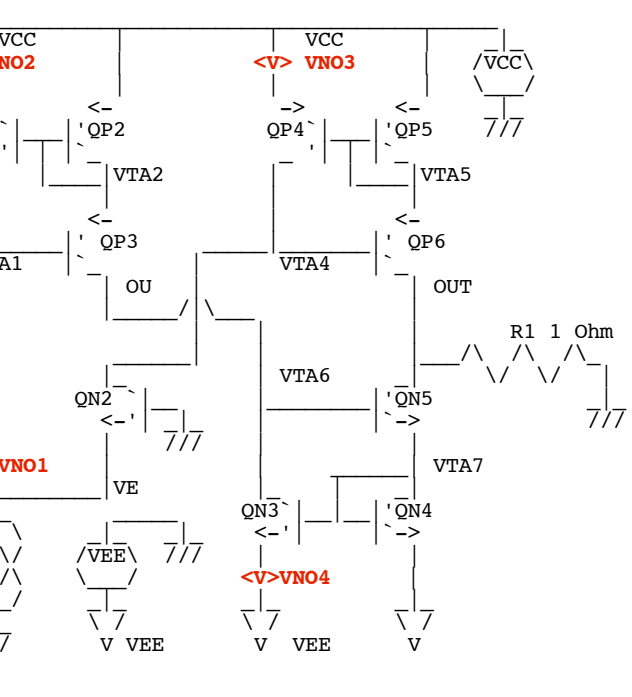
LM3080_Audio_OffsetNoise




```
.OPTIONS  GMIN=1e-12    METHOD=trap   srcsteps = 1  gminsteps = 1
.OPTIONS  ITL1=400      ITL2=100      ITL6=100
.OPTIONS  RELTOL=.001   ABSTOL=1p     VNTOL=1u
*======== ====== ====== ====== ====== ====== ====== ====== ======
VCC       VCC    0      DC     5
VEE       0      VEE    DC     5
VIN       VIN    0      DC     0
VNO1      VNO1   VE     DC     0
VNO2      VNO2   VCC    DC     0
VNO3      VNO3   VCC    DC     0
VNO4      VNO4   VEE    DC     0
IBIAS     VE     0      DC     1u
QN1       VTA1   VIN    VNO1   NPN1   2
QN2       VTA4   0      VE     NPN1   2
QP1       VTA1   VTA2   VNO2   PNP1   1
QP2       VTA2   VTA2   VCC    PNP1   1
QP3       VTA6   VTA1   VTA2   PNP1   1
QP4       VTA4   VTA5   VNO3   PNP1   1
QP5       VTA5   VTA5   VCC    PNP1   1
QP6       OUT    VTA4   VTA5   PNP1   1
QN3       VTA6   VTA7   VNO4   NPN1   1
QN4       VTA7   VTA7   VEE    NPN1   1
QN5       OUT    VTA6   VTA7   NPN1   1
R1        OUT    0      1
```

```
.control
setplot new
set thisData =       data
let $thisData =      0 * vector(18)
set thisData2 =      data2
let $thisData2 =     0 * vector(18)

let n=0
repeat 17
let        unknown.{$thisData2}[n] = n
let n=n+1
endrepeat


*==========Geometry_Sensitivity===================
* Add a voltage source in series with one transistor for each matched pair
* measure the effect of adding a standart error (1mV or 1%)
* Store all gain and offset results for each transistor
* Calibrate each transistor to its area and processing expectations


*#0========Define_1X_NPN_and_PNPL_and_RB_Offsett===========
let        npnoff = .6m
let        pnpoff = 1.1m
let        rboff  = .005
```

```
let         unknown.{$thisData}[0] = npnoff
let         unknown.{$thisData}[1] = pnpoff
let         unknown.{$thisData}[2] = rboff
let         npnbf = @NPN1[bf]
let         pnpbf = @PNP1[bf]
let         npnrb = @NPN1[rb]
let         pnprb = @PNP1[rb]

echo       "Process Expectations  "
echo       "NPN_offset    =  $&npnoff  "
echo       "NPN_beta      =  $&npnbf  "
echo       "NPN_rbase     =  $&npnrb  "
echo       "PNPL_offset   =  $&pnpoff  "
echo       "PNPL_beta     =  $&pnpbf  "
echo       "PNPL_rbase    =  $&pnprb  "
echo       "Rbase_offset =  $&rboff  "
echo       ""

*#0========Measure_With_No_Errors===========
op
let         unknown.{$thisData}[3] = out
let         ibb     = @ibias[dc]
let         icc     =  -1*vcc#branch
echo       "Ibias         =  $&ibb  "
