

Virtuoso 23.1

Module 5 – Monte Carlo Statistical Analysis

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Contents

Monte Carlo Statistical Analysis

Module Objective

In this module, we will learn how to:

- run a Monte Carlo analysis
- display the process and mismatch variations of an iteration

Monte Carlo Statistical Analysis

Monte Carlo Statistical Analysis

- Monte Carlo is a technique used to forecast all the possible outcomes of a circuit design by randomizing its parameters and variables, thus generating a full set of device models.
- Due to imperfections during fabrication, variations subsist. These variations can be:
 - Local (mismatch)
 - Global (process)
- Process Variations are the variations from wafer to wafer; while Mismatch Variation is a variation of two components across the same wafer, which generates for example input offsets in OpAmps and Comparators.

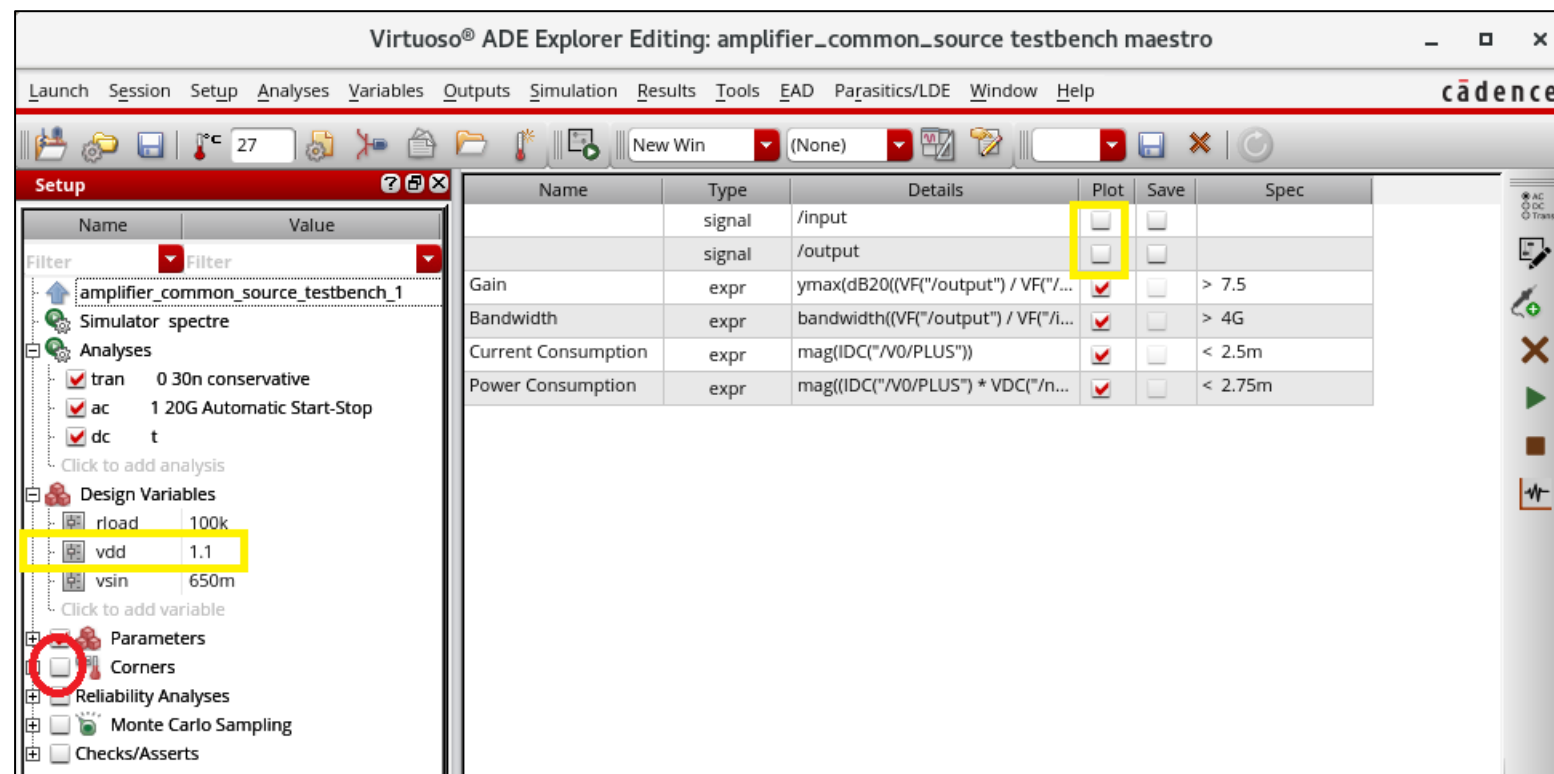
- Monte Carlo simulations give a more realistic insight into the design performance than corner simulations.

