AMERICAN UNIVERSITY OF BEIRUT

Virtuoso 23.1
Module 7 – Reliability Analysis

American University of Beirut (AUB)
Lebanon

cadence

AMERICAN UNIVERSITY OF BEIRUT

Contents

cadence

Module Objective

In this module, we will learn how to:

- Set up Reliability Analysis in ADE Assembler
- Do multiple Reliability Analyses
- Do aging analyses, self-heating analyses, aging analyses with Monte-Carlo, and aging analyses with self heating.
- Include reliability analysis into a run plan

1. Introduction to Reliability and Theoretical Background

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

1. Introduction to Reliability and Theoretical Background

- It is essential to grasp the fundamental concept of reliability analysis and its purpose before delving into this module.
- Success in technology is not solely determined by its initial performance in controlled laboratory settings but by its ability to endure and function optimally under demanding conditions over extended periods.
- This is precisely where the topic of reliability plays a crucial role, defining the capacity of a circuit or system to sustain functionality and performance across diverse operating conditions throughout its operational lifespan.
- To address this challenge, engineers have adopted reliability analysis as a strategic approach, employing statistical methods to estimate component and product lifetimes, as well as failure rates.
- By utilizing these analytical techniques, engineers can gain valuable insights into the reliability of electronic devices and circuits, ensuring that they meet expected performance levels and longevity standards in various applications and even in adverse environments.

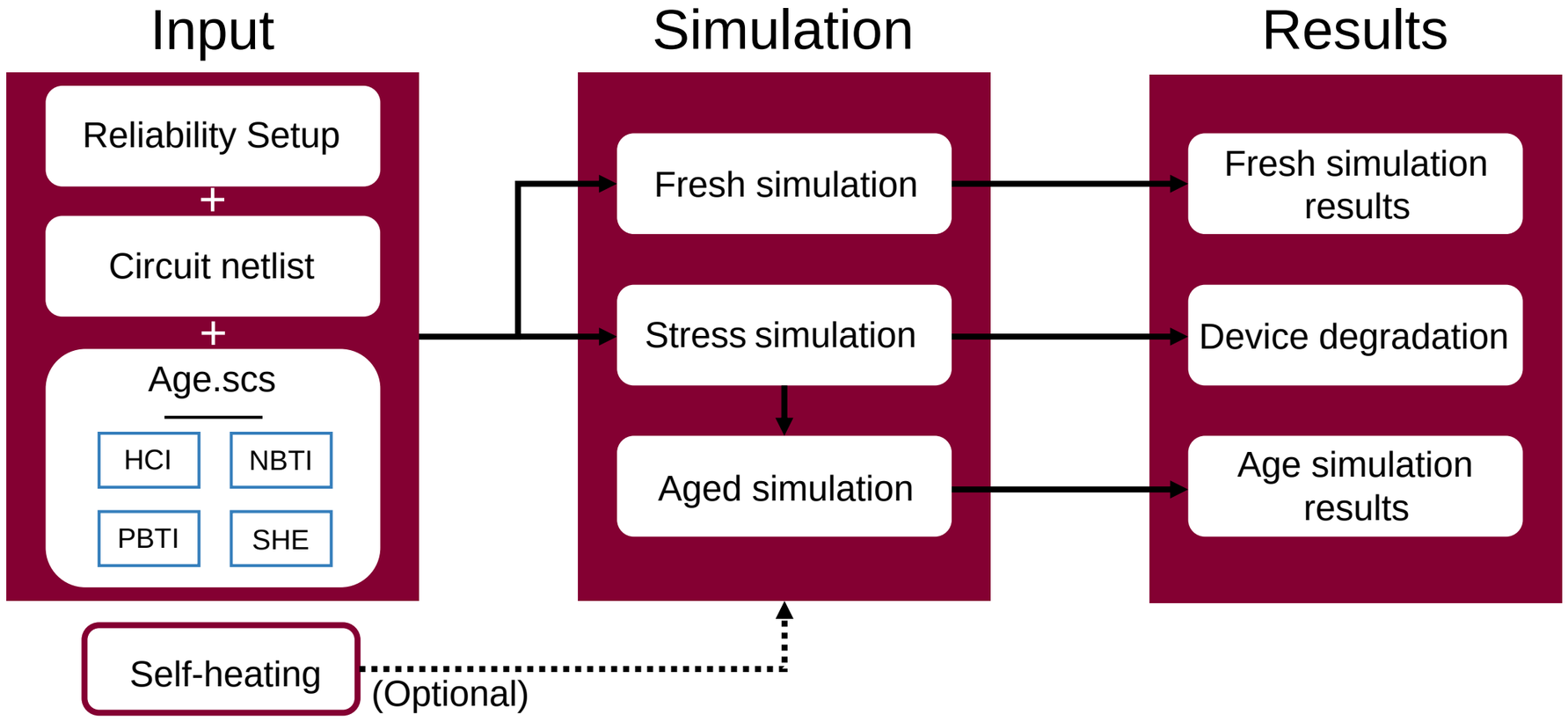
cadence

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

1. Introduction to Reliability and Theoretical Background *(Continued)*

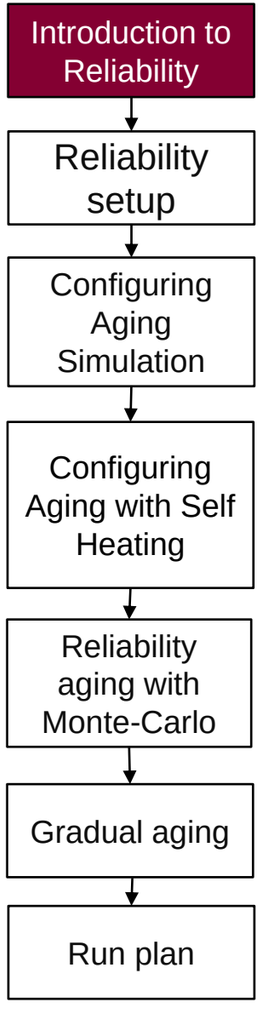
- When we talk about Reliability Analysis in ADE Assembler, these are the required models to run the simulations.



- Note that The Aged simulation cannot occur unless the stress simulation occurs first
- Similarly, The Aged simulation can take place without the stress simulation if a stress file is provided inside the tool.
- An option called self-heating can be added to the simulation (section 2.c).

cadence

AMERICAN UNIVERSITY OF BEIRUT



1. Introduction to Reliability and Theoretical Background *(Continued)*

- The reliability aging flow consist of three main simulation stages.
- The first stage is the "fresh simulation", which is run at nominal circuit conditions. It can be used as a reference point to measure how much the device has degraded as compared to age simulation.
- The second stage is "stress simulation", which is used to calculate the aging parameters and degradation under extreme conditions.
- The result of the third simulation, the "aging simulation", shows the aging effect on the circuit performance based on the aging degradation (from stress simulation) of the transistors.

cadence

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

1. Introduction to Reliability and Theoretical Background *(Continued)*

Reliability analysis involves studying the impact of several **mechanisms** on device performance over time and under various conditions.

- Hot Carrier Injection (HCI): When the transistor gate length gets shorter, the transistor might get damaged by the hot electrons attracted to the gate, which can cause oxide damage.
- Negative Bias Temperature Instability (NBTI): Occurs in PMOS when Vgs is negative. This causes electrical stress which traps carriers (holes) at the interface between the oxide and silicon or within the oxide layer itself. This causes degradation in the performance of the PMOS over time.
- Positive Bias Temperature Instability (PBTI): Occurs in NMOS when Vgs is positive and the temperature is high. Unlike NBTI, interface traps are not created, so full recovery is possible when electrical stress is removed (Vgs=0) and/or temperature is lowered.
- Self-Heating Effects (SHE): In semiconductor devices, the phenomenon of impact ionization, which contributes to Hot Carrier Injection (HCI), can lead to increased self-heating. Remarkably, higher self-heating tends to reduce carriers' mobility and subsequently lowers the threshold voltage (Vth) of the device.

- Note that Device physicists are responsible for these mechanisms, which are experts who specialize in understanding the physical behavior of semiconductor devices.

cadence

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

1. Introduction to Reliability and Theoretical Background *(Continued)*

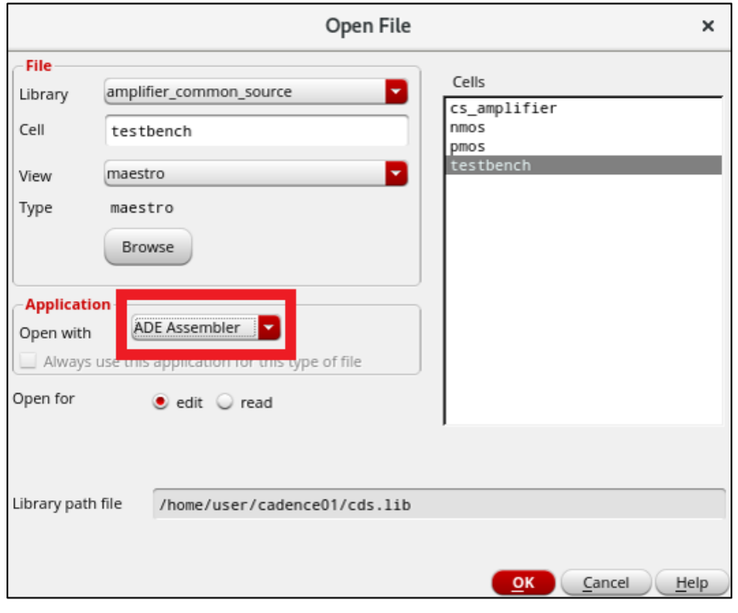
- These reliability mechanisms are included in an Age Model file called “age.scs”, which will be used as an input to the simulation.
- Another input is the circuit netlist, which is a list containing all components and interconnections, along with their properties and values.