echo       "Isupply       =  $&icc "
echo       ""

*==========Measure_Offset_Gain_Each_Transitor==================
* Add 1mv offset one at a time to each transistor
* Measure change at output
* Store gain and offset results for each transistor
* measure transistor area
* calculate each transistors offset from area and npnoff, pnpoff, and rboff


*#1========Measure_OTA_gm_At_1mV===========
alter       vin     dc =     1m
op
let         gm =    abs(out- unknown.{$thisData}[3]) /1m
let         unknown.{$thisData}[4] = gm
alter       vin     dc =     0

*#2========Measure_VNO1_effect===========
alter       vno1    dc =     1m
op
let         procOff = unknown.{$thisData}[0]
let         Tarea   = @qn1[area]
let         Ioutref = unknown.{$thisData}[3]
let         gm      = unknown.{$thisData}[4]
let         vingain  = 1000*(out - Ioutref)/gm
let         pairOff = (1/Tarea)^.5*procOff
let         vinoff  = pairOff*vingain
let         unknown.{$thisData}[5] = vingain
let         unknown.{$thisData}[6] = vinoff
echo       "Pair      ProcOff   Area  Pair_Off  Gain2Vin   Vin_Offset "
echo       "QN1/QN2   $&procOff    $&Tarea     $&pairOff    $&vingain    $&vinoff"

*#3========Measure_VNO2_effect===========
alter       vno1    dc =     0
alter       vno2    dc =     1m
op
let         procOff = unknown.{$thisData}[1]
let         Tarea   = @qp1[area]
let         Ioutref = unknown.{$thisData}[3]
let         gm      = unknown.{$thisData}[4]
let         vingain  = 1000*(out - Ioutref)/gm
let         pairOff = (1/Tarea)^.5*procOff
let         vinoff  = pairOff*vingain
let         unknown.{$thisData}[7] = vingain
let         unknown.{$thisData}[8] = vinoff
echo       "QP1/QP2   $&procOff    $&Tarea     $&pairOff    $&vingain   $&vinoff"

*#4========Measure_VNO3_effect===========
alter       vno2    dc =     0
alter       vno3    dc =     1m
op
let         procOff = unknown.{$thisData}[1]
let         Tarea   = @qp4[area]
let         Ioutref = unknown.{$thisData}[3]
let         gm      = unknown.{$thisData}[4]
let         vingain  = 1000*(out - Ioutref)/gm
let         pairOff = (1/Tarea)^.5*procOff
let         vinoff  = pairOff*vingain
let         unknown.{$thisData}[9] = vingain
```

```
let         unknown.{$thisData}[10] = vinoff
echo       "QP4/QP5    $&procOff     $&Tarea      $&pairOff    $&vingain   $&vinoff"

*#4========Measure_VNO4_effect===========
alter       vno3    dc =     0
alter       vno4    dc =     1m
op
let         procOff = unknown.{$thisData}[0]
let         Tarea   = @qn3[area]
