



lab2 PVT and Monte-Carlo simulation

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Outline

- AC simulation of OPA
- PVT simulation
- Monte-Carlo Simulation



Testbench example



■ 设置Vsin源的 AC magnitude =1



Set DC and AC analyses

| 32) - la | yout_course ts_opa0 schemati | c _ □ × |
|------------------|--|--------------------------------|
| <u>A</u> nalyses | <u>V</u> ariables <u>O</u> utputs <u>S</u> imulation <u>R</u> esults <u>T</u> ools Calibr | re <u>H</u> elp cādence |
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| | Analyses | ? 🗗 X |
| | Type Enable Arguments | ODC |
| Value | 1 dc 🗹 t | [0] |
| | 2 ac 📝 1 1 G Automatic Start-Stop | 119 |
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| | Outputs | ? = × 🕞 |
| | Outputs Name/Signal/Expr Value Plot Save Save | ? 5 × O |
| | Outputs Name/Signal/Expr Value Plot Save DCgain wave Image: Contract of the second secon | e Options |
| | Outputs Name/Signal/Expr Value Plot Save DCgain wave Image: Compare the second se | e Options |
| | Outputs Name/Signal/Expr Value Plot Save Save DCgain wave 2 Phase wave 3 DCgain_value 20.5 | e Options |
| | Outputs Name/Signal/Expr Value Plot Save Save DCgain wave Phase wave 3 DCgain_value 20.5 4 PM_value 95.23 | e Options |



Set DC gain

| <u>∖</u> nalyses <u>V</u> ariables | <u>Outputs</u> Simulation | <u>R</u> esults <u>T</u> ools Calibre <u>H</u> elp | cāden |
|------------------------------------|--|--|-------|
| Value | Export Delete Import Export To Be Sayed To Be Plotted Save <u>A</u> ll | Arguments Itomatic Start-Stop | ? 8 X |







Set DC gain

| | | | • | |
|------------|---------|----------------|----------|-------|
| 1/X | acos | b1f | convolve | dBm |
| 10**X | acosh | bandwidth | cos | delay |
| PN | asin | clip | cosh | deriv |
| Rn | asinh | compare | cross | dft |
| a2d | atan | compression | d2a | dftbb |
| abs | atanh | compressionVRI | dB10 | dnl |
| abs_jitter | average | conjugate 🤇 | dB20 | dutyC |



| lame (opt.) | DC_gain |
|-------------|--|
| xpression | dB20((VF("/vop") - VF("/von"))) From Schematic |
| alculator | Open Get Expression Close |
| /ill be | Plotted/Evaluated |



Set Phase

| Film Schen | MOTION I |
|--------------------------------------|----------|
| Calculator Open Get Expression Close | nauc |



- PVT means Process, Voltage, Temperature
- In XFAB035 technology, Process corner includes tm, wp, ws

y A X & X

- Voltage may include 3.2, 3.3, 3.4V
- Temperature may include -20, 27, 80°

Step1: set variable of supply voltage







Step2: open ADE XL

| ADE XL | | |
|-----------------|---------|------------|
| AD <u>E</u> GXL | | Analyses |
| esign Variable | S | Type Ena |
| Vddx Name | 3 Value | |



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| Č | ADE XL Edit | ting: layo | out_cour |
|--|---|--|---|
| <u>L</u> aunch <u>F</u> ile <u>C</u> reate <u>T</u> ools | <u>O</u> ptions R <u>u</u> n EAD | Pa <u>r</u> asitics/LDE | <u>W</u> indow C |
| 1 🗅 🗁 🗔 🏹 1 🍯 | l 🖞 🖼 🗳 | » 🛛 🔒 | |
| No Parasitics/LDE | 🚽 🐁 🛄 » | Single Run, Sv | weeps and Co |
| Data View | Output | ts Setup 📄 🦷 | esults D |
| Corners Nominal Click to add corner Documents Setup States E Reliability Analyses | Test layout_ layout_ layout_ layout_ layout_ | Name DCgain DCgain Phase DCgain Phase DCgain DCgain DCgain GBW | Type Exp expr dB20 expr phas expr value expr phas expr unity |

| | | Corners Setu |
|-------------------|---------|-------------------|
| SDB PCF 🖬 🖬 | | P 11 11 1 1 1 8 8 |
| Corners | Vominal | |
| Temperature | | |
| Design Variables | | |
| Click to add | | |
| Parameters | | |
| Click to add | | |
| Model Files | | |
| Click to add | | |
| Model Group(s) | | |
| Click to add | | |
| Tests | | |
| 📝ourse:ts_opa0:1 | ✓ | |
| Number of Corners | 1 | |
| | | |
| | | |