cadence

2. Setting up Reliability Analyses

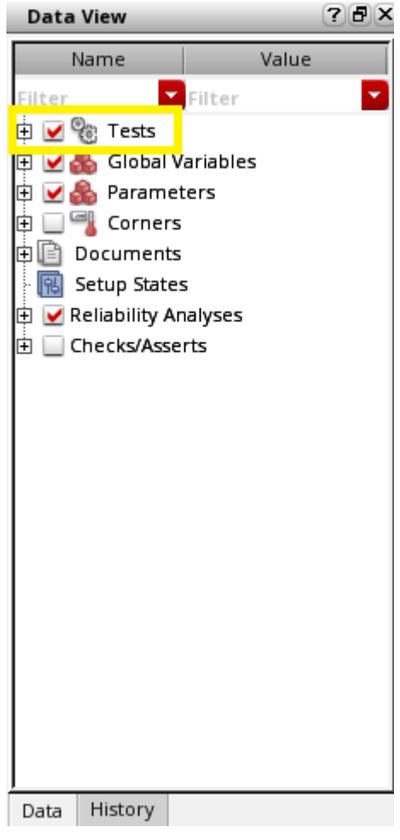
2.a Create Reliability Analysis setup *(Continued)*

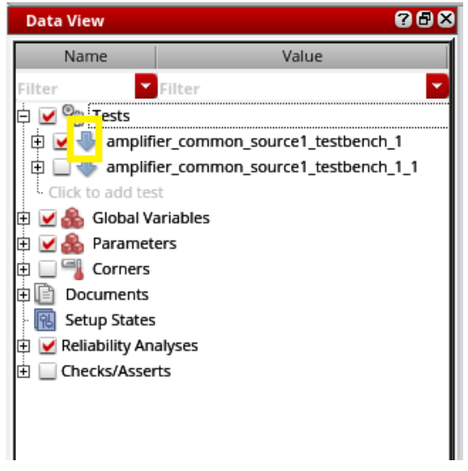
- Select the “amplifier_common_source” library and highlight the testbench cell view then click on maestro view.
- The maestro view should be opened with ADE Assembler (Double check by right clicking on the Maestro view and then selecting “Open With”).



2.a Create Reliability Analysis setup *(Continued)*

- To begin with, to perform a stress simulation followed by an aging simulation, an aging model file for the transistor technology should be provided.
- In the data view on the left of assembler, expand Tests.
- Click on the blue arrow next to the “amplifier_common_source_testbench_1” test.



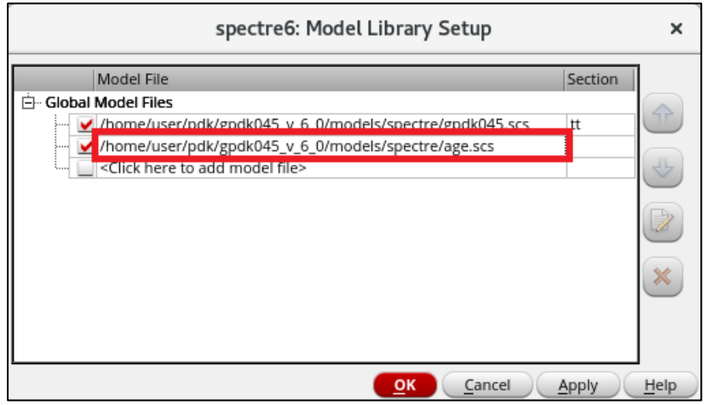


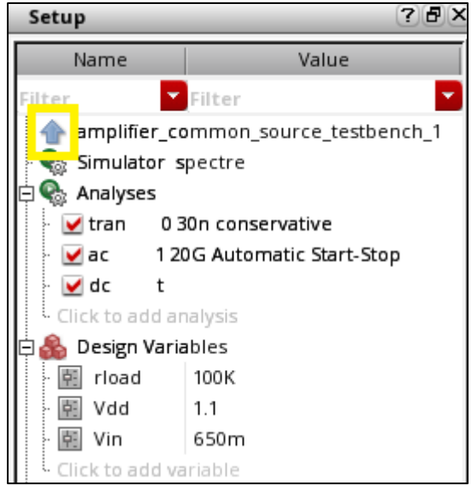
- Note that clicking on the blue down arrow would take you to ADE Explorer.

cadence

2.a Create Reliability Analysis setup *(Continued)*

- After doing so, the ADE Explorer view will show up.
- In the upper menu bar, click on Setup -> Model Libraries…
- The model library setup window should pop up.
- Click on <Click here to add model file>.
- Copy and paste the aging model file location "/home/user/pdk/gpdk045_v_6_0/models/spectre /age.scs".
- Provide the path for the age file and click on OK.
- Close the Model Library setup.
- Head back to ADE Assembler by clicking on the up arrow in the left setup tab.

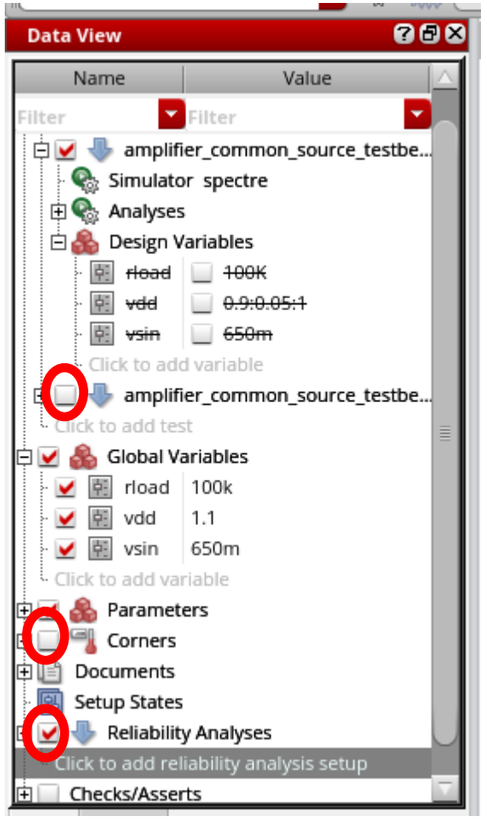




- Note that clicking on the up arrow would take you back to ADE Assembler

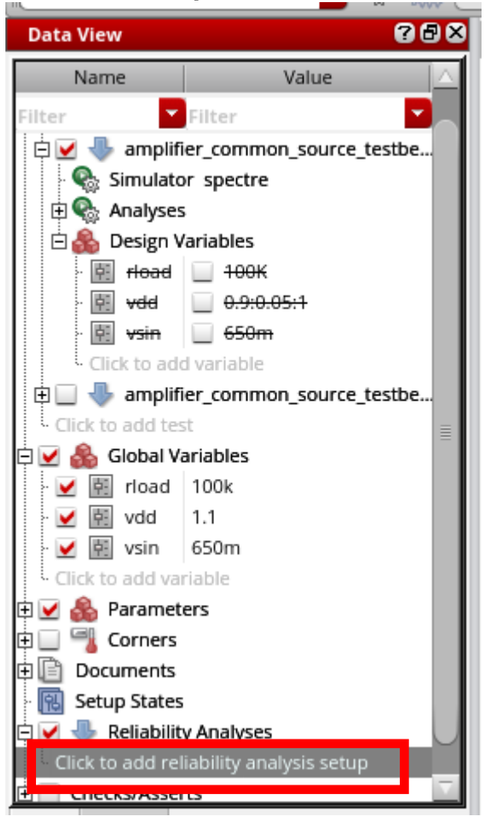
2.a Create Reliability Analysis setup *(Continued)*

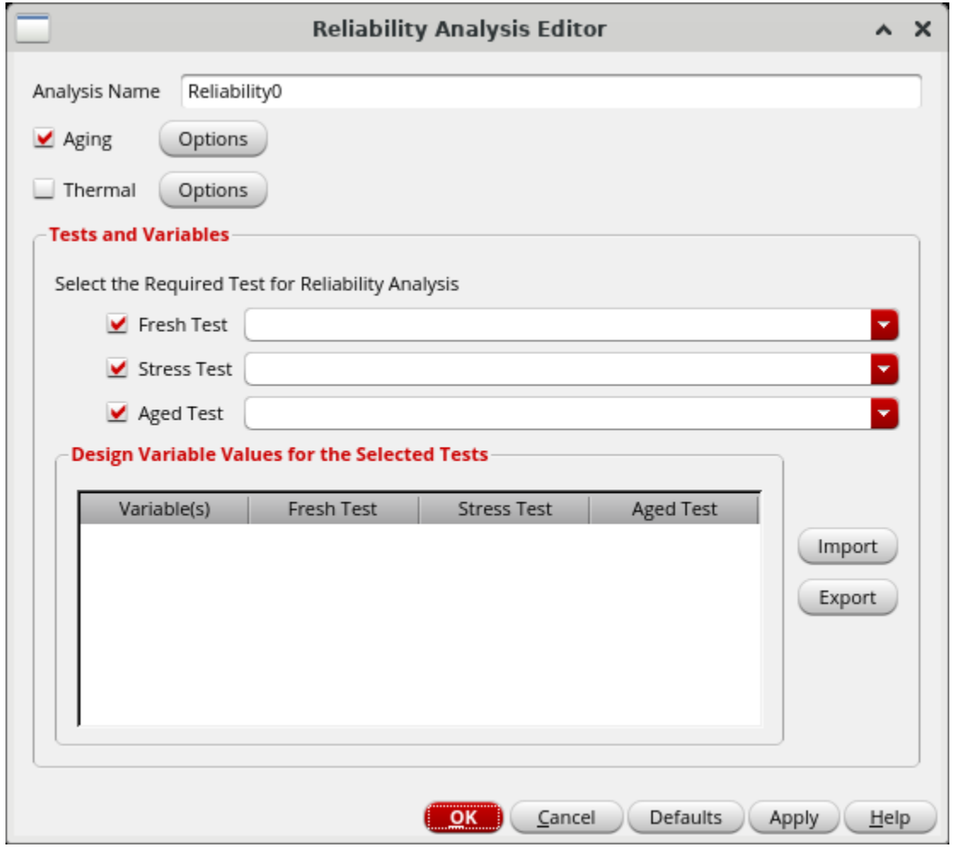
- Now that you are back in ADE Assembler and have provided the aging model file for the 45 nm technology, In the data view window on the left side of assembler, under tests, make sure that the first testbench is selected **only**.
- Unselect Corners.
- Select the Reliability Analyses checkbox.
- The Data view should look like the figure shown in the slide.