let         Ioutref = unknown.{$thisData}[3]
let         gm      = unknown.{$thisData}[4]
let         vingain  = 1000*(out - Ioutref)/gm
let         pairOff = (1/Tarea)^.5*procOff
let         vinoff  = pairOff*vingain
let         unknown.{$thisData}[11] = vingain
let         unknown.{$thisData}[12] = vinoff
echo       "QN3/QN4    $&procOff     $&Tarea      $&pairOff    $&vingain    $&vinoff"

*#6========Add_Up_total_offset===========
let         off1    = unknown.{$thisData}[6]
let         off2    = unknown.{$thisData}[8]
let         off3    = unknown.{$thisData}[10]
let         off4    = unknown.{$thisData}[12]
let         Vin_total =  (  off1^2  + off2^2 + off3^2 + off4^2 )^.5

echo        " "
echo        "Total referred to input offset   $&Vin_total"
echo        " "

*#8========Measure_Maximum_Iout===========
alter       vno4    dc =     0
alter       vin     dc =     -130m
op
let         unknown.{$thisData}[12] = out
alter       vin    dc =     0
op

*==========Calculating_Noise_Each_Transitor==================
* Find Area and Emitter current for each transistor (Qn)
* Noise Resistance = (kt/q)/(2*Ie) + Rb/area
* Input_noise_Qn = 4.07nV/rtHz*sqrt(Noise Resistance/1000)
* output_noise_Qn = output_noiseQn*Gain_Qn

*#7========Calc_VNO1_effect_On_Noise===========
let         icc     = @qn1[ic]
let         Tarea   = @qn1[area]
let         rbb     = @NPN1[rb]/Tarea
let         NoiseR  = rbb + 13m/icc
let         NoiseP  = 4.07n*(2*NoiseR/1000)^.5
let         Gain2in = unknown.{$thisData}[5]
let         VinNois = abs(NoiseP*Gain2in)
let         gm      = unknown.{$thisData}[4]
let         IoutNo  = VinNois*gm
let         unknown.{$thisData}[13] = VinNois
echo       "Pair     Ic           NoiseRes  Pair_Noise   Gain2Vin  VnoiseIn_rtHz  OutNoise_rtHz"
echo       "QN1/QN2  $&icc  $&NoiseR   $&NoiseP  $&Gain2in   $&VinNois    $&IoutNo"

*#8========Calc_VNO2_effect_On_Noise===========
let         icc     = @qp1[ic]
let         Tarea   = @qp1[area]
let         rbb     = @PNP1[rb]/Tarea
let         NoiseR  = rbb + 13m/icc
let         NoiseP  = 4.07e-9*(2*NoiseR/1000)^.5
let         Gain2in = unknown.{$thisData}[7]
let         VinNois = abs(NoiseP*Gain2in)
let         gm      = unknown.{$thisData}[4]
let         IoutNo  = VinNois*gm
let         unknown.{$thisData}[14] = VinNois
echo       "QP1/QP2  $&icc  $&NoiseR   $&NoiseP   $&Gain2in  $&VinNois    $&IoutNo"

*#9========Calc_VNO3_effect_On_Noise===========
let         icc     = @qp4[ic]
let         Tarea   = @qp4[area]
let         rbb     = @PNP1[rb]/Tarea