| | | | | c | orners | Se |
|-------------------|----------|---------|---|-----------|-----------|----|
| SDB PCF 🖬 🖬 | 8 | 0 6 | | Phi | i Itt i õ | 10 |
| Corners | <u>~</u> | Nominal | <u> </u> | CO | | _ |
| Temperature | | | | 0 27 80 | | |
| Design Variables | | - | - | | - | |
| vddx | | | | 2.9 3 3.1 | | |
| Click to add | | | - | | | |
| Parameters | | | | | | |
| Click to add | | | | | | |
| Model Files | | | | | | |
| Click to add | | | | | | |
| Model Group(s) | | | <mode< td=""><td>elgroup></td><td></td><td></td></mode<> | elgroup> | | |
| Click to add | | | | | | |
| Tests | | | | | | |
| ✓ourse:ts_opa0:1 | ✓ | | | | | |
| Number of Corners | | 1 | | 9 | | |











| Corners | ~ | Nominal | 🗹 C0 |
|-------------------|----------|---------|-----------|
| Temperature | | | 0 27 80 |
| Design Variables | | | |
| Vddx | | | 2.9 3 3.1 |
| Click to add | | | |
| Parameters | | | |
| Click to add | | | |
| Model Files | | | |
| Click to add | | | \frown |
| Model Group(s) | | | tm ws wp |
| Click to add | | | |
| Tests | | | |
| ✓ourse:ts_opa0:1 | ~ | | V |
| Number of Corners | | 1 | 27 |



| | Parameter Model Group temperature vddx | Nominal 80 3 | |
|--|---|---|-----|
| est | Output | Nominal Spec Weight Pass/Fa | ail |
| e:ts_opa0:1 e:ts_opa0:1 e:ts_opa0:1 e:ts_opa0:1 | DCgain Phase DCgain_value PM_value | Output <u>L</u> og <u>V</u> iew Netlist Open Terminal | |
| etts_opaoti | GBW | Plot Plot Across Corners Plot Across Design Points | |



- Process variation and mismatch simulation
- Step 1: set output results as values(double click outputs)

| Outputs | | | | 75 |
|-----------------------|-------|------|------|--------------|
| Name/Signal/Expr | Value | Plot | Save | Save Options |
| <mark>1</mark> DCgain | wave | ✓ | | |
| 2 Phase | wave | ⊻ | | |
| | | | | |

| Selected Output | |
|---------------------------------|-----------------|
| DCgain | |
| dB20((VF("/vop") - VF("/von"))) | From Schematic |
| Open Get Expression Close | |
| Plotted/Evaluated | |
| Delete Change Next New Expres | sion |
| Delete Change Herr Herr Lypies | 51011 |
| | Selected Output |



Step 1: set output results as values

E.

| | | | alue | | |
|---|---|--|---|--------------------|--------------|
| spectralPower | tangent | vh yma: | Signal | dB20((VF("/vop") - | VF("/von"))) |
| spectrumMeas | tanh thd | vtime ymin ×**2 ypm | Interpolate At | 10 | |
| lingTime sqrt ssb n stddev vRate tan | totalNoise unityGainFreq value vfreq | xmax zpm xmin xval v**x | Number of occurrences | single | |
| | | | | | |
| | Name (opt.) Expression Calculator Will be Add | DCgain_value value (dB20 ((Open Get V Plotted/Evalue Delete Chan | VF ("/vop") – VF ("/von")) Expression Close uated | From Schematic | |

Step 1: set output results as values

| | Selected Output | |
|-------------|--------------------------------------|----------------|
| Name (opt.) | PM_value | |
| Expression | phaseMargin((VF("/vop") - VF("/von") | From Schematic |
| Calculator | Open Get Expression Close | |
| Will be | ✓ Plotted/Evaluated | |
| | | |
| (And) | | 5 |
| Add | Delete Change Next New Expression | n |

| | Selected Output |
|-------------|---|
| Name (opt.) | GBW |
| Expression | unityGainFreq((VF("/vop") - VF("/von From Schematic |
| Calculator | Open Get Expression Close |
| Will be | ✓ Plotted/Evaluated |
| Add | Delete Change Next New Expression |
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20