2.a Create Reliability Analysis setup *(Continued)*

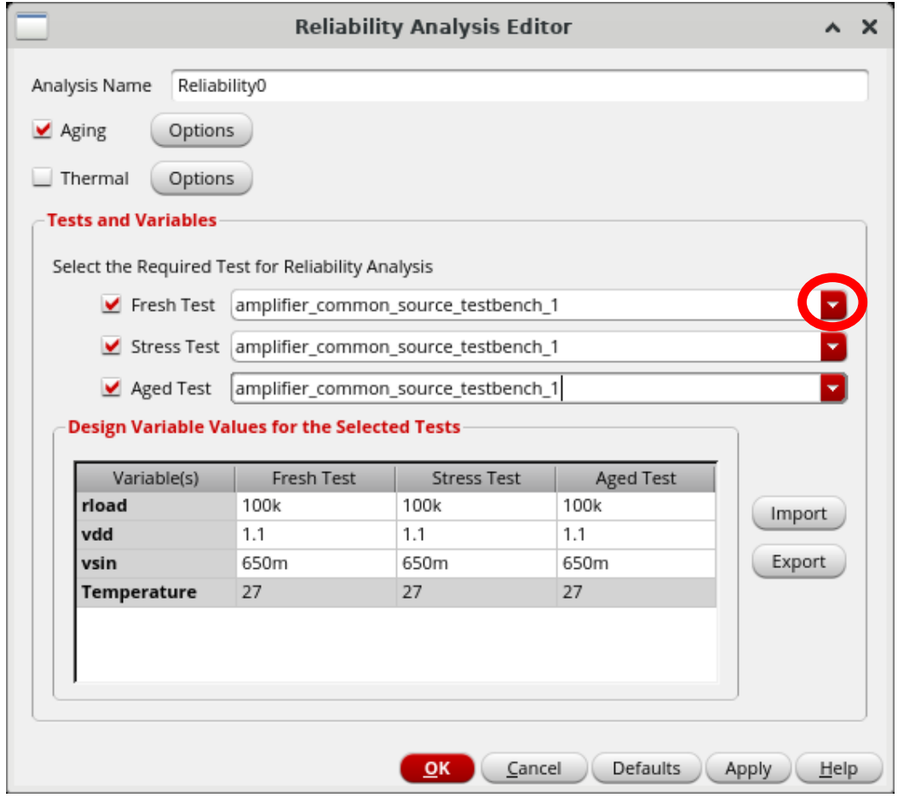
- Click on the text “Click to add reliability analysis setup”.
- This will open the Reliability Analysis Editor form.





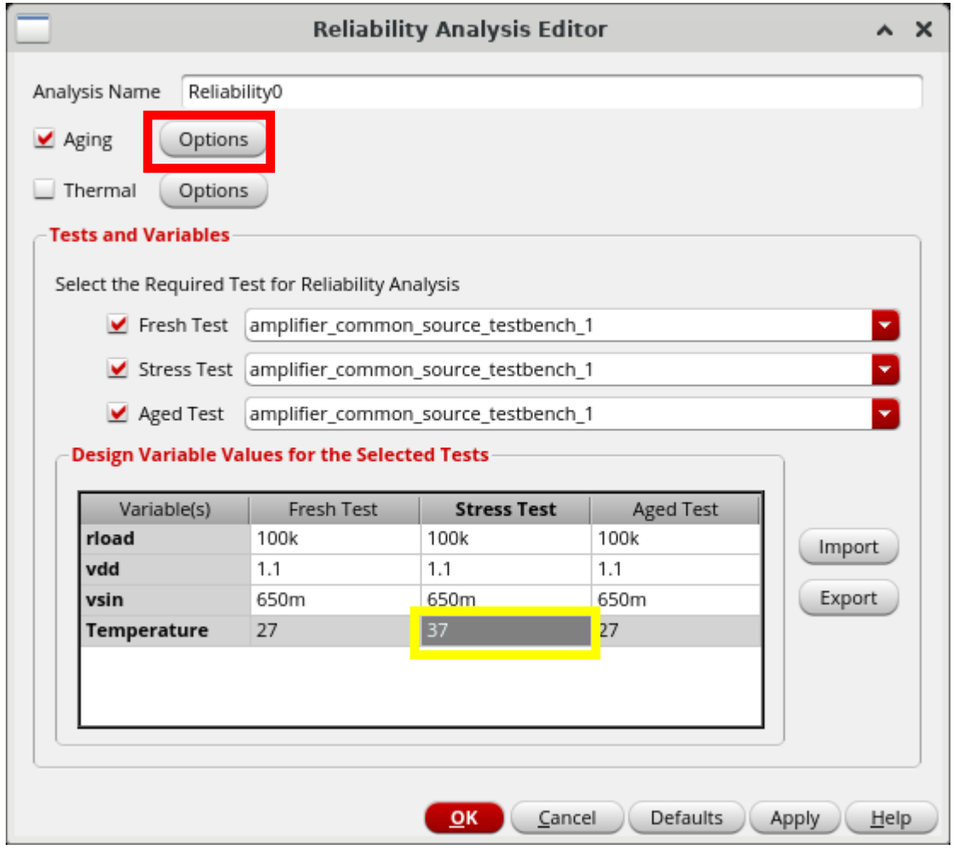
2.a Create Reliability Analysis setup *(Continued)*

- Press on The drop-down button next to each of the three stages (fresh, stress, aged).
- locate the test named "amplifier_common_source_testbench_1“ and choose it.



2.a Create Reliability Analysis setup *(Continued)*

- Set the temperature on the Stress Test to 37 degrees.
- Press on the “Options” button next to the “Aging” check field.



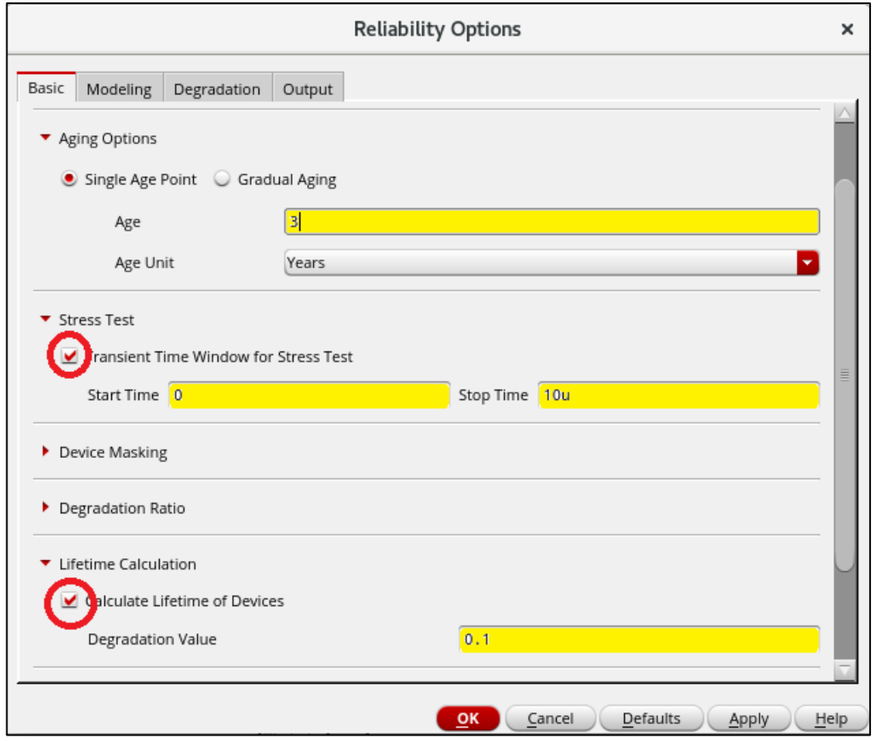
- Note that the table for the Design Variable Values only appears by selecting the required Test for Reliability Analysis
- Note that clicking the Options button will open the Reliability Options form

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- **Reliability setup**
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

2.a Create Reliability Analysis setup *(Continued)*

- Select Aging under Analysis.
- Select Single Age Point under Aging Options and set the Age to 3 years.
- Enable Transient Time Window for Stress Test under Stress Test.
- Set the Start Time to 0 and the Stop Time to 10µs.
- Under Lifetime Calculation, enable Calculate Lifetime of Devices and set the Degradation Value to 0.1.
- Click OK to close Reliability Options form.
- Click OK to close the Reliability Editor form.

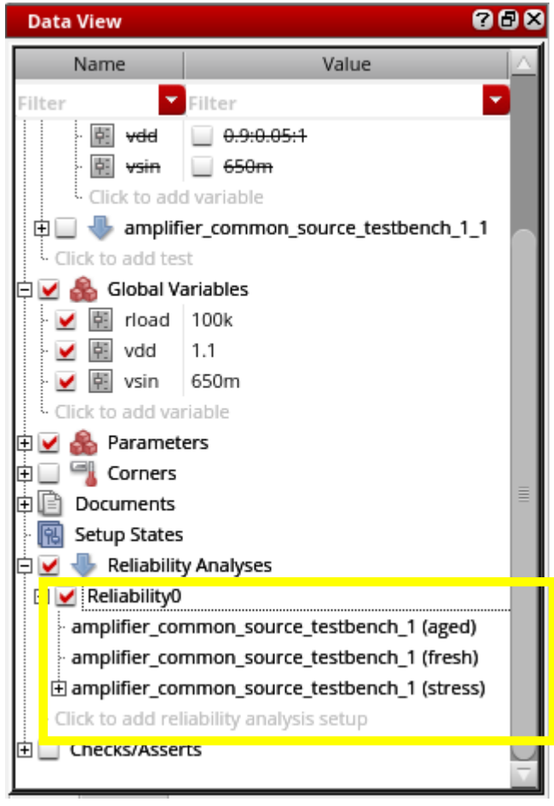


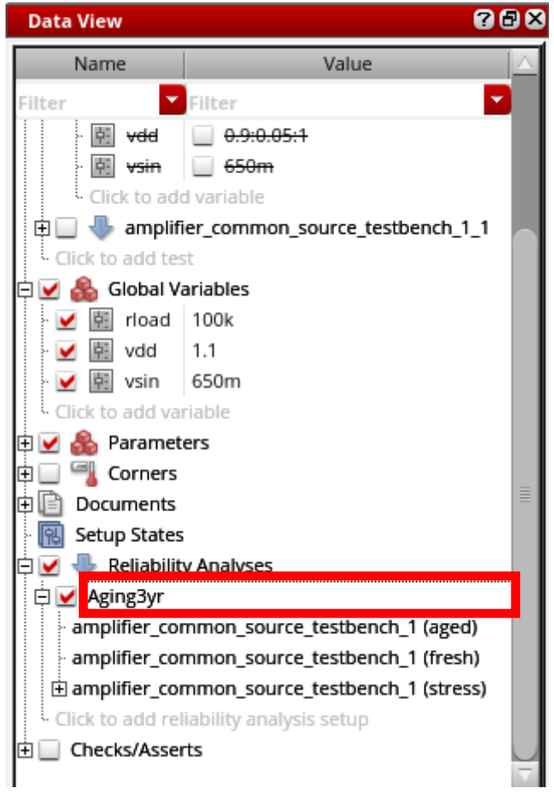
- Note that the Lifetime Calculation shows the percentage point at which the device's electrical characteristics will change based on the chosen Degradation Value (in this case 10%).