Monte Carlo Statistical Analysis (*continued*)

- Since Monte Carlo Analysis simply mimics the variability of the fabrication process, both of the variations can be simulated in Monte Carlo.
- ADE Explorer provides the ability to run Monte Carlo simulations so you can:
 - Estimate the yield of your design.
 - Generate information about the performance of your circuit design.
- Yield is the unit of measure for statistical design. It is defined as the ratio of the number of designs that pass the performance specifications to the total number of designs that are produced. It may also be thought of as the probability that a given design sample will pass the specifications.

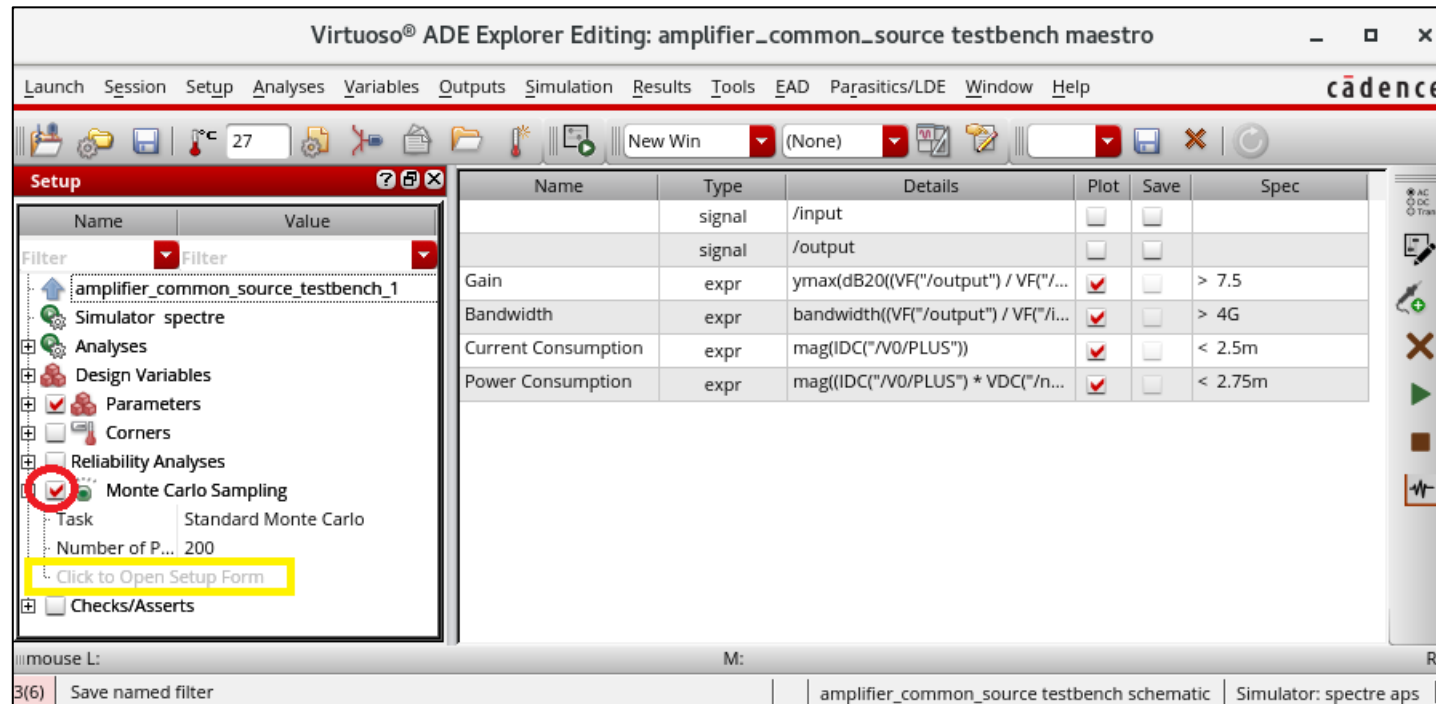
Monte Carlo Statistical Analysis (*continued*)

- Select the “amplifier_common_source” library, the “testbench” cell, and double click on the maestro view.
- To run Monte Carlo, make sure that Corners are unchecked, and Sweeps are removed. Also, uncheck the Plot of the output and input expressions.