let         NoiseR  = rbb + 13m/icc
let         NoiseP  = 4.07e-9*(2*NoiseR/1000)^.5
let         Gain2in = unknown.{$thisData}[9]
let         VinNois = abs(NoiseP*Gain2in)
let         gm      = unknown.{$thisData}[4]
let         IoutNo  = VinNois*gm
let         unknown.{$thisData}[15] = VinNois
echo       "QP4/QP5  $&icc  $&NoiseR   $&NoiseP $&Gain2in  $&VinNois    $&IoutNo"

*#10=======Calc_VNO4_effect_On_Noise===========
```

```
let        icc     = @qn3[ic]
let        Tarea   = @qn3[area]
let        rbb     = @NPN1[rb]/Tarea
let        NoiseR  = rbb + 13m/icc
let        NoiseP  = 4.07e-9*(2*NoiseR/1000)^.5
let        Gain2in = unknown.{$thisData}[9]
let        VinNois = abs(NoiseP*Gain2in)
let        gm      = unknown.{$thisData}[4]
let        IoutNo  = VinNois*gm
let        unknown.{$thisData}[16] = VinNois
echo      "QN3/QN4  $&icc  $&NoiseR   $&NoiseP $&Gain2in  $&VinNois    $&IoutNo"

*#11=======Add_Up_All_Noise===========

let        off1   = unknown.{$thisData}[13]
let        off2   = unknown.{$thisData}[14]
let        off3   = unknown.{$thisData}[15]
let        off4   = unknown.{$thisData}[16]
let        Vin_T  =  (  off1^2  + off2^2 + off3^2 + off4^2 )^.5
let        Out_T  = Vin_T*gm
let        ibb    = @ibias[dc]
let        ibb    = unknown.{$thisData}[12]
let        SigNo  = 20*log(ibb/(Out_T*141)) -3

let        Rgm    = 1/unknown.{$thisData}[4]
let        Vin_max = ibb*Rgm

echo       " "
echo       "Rgm  (vin/iout)                        $&Rgm Ohms"
echo       "Total referred to input noise_rtHz     $&Vin_T V"
echo       "Vin maxium                             $&Vin_max V"
echo       "Total output current noise_rtHz        $&Out_T A"
echo       "Clipping +/- output current            $&ibb A"
echo       "Clipping 20-20KHz output S/N           $&SigNo dB"

echo       " "


*let y = unknown.{$thisData}
*let x = unknown.{$thisData2}
*plot y vs x


.endc



*======== models Using Near Perfect Transistors ==================
.model     NPN1   NPN(    BF =   200     VAF =  100     rb=400 )
.model     PNP1   PNP(    BF =   30      VAF =  150     rb=900 )
*======== ====== ====== ====== ====== ====== ====== ====== ======

.end




======================END_OF_SPICE=======================
```

To Covert PDF to plain text click below
http://www.fileformat.info/convert/doc/pdf2txt.htm

Circuit: LM3080_Audio_OffsetNoise

```
Process          Expectations
NPN_offset    =  0.0006
NPN_beta      =  200
NPN_rbase     =  400
PNPL_offset   =  0.0011
PNPL_beta     =  30