cadence

2.a Create Reliability Analysis setup *(Continued)*

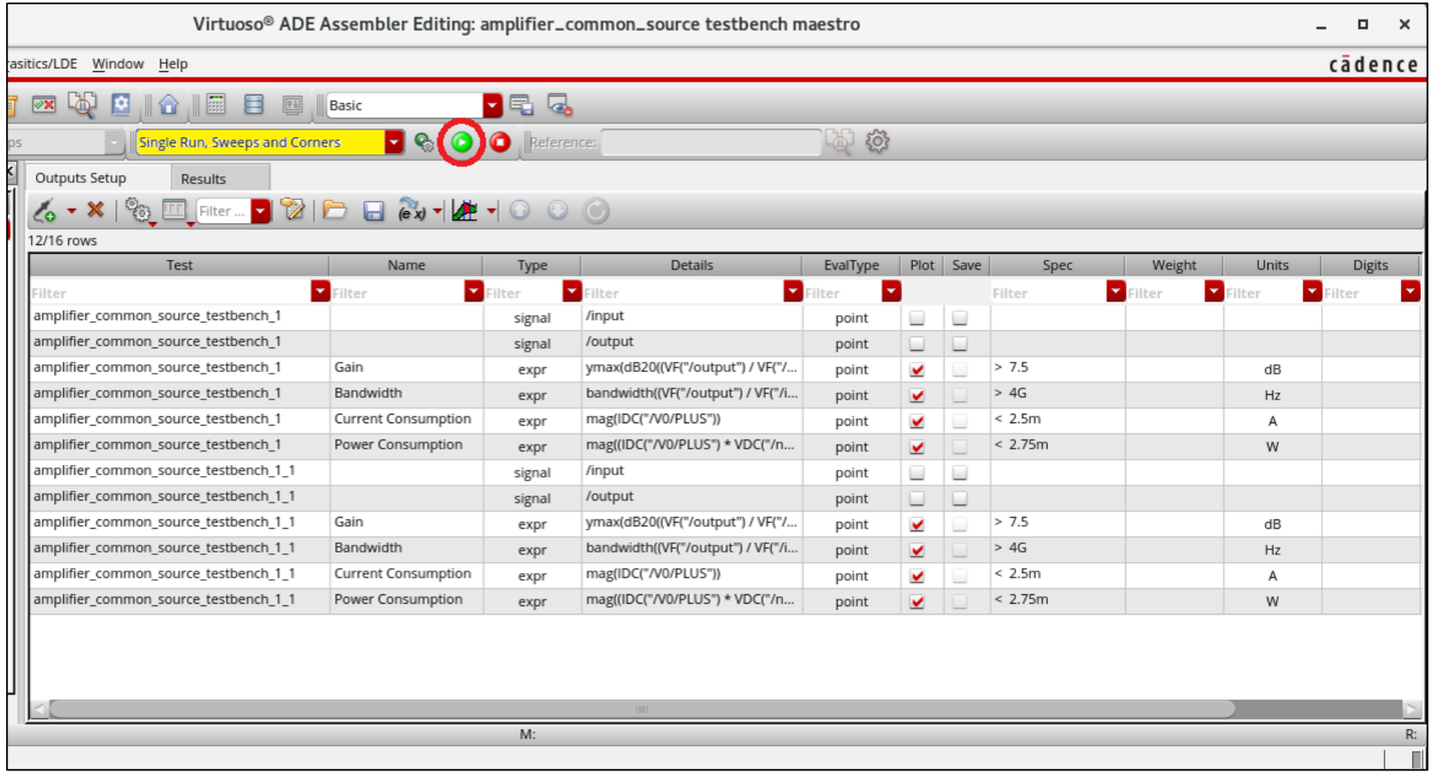
- Your Data View should look like the figure below on the left.
- Double-click on `Reliability0` and rename it to `Aging3yr`.





2.b. Configuring Age Simulation

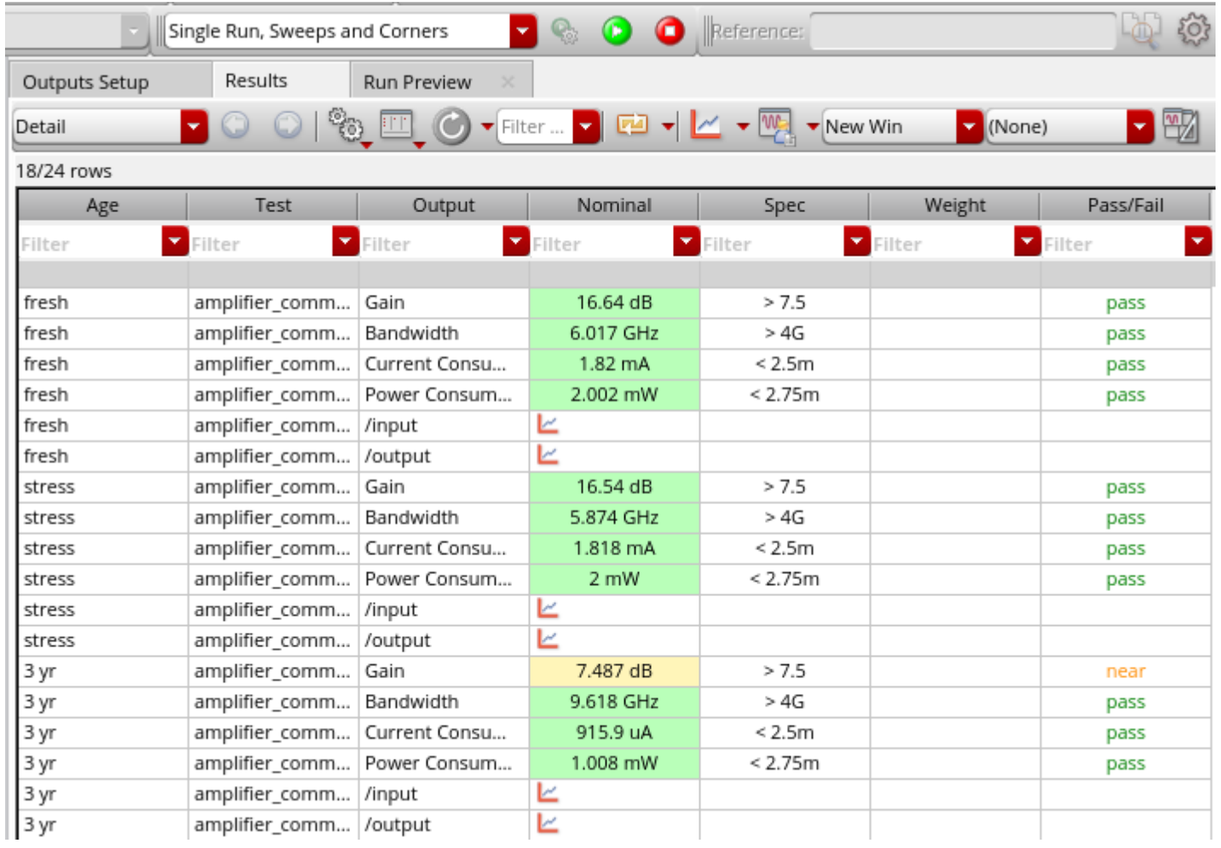
- Make sure that the Run mode is set to “Single Run, Sweeps and Corners”.
- Click on the green Run Simulation button.



cadence

2.b. Configuring Age Simulation (continued)

- In this case, the Gain nearly fails to meet the specifications.



18/24 rows

Age	Test	Output	Nominal	Spec	Weight	Pass/Fail
fresh	amplifier_comm...	Gain	16.64 dB	> 7.5		pass
fresh	amplifier_comm...	Bandwidth	6.017 GHz	> 4G		pass
fresh	amplifier_comm...	Current Consu...	1.82 mA	< 2.5m		pass
fresh	amplifier_comm...	Power Consum...	2.002 mW	< 2.75m		pass
fresh	amplifier_comm...	/input				
fresh	amplifier_comm...	/output				
stress	amplifier_comm...	Gain	16.54 dB	> 7.5		pass
stress	amplifier_comm...	Bandwidth	5.874 GHz	> 4G		pass
stress	amplifier_comm...	Current Consu...	1.818 mA	< 2.5m		pass
stress	amplifier_comm...	Power Consum...	2 mW	< 2.75m		pass
stress	amplifier_comm...	/input				
stress	amplifier_comm...	/output				
3 yr	amplifier_comm...	Gain	7.487 dB	> 7.5		near
3 yr	amplifier_comm...	Bandwidth	9.618 GHz	> 4G		pass
3 yr	amplifier_comm...	Current Consu...	915.9 uA	< 2.5m		pass
3 yr	amplifier_comm...	Power Consum...	1.008 mW	< 2.75m		pass
3 yr	amplifier_comm...	/input				
3 yr	amplifier_comm...	/output				

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- **Configuring Aging with Self Heating**
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