Step 2: change model library

| ADE 1240 | ADE L (26) - layout_cours | e ts_opa1 schematic | spectre25: Model Library Setup | |
|-------------------------|---|---|--|--|
| Launch S <u>e</u> ssion | Set <u>up A</u> nalyses <u>V</u> ariables <u>O</u> utputs | <u>S</u> imulation <u>R</u> esults <u>T</u> ools Ca | Model File | Section |
| Design Variables | Design Simulator/Directory/Host High-Performance Simulation Model Libraries Temperature Stimuli Stimulation <u>Files</u> MATLAB/Simulink | nable Argumer t 1 1G Automatic Start-Stop | Global Model Eles Global Model Eles Process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/bsim3v3.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/bsim3v3.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/cap.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/cap.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/cap.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/cap.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/cap.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/sin3.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/nd.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/sin3.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/sin3.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/sin3.scs /process/xfab/xh035/cadence/v6_2/spectre/v6_2_4/mos/sin3.scs | 3s tm tm tm tm tm tm tm mc_g |
| | Outputs Name/S 1 DCgain 2 Phase | iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii | 0 | Cancel Apply |



Step 3: open ADE XL









Step 4: setup for ADE XL

| 🖕 » Monte Carlo Sampling 🗾 🗞 🚳 🧿 🙆 | | | | | | |
|------------------------------------|--------|------|------------------------|----------|--|--|
| Outputs Setup Results Diagnostics | | | | | | |
| 🎸 • 🗶 🎭 💷 🍞 🗁 🕞 🕤 💿 🦿 | | | | | | |
| Test 🔺 | Name | Туре | Expression/Signal/File | EvalType | | |
| layout | DCgain | expr | dB20(VF("/vout")) | point | | |
| layout | Phase | expr | phase(VF("/vout")) | point | | |
| layout | DCgain | expr | value(dB20(VF("/vout") | point | | |

| | Monte | Carlo | × |
|--------------------------------|--|----------------------------|------|
| - <mark>Statis</mark> O Pro | stical Variation | natch 🥑 All | |
| Samp | ling Method | | - |
| Rando | im 🔽 | | |
| Numb | er of Points | 100 | |
| Numbe | er of Bins | | -1 |
| 🗌 Aut | o Stop Using S | ignificance Test | |
| Target | Yield | 99.73 | % |
| alpha | | 0.05 | |
| Resul ⊻ Sav | ts Database S ve Process Dat ve Mismatch Da | Save Options — a ata | |
| Other | Options | | 3 |
| 🗌 Use | Reference Poi | int | |
| 🛃 Run | Nominal Simu | lation | |
| Sav | e Data to Allov | v Family Plots | |
| Monte | Carlo Seed | | |
| 🛄 Star | ting Run Numb | er | |
| Specif | y Instances/De | vices (Not Specif | ied) |
| | ОК | Cancel | lelp |



Step 5: check histogram

| 山 » M | onte Carlo Samplin | g | - 🗞 - | 🚸 💿 🙆 | Referer | ice: | | | |
|--------------|------------------------|-------------|----------------------|----------------|---|-------------|-----------------|----------------------|-----------------|
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| Outputs Se | tup Results | Diagr | nostics | | | | | Calibre <u>H</u> elp | cādence |
| Yield | . | III. 🖬 | 🛛 🗠 Rep | olace 🔽 | 12 1 | 🧧 💌 | 🙀 🗊 » | | |
| Test | Name | Yield | Min Targ | jet Max | Me 🍄 | ayout_cours | e:ts_opa1:1 🔹 🕨 | Plot/Print Ver | sus Iteration 📄 |
| Parameters: | Yield Estimate: 10 | 10 %(200 pa | assed/200 pts) | Confidenc | e Level: <n(< td=""><td>ot set></td><td></td><td>Print Correlati</td><td>on [</td></n(<> | ot set> | | Print Correlati | on [|
| 🛛 – 🞲 layou | it_course:ts_opa1:1 | 1 | | | | | | Histogram | |
| | DCgain DCgain_value | υ 100 ε | 0 info 33.82 info |) U) 85.57 | U 84.78 | U 341.2m | | Scatterplot | |
| | Phase | 0 | 0 info |) () | 0 | 0 | | | |
| | | | | | | | | | × |
| | | | | | | | | | |



Step 5: check histogram

| | Histogra | am × |
|--|-----------|----------------------------|
| V-axis DCgain_value DEL_dbf LEL_dcjc LEL_dcje LEL_dis LEL_dis LEL_drb | | Plot DCgain_value |
| Number of Bins | 10 | |
| Туре | standard | |
| Plot Mode | Replace 🔽 | |
| Annotations Density Estimator Std Dev Lines | | |
| Additional Plots Normal Quantile Plots | | Cancel Defaults Apply Help |







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