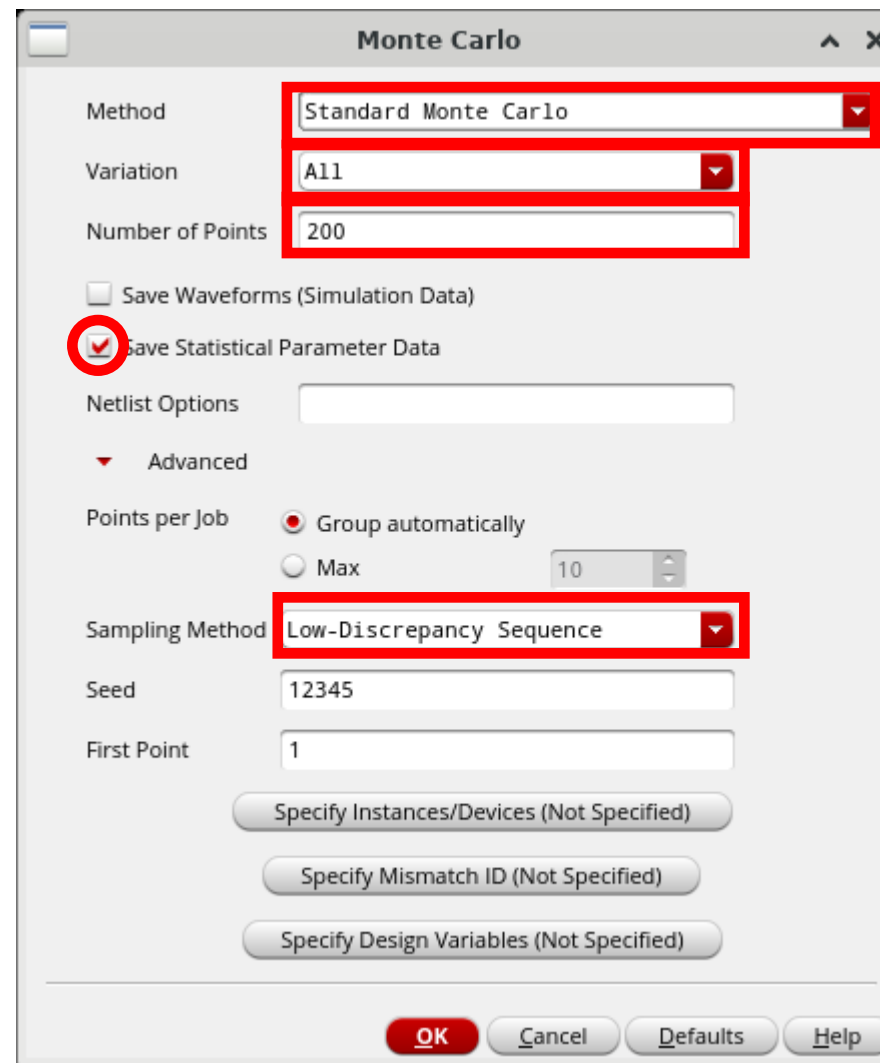
Monte Carlo Statistical Analysis (*continued*)

- Check the **Monte Carlo Sampling** checkbox, then click on **Click to Open Setup Form**.



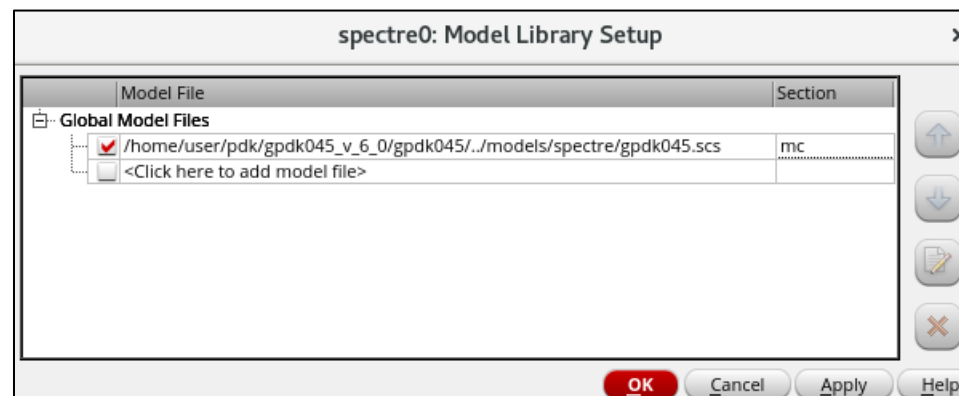
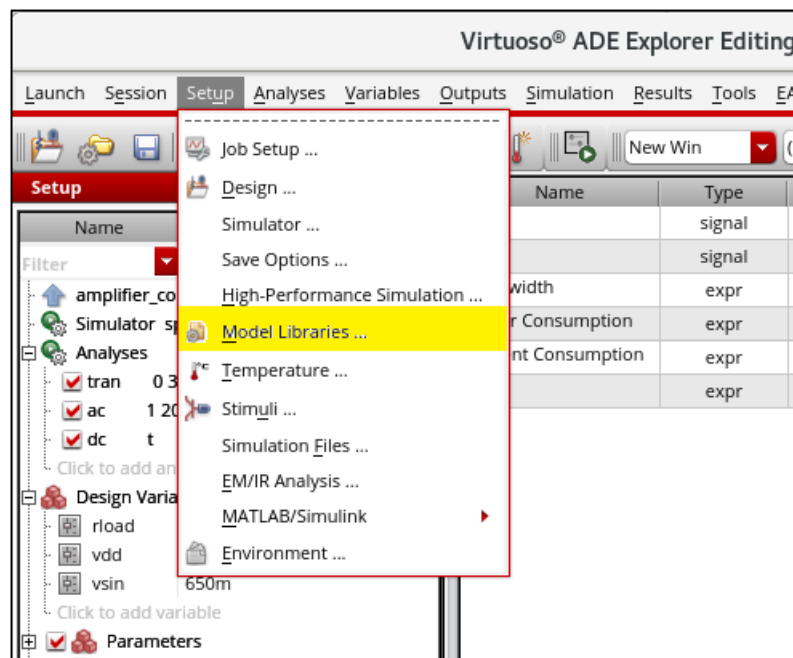
Monte Carlo Statistical Analysis (*continued*)