2.c. Configuring aging with self-heating

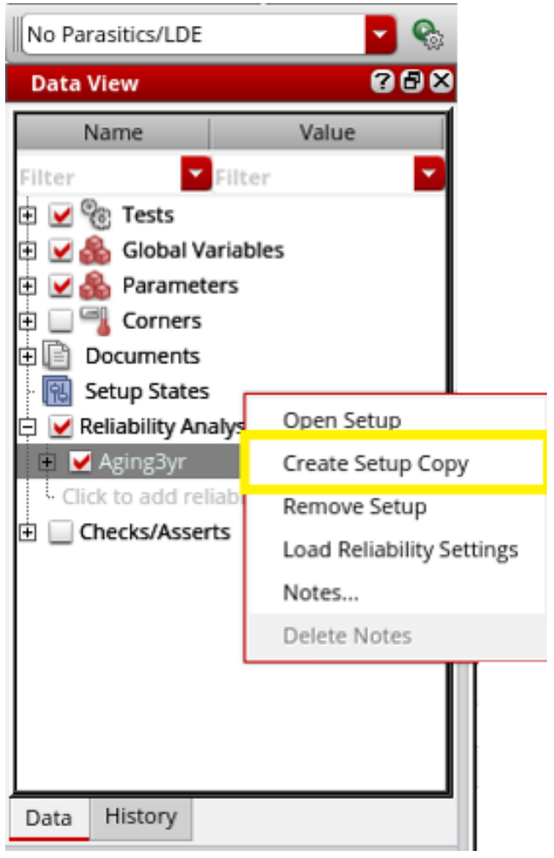
- In this part of the Module, we will be looking into the effect of performing aging simulation with self-heating.
- Up to this point, we have explored aging simulations, which show us the long-term degradation effects caused by mechanisms such as HCI, NBTI, PBTI.
- However, there is an additional factor that plays an important role when it comes to reliability analysis, and that is self-heating, which is the heat generated from devices due to the electrical current passing through its components.
- By including self-heating in our reliability analysis, we can gain more knowledge about how our amplifier responds to these varying thermal conditions.

- Note that self-heating focuses on how the device generates and dissipates heat, while the Temperature variable allows us to set the external temperature for our simulations.

cadence

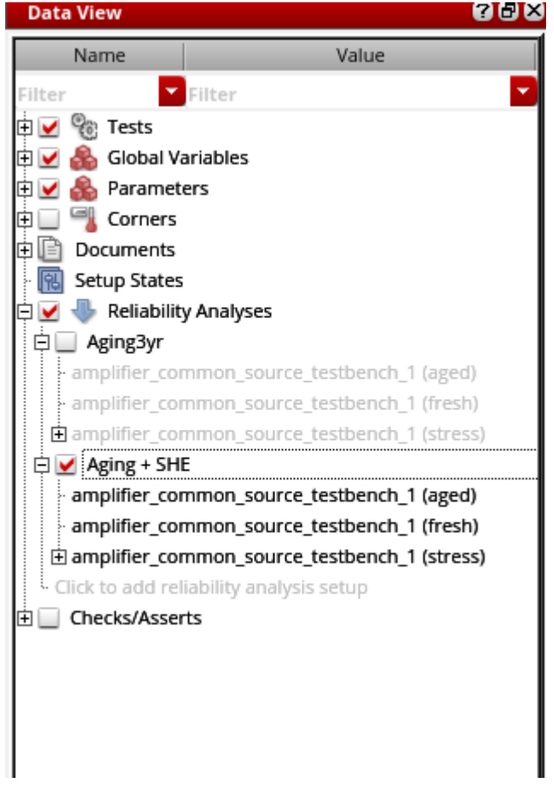
2.c. Configuring aging with self-heating *(Continued)*

- The pre-existing aging Reliability setup will be used by creating a copy of it and doing the necessary modifications.
- Start by right clicking on the previous aging simulation Aging3yr in the Data view and select on Create Setup Copy.
- A new Reliability analysis should show up named Aging3yr:1.
- Double Click on Aging3yr:1 and rename it to Aging + SHE.



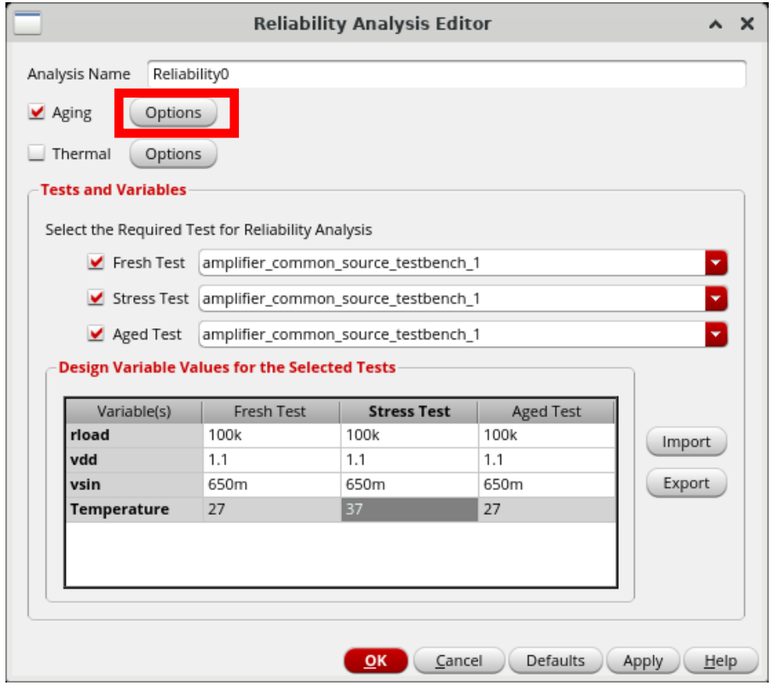
2.c. Configuring aging with self-heating *(Continued)*

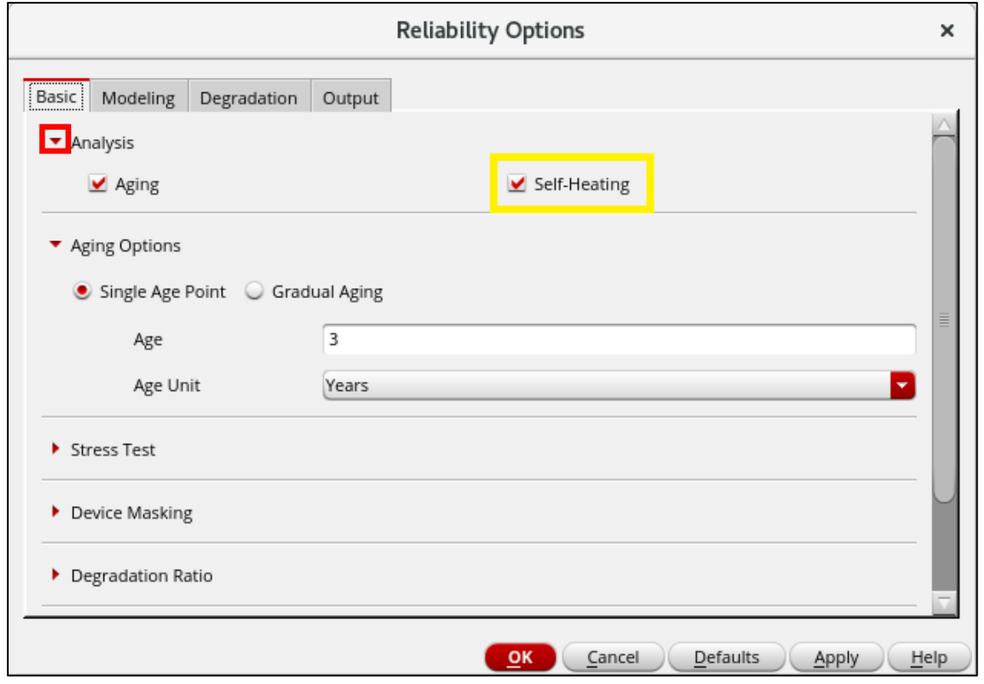
- Make sure to disable the Aging3yr Reliability analysis and to check the Aging + SHE simulation.
- The Data view of ADE Assembler should look like the figure on the right.
- Now, right click on Aging + SHE and select Open Setup.
- The Reliability analysis form should show up.



2.c. Configuring aging with self-heating *(Continued)*

- Click on the options button.
- Select the Self-Heating check box as shown in the below figure.
- Select OK and Close the Reliability options menu.

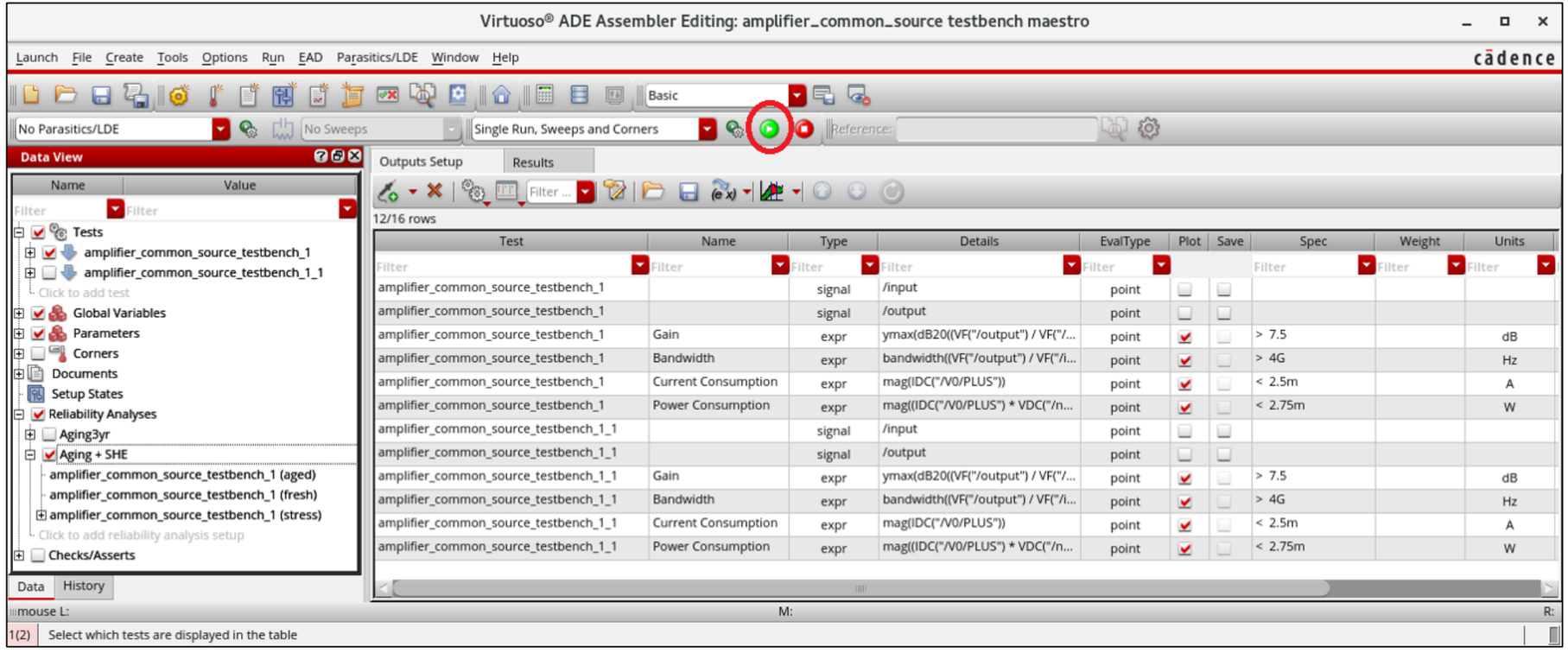




- Note that selecting the “Self-Heating” option under Analysis will produce more accurate results, as it establishes a more realistic procedure.