PNPL_rbase    =  900
Rbase_offset =  0.005

Ibias         =  1E-06
Isupply       =  1.98706E-06

Pair       ProcOff    Area   Pair_Off   Gain2Vin    Vin_Offset
QN1/QN2    0.0006     2      0.00042    1.00025     0.000424371
QP1/QP2    0.0011     1      0.0011     0.91927     0.0010112
QP4/QP5    0.0011     1      0.0011    -0.92239    -0.00101463
QN3/QN4    0.0006     1      0.0006    -1.00849    -0.000605095
```

Total referred to input offset **0.0016119**

Pair	Ic	NoiseRes	Pair_Noise	Gain2Vin	VnoiseIn_rtHz	OutNoise_rtHz
QN1/QN2	4.97832E-07	26313.2	2.95255E-08	1.00025	2.95329E-08	5.64032E-13
QP1/QP2	4.82191E-07	27860.3	3.0381E-08	0.91927	2.79284E-08	5.33388E-13
QP4/QP5	4.81813E-07	27881.4	3.03925E-08	-0.92239	2.80338E-08	5.35401E-13
QN3/QN4	4.94213E-07	26704.5	2.97441E-08	-0.92239	2.74357E-08	5.23978E-13

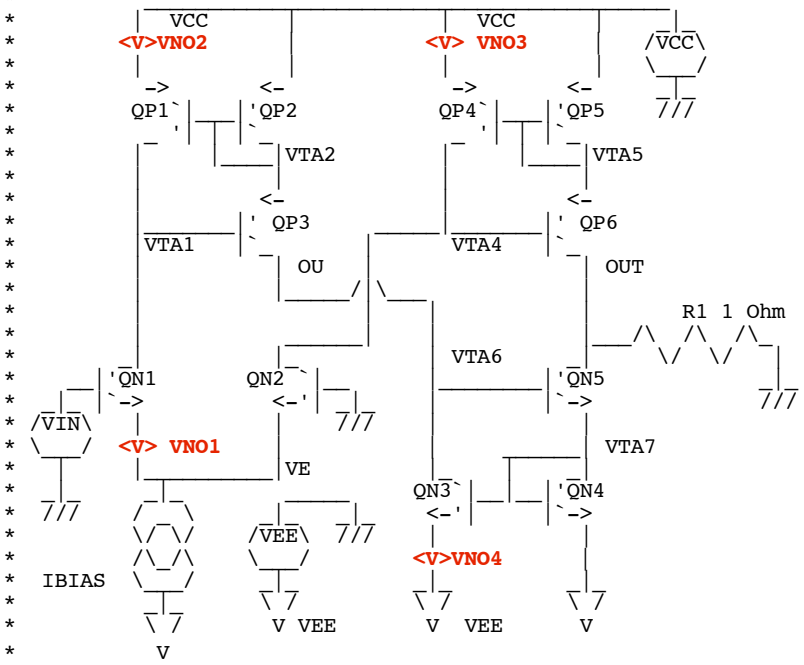
Rgm (vin/iout) 52360.3 Ohms
Total referred to input noise_rtHz **5.64871E-08 V**
Vin maxium **0.0512053 V**
Total output current noise_rtHz 1.07881E-12 A
Clipping +/- output current **9.7794E-07 A**
Clipping 20-20KHz output S/N **73.1629 dB**

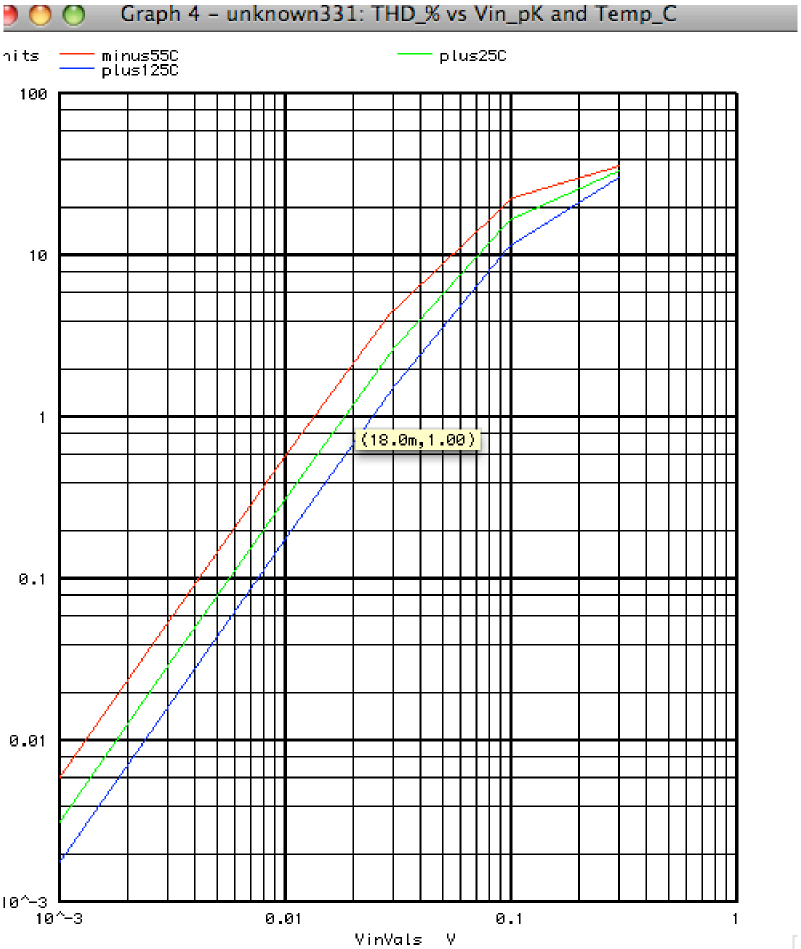
The LM3080 architecture provides a good standard way to measure differential input stages for Operational Transconductor Amplifiers (OTA). Signal to noise in particular tracks the square root of the supply current. Any comparisons made should respect that fact.

This simulation allows the introduction of expected process parameters like beta, offset, rbase, etc. Spice's "alter" state is used find the error contributions of each matched pair. In the LM3080 architecture, there are four matched pairs. If all the pair pairs had the same expected offset, then the total OTA noise and offset would be expected to be a factor of two worst than what comes from just the differential input stage.

The fact that differential input stage is distorted further reduces the offset and noise performance. If a the input signal is kept below the 1% level (+/-18mVpk), a 1.6mV worth of offset is only a factor of ten lower than this practical input level.

The distortion is often lowered by using a pre-distortion stage, which introduces other issues. Assuming the pre-distortion can be done without adding any offset and noise, then the input signal could be raised to the point just below where the output current clips at the 100% maximum output current. Without the pre-distortion stage, the 1% distortion level produces output current at 35% of the maximum output current.