- Notice that ADE Explorer provides a variety of advanced statistical simulation algorithms beside the “Standard Monte Carlo” method.
- Under Variation you can choose to simulate “Mismatch”, “Process” or “All”.
- Set the “Number Of Points” to 200.
- Click on **Advanced**.
- Make sure the “Sampling Method” is set to Low-Discrepancy Sequence.
- Click on **OK**.



Monte Carlo Statistical Analysis (*continued*)

- Make sure that the process corner “**mc**” is selected.



- Click on the green **Run Simulation** icon on the right side of your window.
- Expressions in the Output Setup tab that have the “Plot” enabled, will have a histogram plotted.

- If the Model Library is not set, please check Module 3 slide 14.

Monte Carlo Statistical Analysis (*continued*)

- The display changes automatically to “Yield”.
- The number of passing and failing trials is recorded and these numbers are used to compute an estimate of the yield.
- The yield for each output is displayed along with a total estimated yield.
- The Yield Estimate in this case is 100%. Note that it is usually quite difficult to meet all corners (100% yield).

Outputs Setup

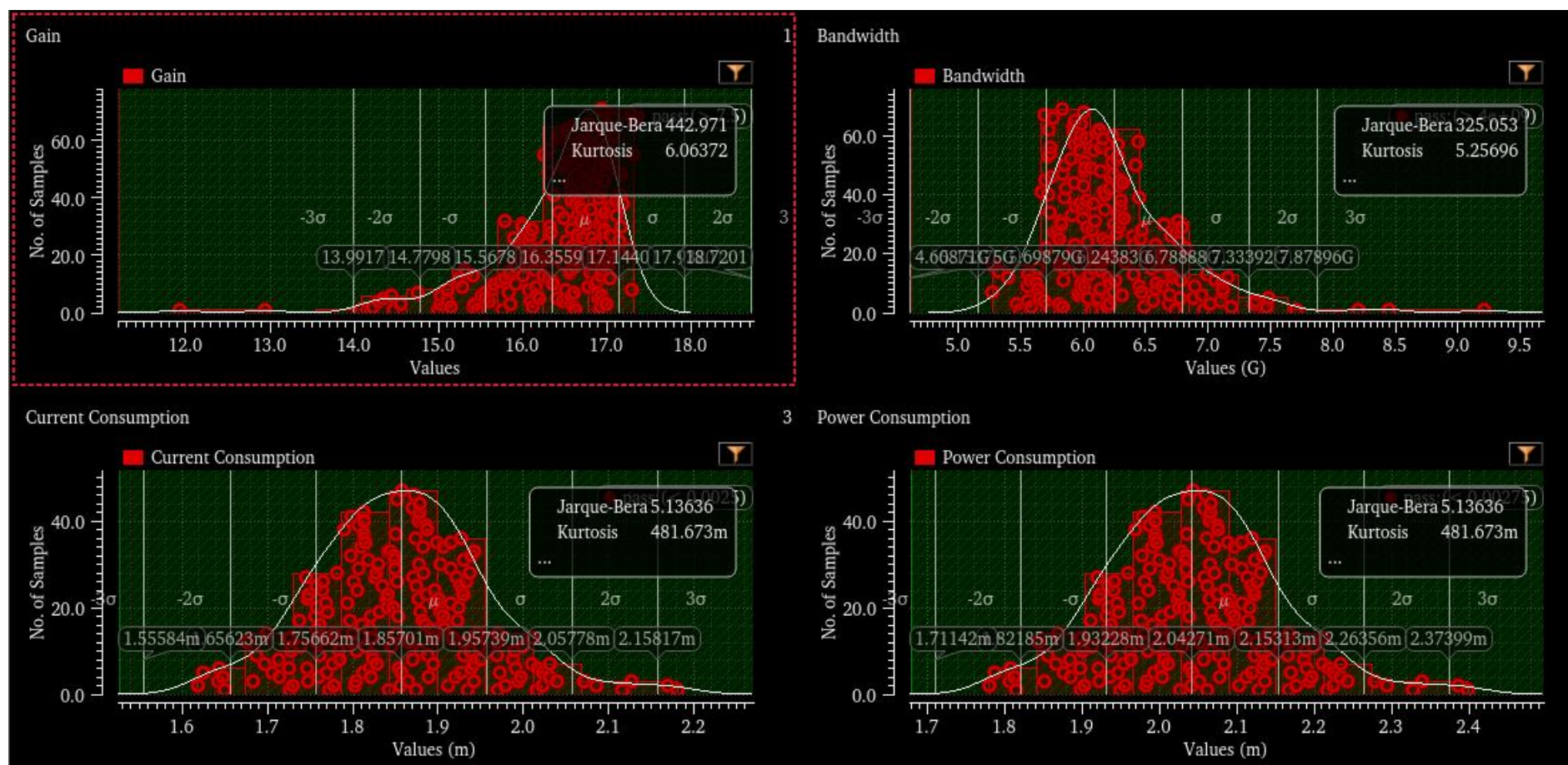
Results

Yield

Test	Name	Yield	Min	Target	Max	Mean	Std Dev	Cpk	Errors
Yield Estimate: 100 %(200 passed/200 pts) Confidence Level: <not set> Filter: <not set>									
-	amplifier_common_source_testbench_1								
-	Gain(summary)	100% (200/200)	11.93 dB	> 7.5	17.32 dB	16.36 dB	788.1 mdB	3.75	0
	Gain	100% (200/200)	11.93 dB	> 7.5	17.32 dB	16.36 dB	788.1 mdB	3.75	0
-	Bandwidth(summary)	100% (200/200)	5.271 GHz	> 4G	9.209 GHz	6.244 GHz	545 MHz	1.37	0
	Bandwidth	100% (200/200)	5.271 GHz	> 4G	9.209 GHz	6.244 GHz	545 MHz	1.37	0
-	Current Consumption(summary)	100% (200/200)	1.618 mA	< 2.5m	2.181 mA	1.857 mA	100.4 uA	2.14	0
	Current Consumption	100% (200/200)	1.618 mA	< 2.5m	2.181 mA	1.857 mA	100.4 uA	2.14	0
-	Power Consumption(summary)	100% (200/200)	1.78 mW	< 2.75m	2.399 mW	2.043 mW	110.4 uW	2.14	0
	Power Consumption	100% (200/200)	1.78 mW	< 2.75m	2.399 mW	2.043 mW	110.4 uW	2.14	0

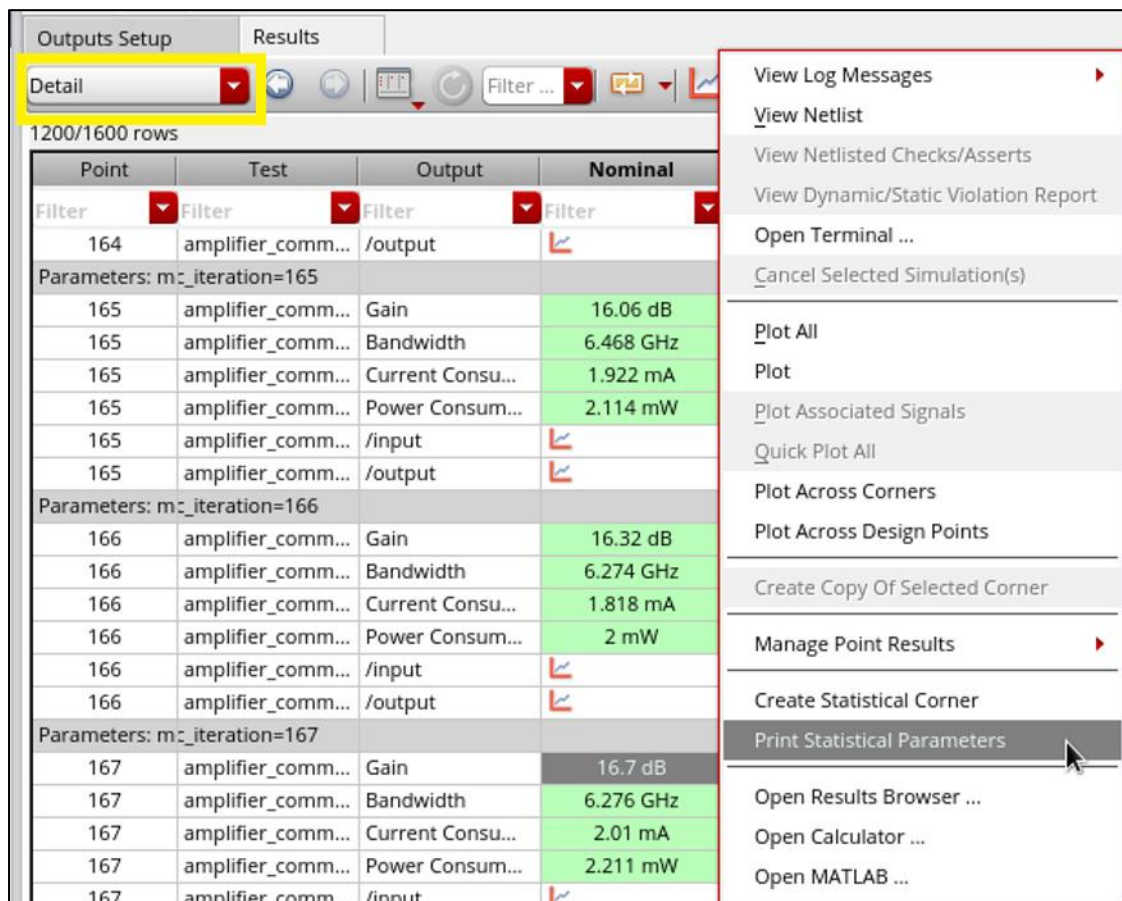
Monte Carlo Statistical Analysis (*continued*)

- The results are also plotted using a histogram for each output expression.
- The Gain, Bandwidth, Current and Power Consumption pass all 200 iterations of corners.