2.c. Configuring aging with self-heating *(Continued)*

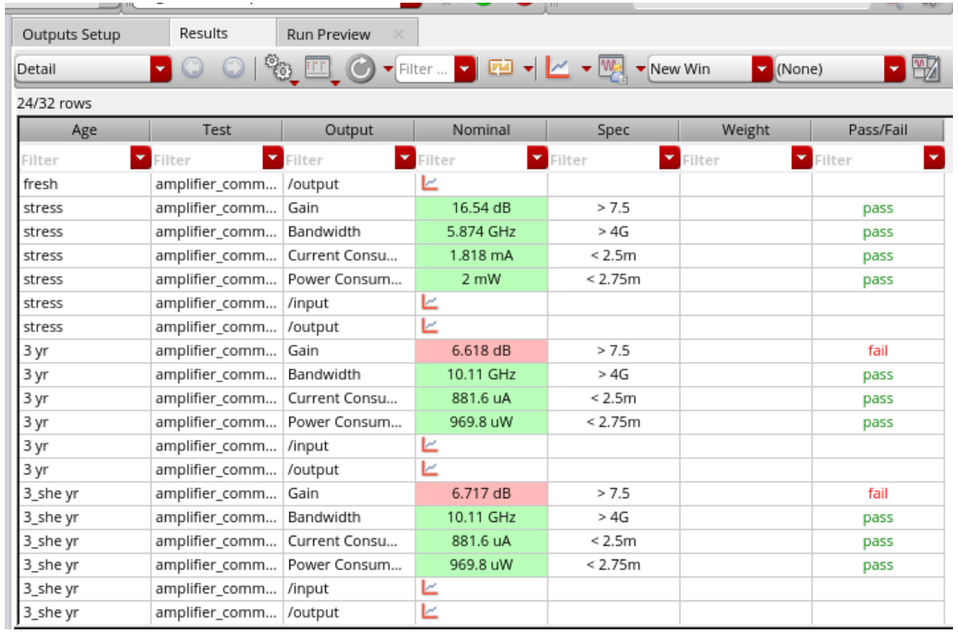
- After that you have configured the setup for the Reliability setup for aging and self heating, in the ADE Assembler window, Click on Run Simulation.



cadence

2.c. Configuring aging with self-heating *(Continued)*

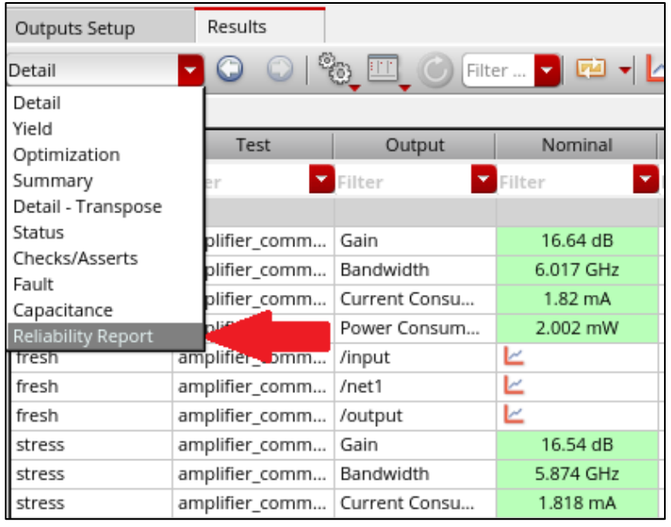
- From the figure displayed on the right, the results of interest to us are the last results labeled by *"3_she yr"* being the combination of the aging and self-heating effect together.
- The specs simulation findings between the aging simulation and the aging combined with the self-heating effect are different, indicating that self-heating and aging have an interaction.
- The gain at a 3-year aging value, both with and without the self-heating effect, is 66% less than the specified 15 dB needed value, but the rest of the specs still meet the standards.



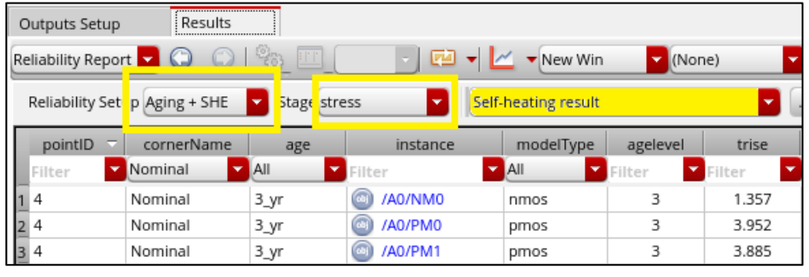
Age	Test	Output	Nominal	Spec	Weight	Pass/Fail
Filter	Filter	Filter	Filter	Filter	Filter	Filter
fresh	amplifier_comm...	/output				
stress	amplifier_comm...	Gain	16.54 dB	> 7.5		pass
stress	amplifier_comm...	Bandwidth	5.874 GHz	> 4G		pass
stress	amplifier_comm...	Current Consu...	1.818 mA	< 2.5m		pass
stress	amplifier_comm...	Power Consum...	2 mW	< 2.75m		pass
stress	amplifier_comm...	/input				
stress	amplifier_comm...	/output				
3 yr	amplifier_comm...	Gain	6.618 dB	> 7.5		fail
3 yr	amplifier_comm...	Bandwidth	10.11 GHz	> 4G		pass
3 yr	amplifier_comm...	Current Consu...	881.6 uA	< 2.5m		pass
3 yr	amplifier_comm...	Power Consum...	969.8 uW	< 2.75m		pass
3 yr	amplifier_comm...	/input				
3 yr	amplifier_comm...	/output				
3_she yr	amplifier_comm...	Gain	6.717 dB	> 7.5		fail
3_she yr	amplifier_comm...	Bandwidth	10.11 GHz	> 4G		pass
3_she yr	amplifier_comm...	Current Consu...	881.6 uA	< 2.5m		pass
3_she yr	amplifier_comm...	Power Consum...	969.8 uW	< 2.75m		pass
3_she yr	amplifier_comm...	/input				
3_she yr	amplifier_comm...	/output				

2.c. Configuring aging with self-heating *(Continued)*

- Furthermore, one can also check the rise in temperature for each device available in the schematic view of the designed common source amplifier.
- To do so, in the Results tab, switch to Reliability Report View.



- Next, in the Reliability Setup window, make sure that the Reliability Setup is set to Aging + SHE, the stage is selected to Stress and Self-heating result is selected.



2.c. Configuring aging with self-heating *(Continued)*

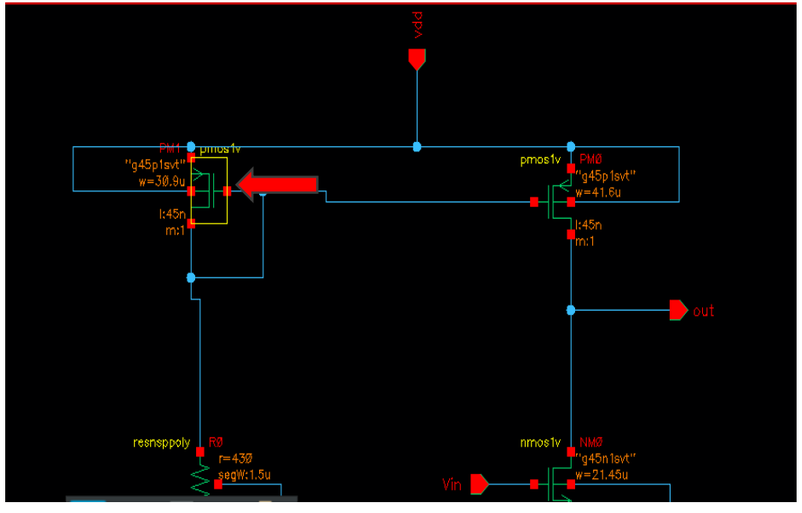
- This way, one can check the temperature rise of each device.
- Furthermore, by clicking on any instance of the circuit, a schematic view of the amplifier will pop up in another window showcasing the specific device.
- For example, by clicking on the /A0/PM1 instance of the circuit having a temperature rise value of 4.745 degrees Celsius, the schematic view of the circuit should pop up.

Outputs Setup | Results | Run Preview

Reliability Report | New Win

Reliability Setup: Aging + SHE | Stage: stress

	pointID	cornerName	age	instance	modelType	agelevel	trise
	Filter	Nominal	All	Filter	All	Filter	Filter
1	4	Nominal	3_yr	/A0/NM0	nmos	3	346.1m
2	4	Nominal	3_yr	/A0/PM0	pmos	3	3.309
3	4	Nominal	3_yr	/A0/PM1	pmos	3	3.147
4	3	Nominal	3_yr	/A0/NM0	nmos	3	346.1m
5	3	Nominal	3_yr	/A0/PM0	pmos	3	3.309
6	3	Nominal	3_yr	/A0/PM1	pmos	3	3.147
7	2	Nominal	3_yr	/A0/NM0	nmos	3	3.921
8	2	Nominal	3_yr	/A0/PM0	pmos	3	3.867
9	2	Nominal	3_yr	/A0/PM1	pmos	3	4.745



- Note that the figure on the right showcases the instance of the selected device labeled as /A0/PM1.