```
=====================WinSPICE_Version=======================

LM3080_Audio_OffsetNoise
*
*          __________________________________________
*         |  VCC       |           |  VCC       |     _|_
*        <V>VNO2       |          <V> VNO3      |    /VCC\
*         |            |           |            |    \___/
*          ->        <-             ->        <-      _|_
*        QP1`|___|'QP2            QP4`|___|'QP5       ///
*         _ '|   |`_               _ '|   |`_
*         |      |___|VTA2         |      |___|VTA5
*         |           <-           |           <-
*         |VTA1______|' QP3   _____|VTA4______|' QP6
*         |          |`_     |                |`_
*         |             | OU  |                  | OUT
*         |             |____/ \___              |
*         |                  |     |             |      R1  1 Ohm
*         |             _____|     |             |___/\  /\  /\_
*         |            |           |  VTA6       |     \/  \/   |
*     ___|'QN1      QN2`|___       |_____________|'QN5        _|_
*    _|_ |`->         <-'  _|_     |             |`->         ///
*   /VIN\   |           |   ///    |                |
*   \___/  <V> VNO1     |          |              __|  VTA7
*     |     |___________|VE        |             |    |
*    _|_   _|_        ____        QN3`|___|___|'QN4
*    ///  / _ \      _|_   _|_     <-'        |`->
*         \/ \/     /VEE\  ///      |            |
*         /\_/\     \___/         <V>VNO4       |
*  IBIAS  \___/      _|_            |            |
*          _|_       \ /           \ /          \ /
*          \ /       V VEE          V   VEE      V
*           V
*
.OPTIONS  GMIN=1e-12    METHOD=trap   srcsteps = 1  gminsteps = 1
.OPTIONS  ITL1=400      ITL2=100      ITL6=100
.OPTIONS  RELTOL=.001   ABSTOL=1p     VNTOL=1u
```

```
*======== ====== ====== ====== ====== ====== ====== ====== ======
VCC       VCC    0      DC     5
VEE       0      VEE    DC     5
VIN       VIN    0      DC     0
VNO1      VNO1   VE     DC     0
VNO2      VNO2   VCC    DC     0
VNO3      VNO3   VCC    DC     0
VNO4      VNO4   VEE    DC     0
IBIAS     VE     0      DC     1u
QN1       VTA1   VIN    VNO1   NPN1   1
QN2       VTA4   0      VE     NPN1   1
QP1       VTA1   VTA2   VNO2   PNP1   1
QP2       VTA2   VTA2   VCC    PNP1   1
QP3       VTA6   VTA1   VTA2   PNP1   1
QP4       VTA4   VTA5   VNO3   PNP1   1
QP5       VTA5   VTA5   VCC    PNP1   1
QP6       OUT    VTA4   VTA5   PNP1   1
QN3       VTA6   VTA7   VNO4   NPN1   1
QN4       VTA7   VTA7   VEE    NPN1   1
QN5       OUT    VTA6   VTA7   NPN1   1
R1        OUT    0      1

.control
setplot new
set thisData =      data
let $thisData =     0 * vector(18)
set thisData2 =      data2
let $thisData2 =     0 * vector(18)

let n=0
repeat 17
let        unknown.{$thisData2}[n] = n
let n=n+1
endrepeat


**0========Define_1X_NPN_and_PNPL_and_RB_Offsett===========
let        npnoff = .6m
let        pnpoff = 1.1m
let        rboff  = .005
let        unknown.{$thisData}[0] = npnoff
let        unknown.{$thisData}[1] = pnpoff
let        unknown.{$thisData}[2] = rboff
let        npnbf = @NPN1[bf]
let        pnpbf = @PNP1[bf]
let        npnrb = @NPN1[rb]
let        pnprb = @PNP1[rb]

echo      "NPN_offset   =  $&npnoff  "