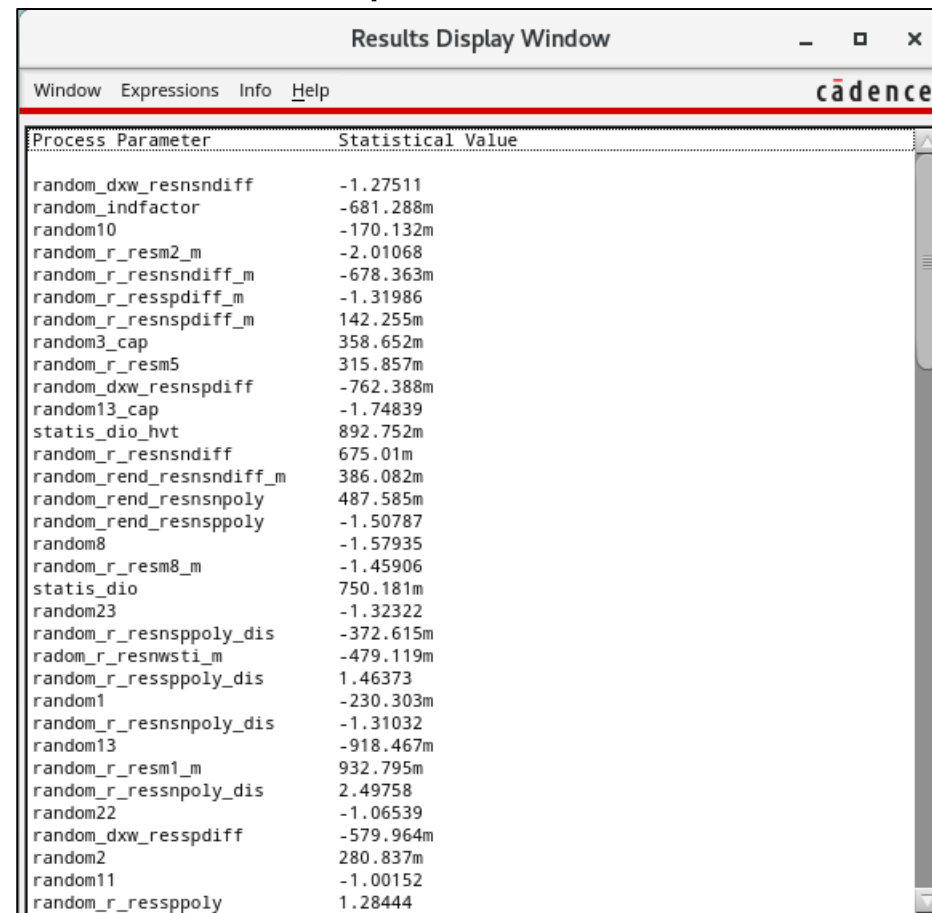


Monte Carlo Statistical Analysis (continued)

- To delve deeper into a design specification, consider exploring the "Detail" display view and selecting the design point. In this investigation, right-click on the point and choose "Print Statistical Parameters."
- This approach allows a more comprehensive examination of the process.



Point	Test	Output	Nominal
164	amplifier_comm...	/output	
Parameters: mc_iteration=165			
165	amplifier_comm...	Gain	16.06 dB
165	amplifier_comm...	Bandwidth	6.468 GHz
165	amplifier_comm...	Current Consu...	1.922 mA
165	amplifier_comm...	Power Consum...	2.114 mW
165	amplifier_comm...	/input	
165	amplifier_comm...	/output	
Parameters: mc_iteration=166			
166	amplifier_comm...	Gain	16.32 dB
166	amplifier_comm...	Bandwidth	6.274 GHz
166	amplifier_comm...	Current Consu...	1.818 mA
166	amplifier_comm...	Power Consum...	2 mW
166	amplifier_comm...	/input	
166	amplifier_comm...	/output	
Parameters: mc_iteration=167			
167	amplifier_comm...	Gain	16.7 dB
167	amplifier_comm...	Bandwidth	6.276 GHz
167	amplifier_comm...	Current Consu...	2.01 mA
167	amplifier_comm...	Power Consum...	2.211 mW
167	amplifier_comm...	/input	