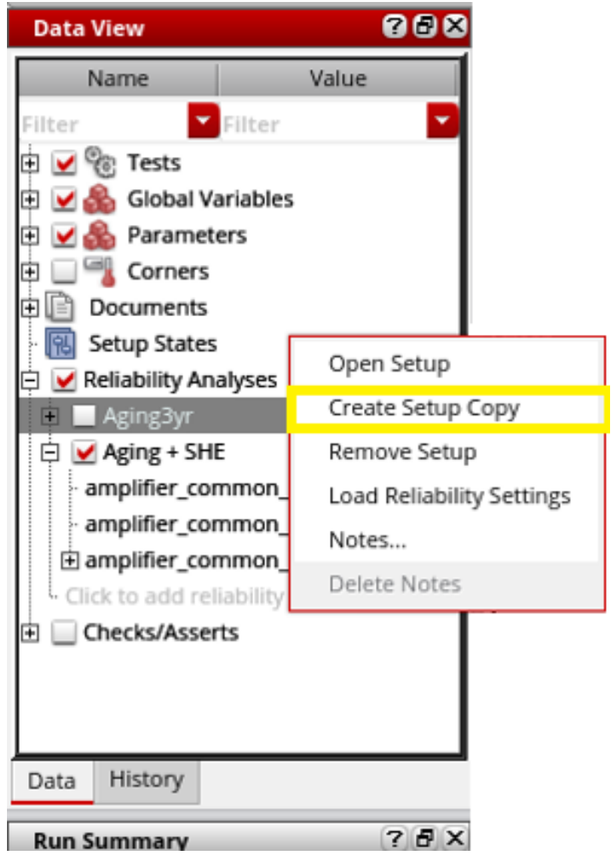
cadence

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- **Reliability aging with Monte-Carlo**
- Gradual aging
- Run plan

2.d. Reliability aging with Monte-Carlo

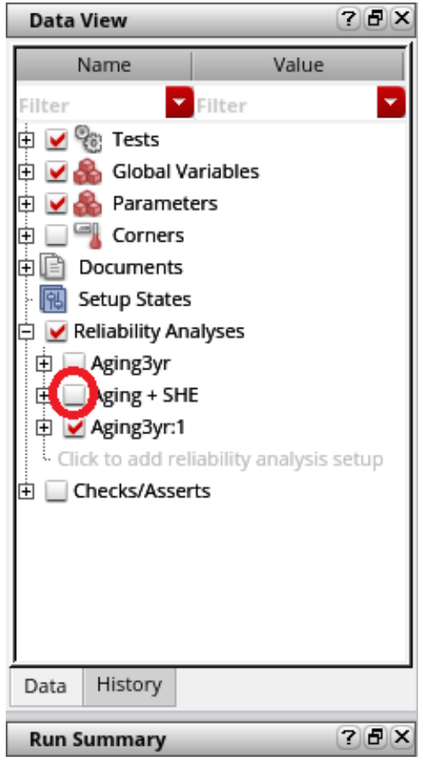
- Another important type of simulation is Monte-Carlo, which offers a robust approach to evaluate the reliability of our design, while accounting for variability and uncertainty.
- Begin by heading to the Data view, under Reliability Analyses, right click on the first setup `Aging3yr` and select “Create Setup Copy”.

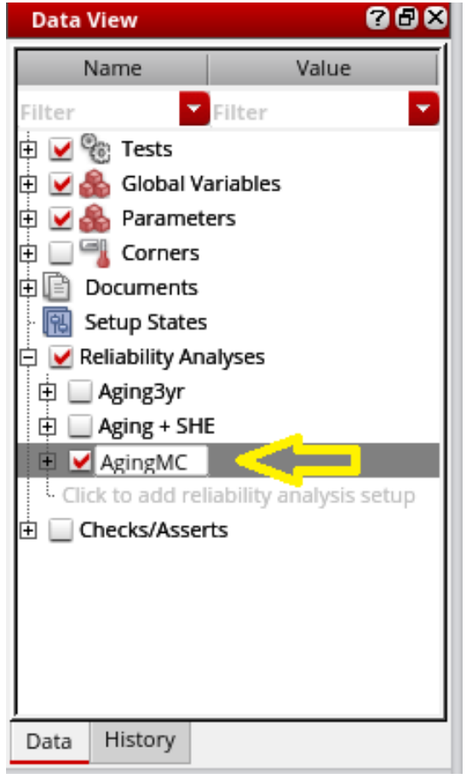


cadence

2.d. Reliability aging with Monte-Carlo *(continued)*

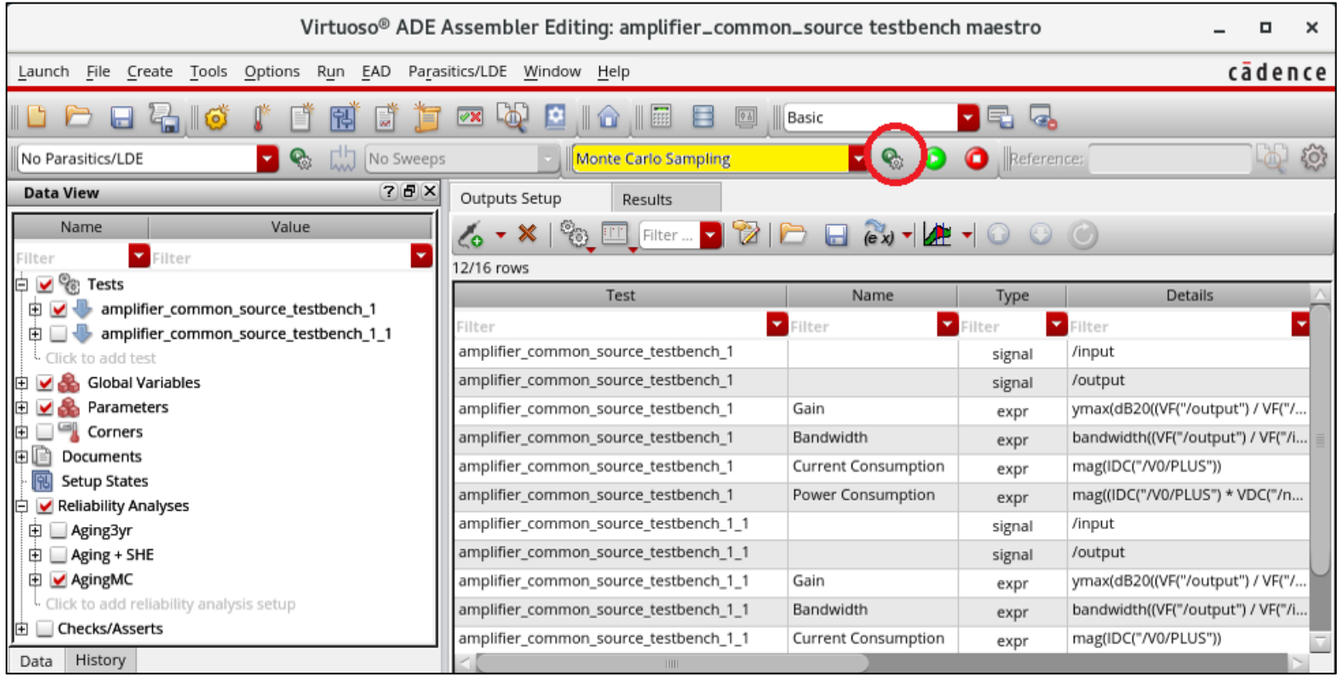
- A new Reliability analysis should show up named Aging3yr:1.
- Double Click on Aging3yr:1 and rename it to `AgingMC`.
- Make sure to disable the Aging3yr and Aging + SHE Reliability analyses and to check the `AgingMC` simulation.





2.d. Reliability aging with Monte-Carlo *(continued)*

- From the **Run Mode** drop-down list, right above the **Results** tab, select **Monte-Carlo Sampling**.
- Click on the **Simulation Options** button next to the Run Mode.



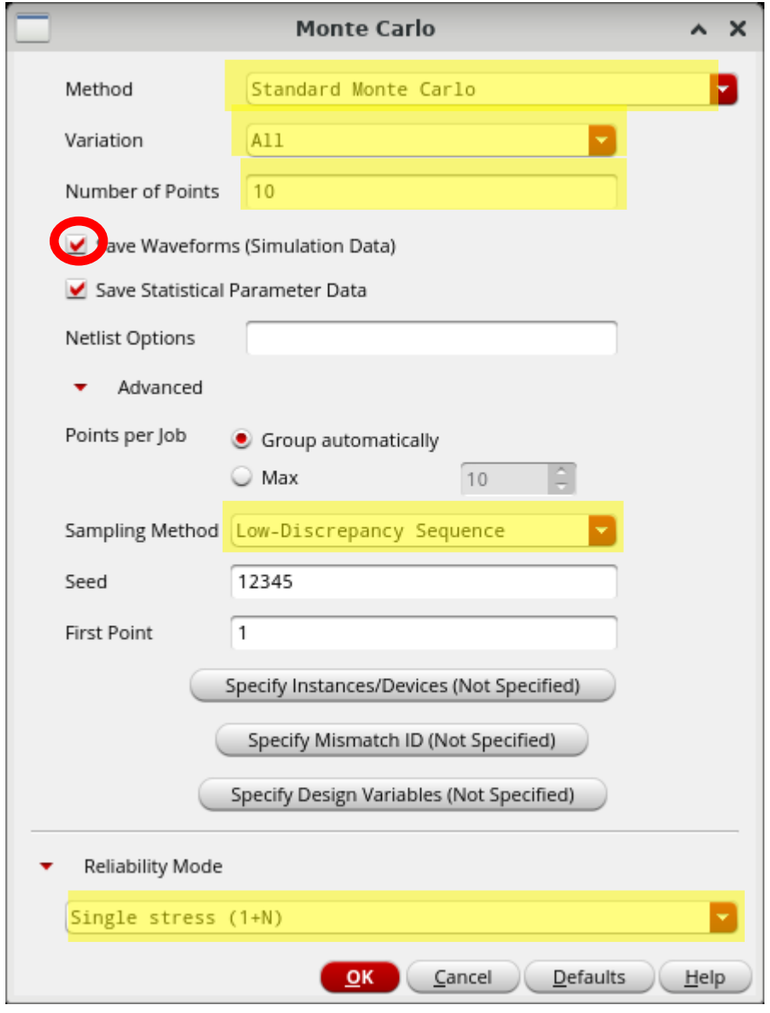
- Note that by clicking on the simulation options button will open the Monte-Carlo form.