echo      "NPN_beta     =  $&npnbf  "
echo      "NPN_rbase    =  $&npnrb  "
echo      "PNPL_offset  =  $&pnpoff  "
echo      "PNPL_beta    =  $&pnpbf  "
echo      "PNPL_rbase   =  $&pnprb  "
echo      "Rbase_offset =  $&rboff  "
echo      ""

**0========Measure_With_No_Errors===========
op
let        unknown.{$thisData}[3] = out
let        ibb    = @ibias[dc]
let        icc    =  -1*vcc#branch
echo      "Ibias        =  $&ibb  "
echo      "Isupply      =  $&icc "
echo      ""
**1========Measure_gm_At_1mV===========
alter      vin    dc =    1m
op
let        gm =   abs(out- unknown.{$thisData}[3]) /1m
let        unknown.{$thisData}[4] = gm
alter      vin    dc =    0

**2========Measure_VNO1_effect===========
alter      vno1   dc =    1m
op
let        procOff = unknown.{$thisData}[0]
let        Tarea   = @qn1[area]
let        Ioutref = unknown.{$thisData}[3]
let        gm      = unknown.{$thisData}[4]
let        vingain  = 1000*(out - Ioutref)/gm
let        pairOff = (1/Tarea)^.5*procOff
let        vinoff  = pairOff*vingain
let        unknown.{$thisData}[5] = vingain
let        unknown.{$thisData}[6] = vinoff
```

```
echo      "Pair      ProcOff   Area  Pair_Off  Gain2Vin   Vin_Offset "
echo      "QN1/QN2   $&procOff    $&Tarea     $&pairOff    $&vingain    $&vinoff"

**3========Measure_VNO2_effect==========
alter      vno1   dc =    0
alter      vno2   dc =    1m
op
let        procOff = unknown.{$thisData}[1]
let        Tarea   = @qp1[area]
let        Ioutref = unknown.{$thisData}[3]
let        gm      = unknown.{$thisData}[4]
let        vingain  = 1000*(out - Ioutref)/gm
let        pairOff = (1/Tarea)^.5*procOff
let        vinoff  = pairOff*vingain
let        unknown.{$thisData}[7] = vingain
let        unknown.{$thisData}[8] = vinoff
echo      "QP1/QP2   $&procOff    $&Tarea     $&pairOff    $&vingain   $&vinoff"

**4========Measure_VNO3_effect==========
alter      vno2   dc =    0
alter      vno3   dc =    1m
op
let        procOff = unknown.{$thisData}[1]
let        Tarea   = @qp4[area]
let        Ioutref = unknown.{$thisData}[3]
let        gm      = unknown.{$thisData}[4]
let        vingain  = 1000*(out - Ioutref)/gm
let        pairOff = (1/Tarea)^.5*procOff
let        vinoff  = pairOff*vingain
let        unknown.{$thisData}[9] = vingain
let        unknown.{$thisData}[10] = vinoff
echo      "QP4/QP5   $&procOff    $&Tarea     $&pairOff   $&vingain  $&vinoff"

**5========Measure_VNO4_effect==========
alter      vno3   dc =    0
alter      vno4   dc =    1m
op
let        procOff = unknown.{$thisData}[0]
let        Tarea   = @qn3[area]
let        Ioutref = unknown.{$thisData}[3]
let        gm      = unknown.{$thisData}[4]
let        vingain  = 1000*(out - Ioutref)/gm
let        pairOff = (1/Tarea)^.5*procOff
let        vinoff  = pairOff*vingain
let        unknown.{$thisData}[11] = vingain
let        unknown.{$thisData}[12] = vinoff
echo      "QN3/QN4   $&procOff    $&Tarea     $&pairOff   $&vingain   $&vinoff"

**6========Measure_total_offset==========
let        off1   = unknown.{$thisData}[6]
let        off2   = unknown.{$thisData}[8]
let        off3   = unknown.{$thisData}[10]
let        off4   = unknown.{$thisData}[12]
let        Vin_total =  (  off1^2  + off2^2 + off3^2 + off4^2 )^.5

echo       " "
echo       "Total referred to input offset   $&Vin_total"