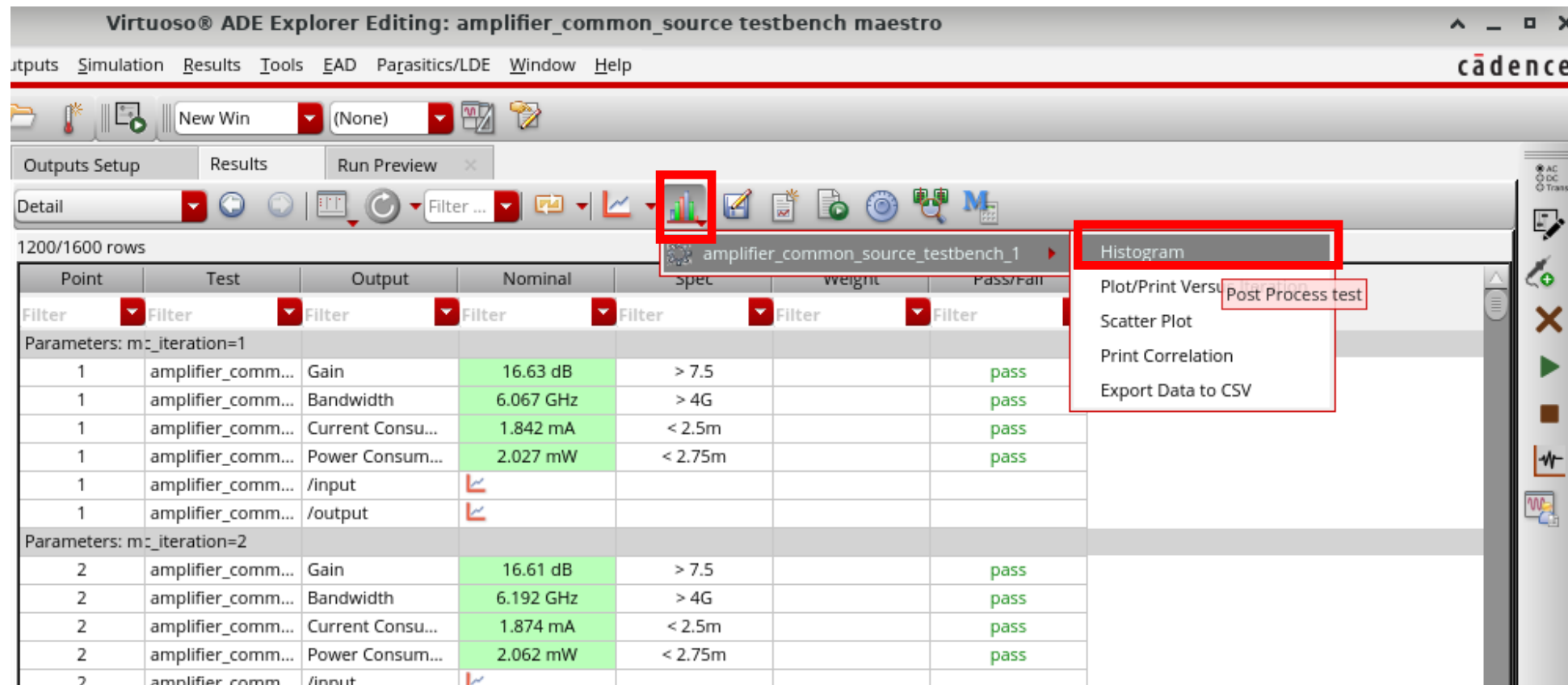


Process Parameter	Statistical Value
random_dwx_resnsndiff	-1.27511
random_indfactor	-681.288m
random10	-170.132m
random_r_resm2_m	-2.01068
random_r_resnsndiff_m	-678.363m
random_r_resspdiff_m	-1.31986
random_r_resnsppdiff_m	142.255m
random3_cap	358.652m
random_r_resm5	315.857m
random_dwx_resnsppdiff	-762.388m
random13_cap	-1.74839
statis_dio_hvt	892.752m
random_r_resnsndiff	675.01m
random_rend_resnsndiff_m	386.082m
random_rend_resnsnpoly	487.585m
random_rend_resnsppoly	-1.50787
random8	-1.57935
random_r_resm8_m	-1.45906
statis_dio	750.181m
random23	-1.32322
random_r_resnsppoly_dis	-372.615m
radom_r_resnwsti_m	-479.119m
random_r_ressppoly_dis	1.46373
random1	-230.303m
random_r_resnsnpoly_dis	-1.31032
random13	-918.467m
random_r_resm1_m	932.795m
random_r_resnsnpoly_dis	2.49758
random22	-1.06539
random_dwx_resspdiff	-579.964m
random2	280.837m
random11	-1.00152
random_r_ressppoly	1.28444

- Note that this technique is mostly used in the event of a design point failure.

Monte Carlo Statistical Analysis (continued)

- You can also plot the histogram for any of the outputs, select the **Post Processing operations for Monte Carlo** icon → **amplifier_common_source_testbench_1** → **Histogram**.



Virtuoso® ADE Explorer Editing: amplifier_common_source_testbench_maestro

cadence

Outputs Setup Results Run Preview

Detail

1200/1600 rows

amplifier_common_source_testbench_1

Histogram

Plot/Print Versus Post Process test

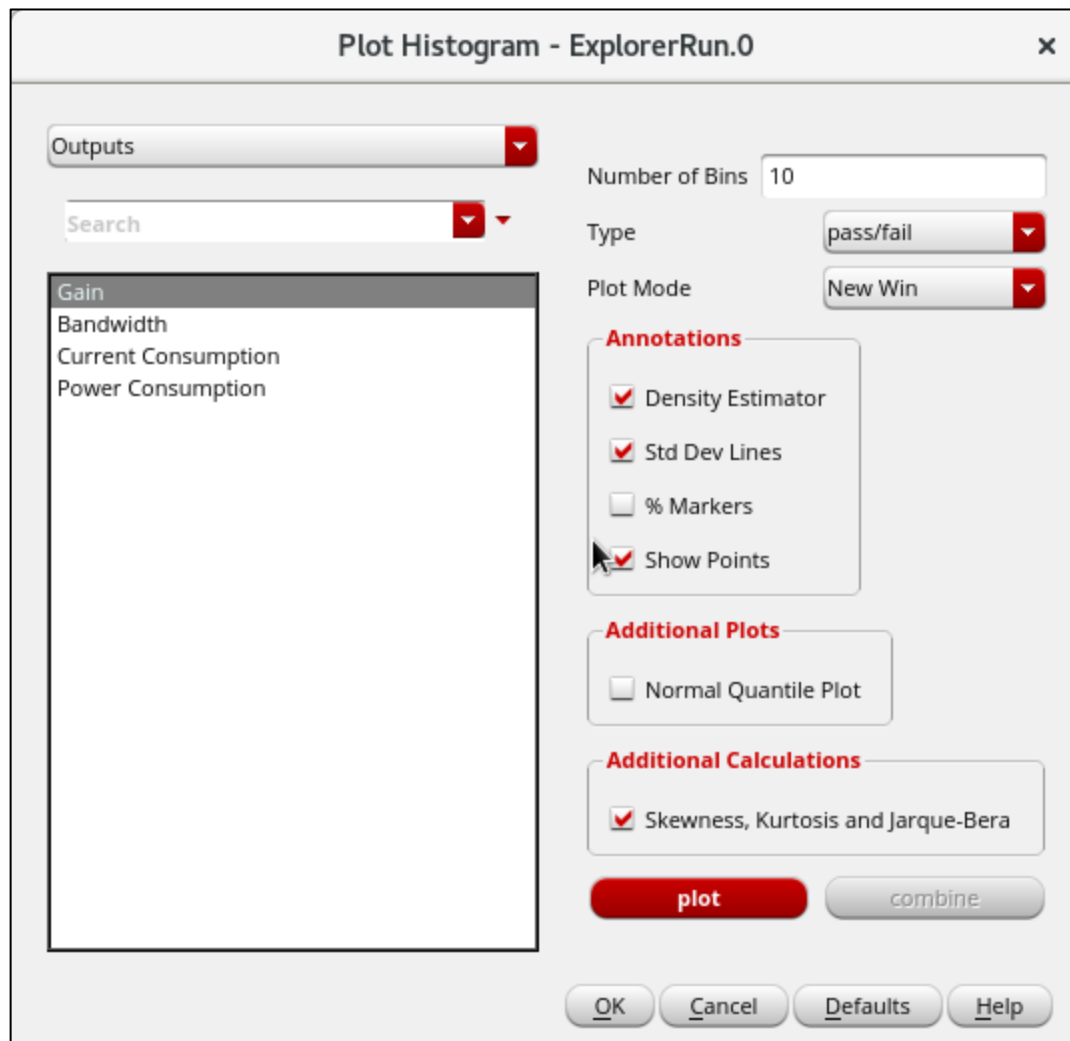
Scatter Plot

Print Correlation

Export Data to CSV

Point	Test	Output	Nominal	Spec	Weight	Pass/Fail
Parameters: mc_iteration=1						
1	amplifier_comm...	Gain	16.63 dB	> 7.5		pass
1	amplifier_comm...	Bandwidth	6.067 GHz	> 4G		pass
1	amplifier_comm...	Current Consu...	1.842 mA	< 2.5m		pass
1	amplifier_comm...	Power Consum...	2.027 mW	< 2.75m		pass
1	amplifier_comm...	/input				
1	amplifier_comm...	/output				
Parameters: mc_iteration=2						
2	amplifier_comm...	Gain	16.61 dB	> 7.5		pass
2	amplifier_comm...	Bandwidth	6.192 GHz	> 4G		pass
2	amplifier_comm...	Current Consu...	1.874 mA	< 2.5m		pass
2	amplifier_comm...	Power Consum...	2.062 mW	< 2.75m		pass
2	amplifier_comm...	/input				

Monte Carlo Statistical Analysis (*continued*)



- Select the output you want to plot, and accordingly choose the **Number of Bins**, **Type**, etc., then click on **plot**.