echo       " "

**7========Measure_Maximum_Iout==========
alter      vno4   dc =    0
alter      vin    dc =    -130m
op
let        unknown.{$thisData}[12] = out
alter      vin   dc =    0
op

**9========Calc_VNO1_effect_On_Noise==========
let        icc     = @qn1[ic]
let        Tarea   = @qn1[area]
let        rbb     = @NPN1[rb]/Tarea
let        NoiseR  = rbb + 13m/icc
let        NoiseP  = 4.07n*(2*NoiseR/1000)^.5
let        Gain2in = unknown.{$thisData}[5]
let        VinNois = abs(NoiseP*Gain2in)
let        gm      = unknown.{$thisData}[4]
let        IoutNo  = VinNois*gm
let        unknown.{$thisData}[13] = VinNois
echo      "Pair ,   Ic ,       NoiseRes, Pair_Noise, Gain2Vin, VnoiseIn_rtHz,OutNoise_rtHz"
echo      "QN1/QN2, $&icc, $&NoiseR, $&NoiseP, $&Gain2in, $&VinNois, $&IoutNo"

**9========Calc_VNO2_effect_On_Noise==========
let        icc     = @qp1[ic]
let        Tarea   = @qp1[area]
```

```
let        rbb     = @PNP1[rb]/Tarea
let        NoiseR  = rbb + 13m/icc
let        NoiseP  = 4.07e-9*(2*NoiseR/1000)^.5
let        Gain2in = unknown.{$thisData}[7]
let        VinNois = abs(NoiseP*Gain2in)
let        gm      = unknown.{$thisData}[4]
let        IoutNo  = VinNois*gm
let        unknown.{$thisData}[14] = VinNois
echo      "QP1/QP2, $&icc, $&NoiseR, $&NoiseP, $&Gain2in, $&VinNois, $&IoutNo"

**!)========Calc_VNO3_effect_On_Noise===========
let        icc     = @qp4[ic]
let        Tarea   = @qp4[area]
let        rbb     = @PNP1[rb]/Tarea
let        NoiseR  = rbb + 13m/icc
let        NoiseP  = 4.07e-9*(2*NoiseR/1000)^.5
let        Gain2in = unknown.{$thisData}[9]
let        VinNois = abs(NoiseP*Gain2in)
let        gm      = unknown.{$thisData}[4]
let        IoutNo  = VinNois*gm
let        unknown.{$thisData}[15] = VinNois
echo      "QP4/QP5, $&icc, $&NoiseR, $&NoiseP, $&Gain2in, $&VinNois, $&IoutNo"

**11=======Calc_VNO4_effect_On_Noise===========
let        icc     = @qn3[ic]
let        Tarea   = @qn3[area]
let        rbb     = @NPN1[rb]/Tarea
let        NoiseR  = rbb + 13m/icc
let        NoiseP  = 4.07e-9*(2*NoiseR/1000)^.5
let        Gain2in = unknown.{$thisData}[9]
let        VinNois = abs(NoiseP*Gain2in)
let        gm      = unknown.{$thisData}[4]
let        IoutNo  = VinNois*gm
let        unknown.{$thisData}[16] = VinNois
echo      "QN3/QN4, $&icc, $&NoiseR, $&NoiseP, $&Gain2in, $&VinNois, $&IoutNo"

let        off1   = unknown.{$thisData}[13]
let        off2   = unknown.{$thisData}[14]
let        off3   = unknown.{$thisData}[15]
let        off4   = unknown.{$thisData}[16]
let        Vin_T  =  (  off1^2  + off2^2 + off3^2 + off4^2 )^.5
let        Out_T  = Vin_T*gm
let        ibb    = @ibias[dc]
let        ibb    = unknown.{$thisData}[12]
let        SigNo  = 20*log(ibb/(Out_T*141)) -3

echo       " "
echo       "Total referred to input noise_rtHz   $&Vin_T V"
echo       "Total output current noise_rtHz      $&Out_T A"
echo       "Clipping +/- output current          $&ibb A"
echo       "Clipping 20-20KHz output S/N         $&SigNo dB"

echo       " "



.endc



*======== models Using Near Perfect Transistors ==================
.model    NPN1   NPN(   BF =   200    VAF =  100    rb=400 )
.model    PNP1   PNP(   BF =   30     VAF =  150    rb=900 )
*======== ====== ====== ====== ====== ====== ====== ====== ======

.end
```