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- **Reliability aging with Monte-Carlo**
- Gradual aging
- Run plan

2.d. Reliability aging with Monte-Carlo *(continued)*

- Set the number of points to 10.
- Select “All” for **Variation**.
- Select “Standard Monte Carlo” for **Method**.
- Enable the “Save waveforms (Simulation Data)” option.
- Click on **Advanced.**
- Select “Low-Discrepancy Sequence” for **Sampling Method.**
- Click on **Reliability Mode.**
- Select “Single stress (1+N)” for the **Reliability Mode**.
- Press on OK to close the form.



- Note that you can choose the Multi stress (N+N) flow in the Reliability Mode for more accurate results
- Note that the number of fixed points for a Monte Carlo simulation is usually >100, but we picked 10 points for a quick simulation.

cadence

AMERICAN UNIVERSITY OF BEIRUT

Introduction to Reliability
Reliability setup
Configuring Aging Simulation
Configuring Aging with Self Heating
Reliability aging with Monte-Carlo
Gradual aging
Run plan

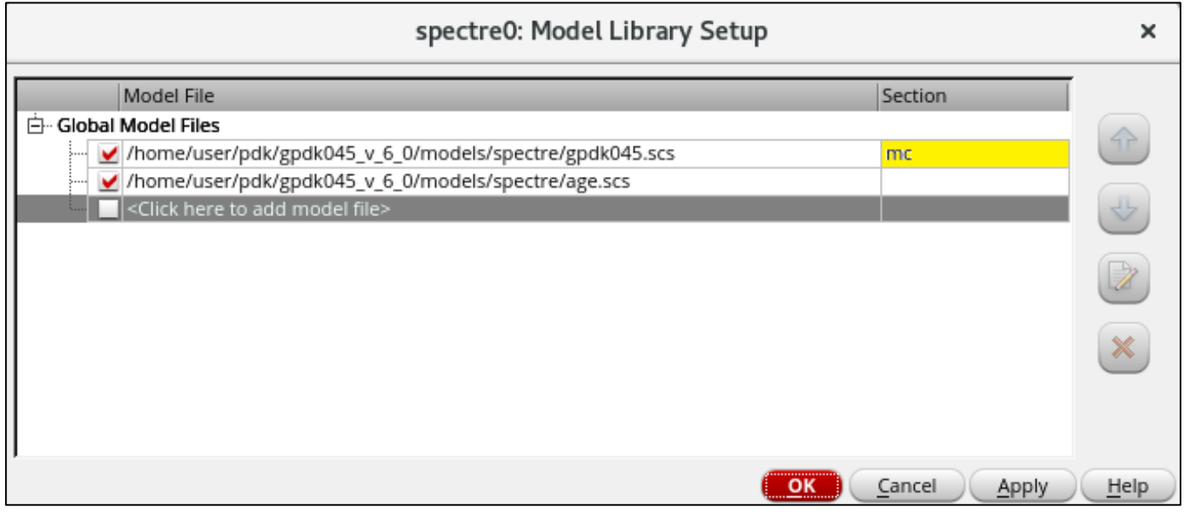
2.d. Reliability aging with Monte-Carlo *(continued)*

- There are two types of Reliability modes to run the Monte Carlo simulation:
  - Single Stress (1+N flow)
  - Multi Stress (N+N flow)
- The main difference is that in the single stress, the stress simulation is done only at the first iteration. The other iterations are only running the fresh and aging simulations using the degradation models generated from the first simulation.
- However, in the multi stress simulation (N+N), the stress simulation is run in each iteration, and the degradation files generated will be used for the aging simulations.
- Note that the N+N will provide more accurate results, but will run twice the simulations as 1+N.

cadence

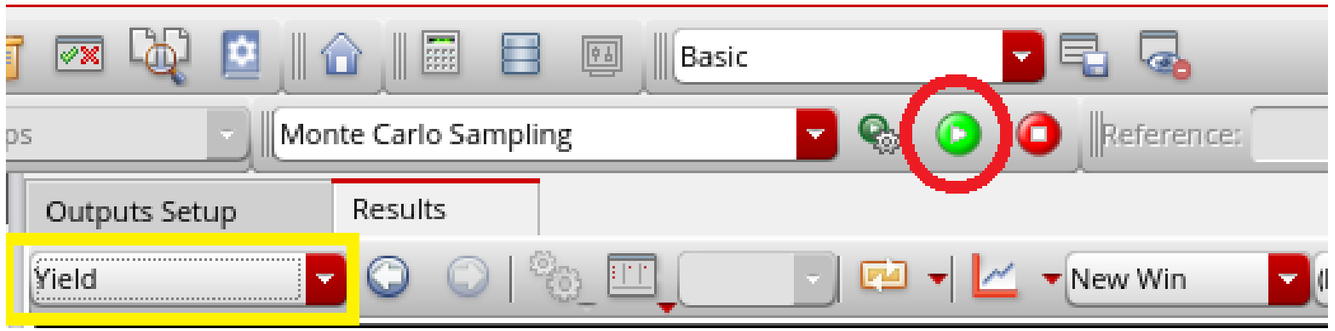
2.d. Reliability aging with Monte-Carlo *(continued)*

- Before running the simulation, head over to **ADE Explorer** by clicking on the blue arrow next to “amplifier_common_source_testbench_1” under **Tests**.
- In the upper menu bar, click on Setup -> Model Libraries…
- Change the section to **mc.**



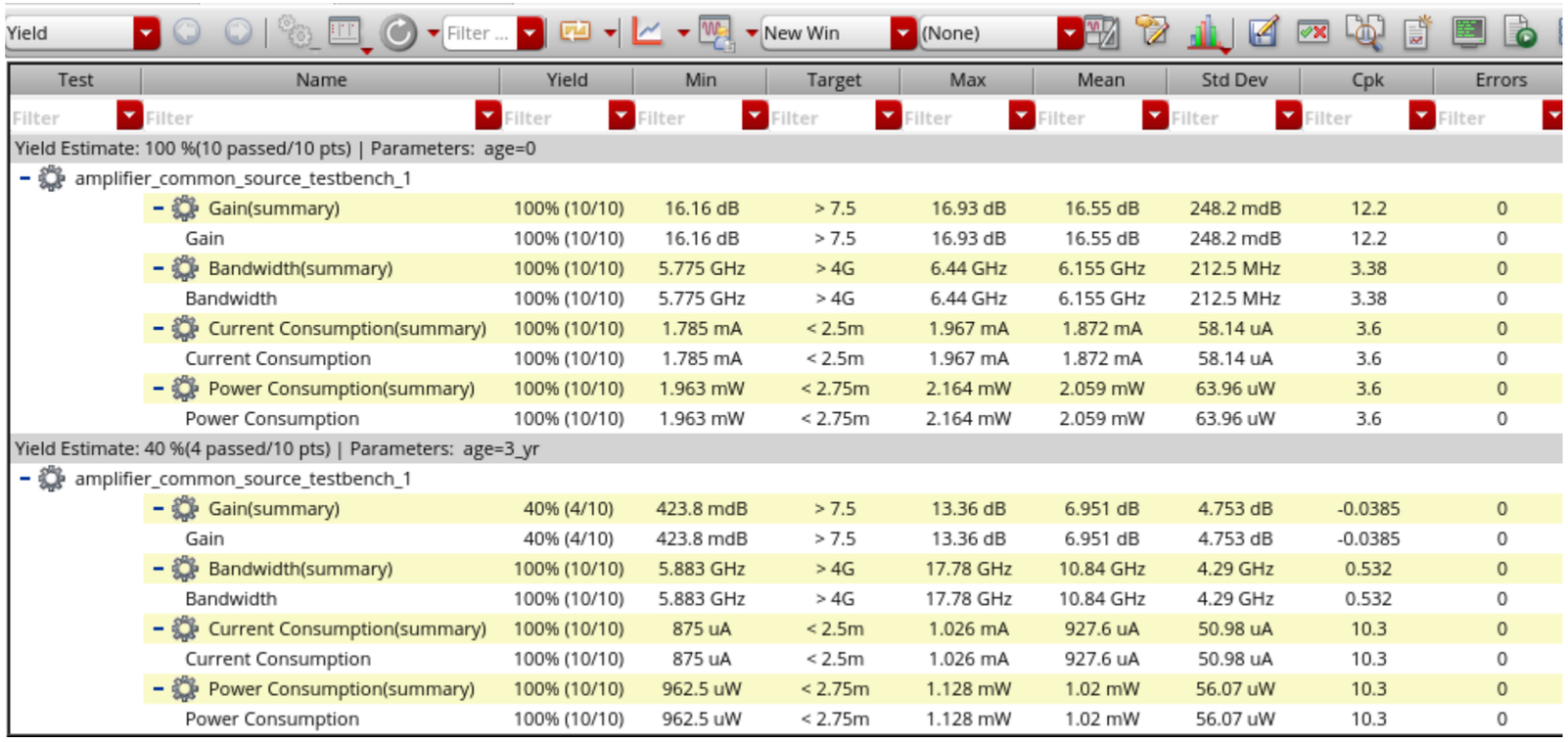
2.d. Reliability aging with Monte-Carlo *(continued)*

- Return to ADE Assembler by clicking on the up arrow in the left setup tab.
- Click on the green **Run Simulation** icon.
- Make sure to change the **Results view** from **Detail** to **Yield**.



2.d. Reliability aging with Monte-Carlo *(continued)*

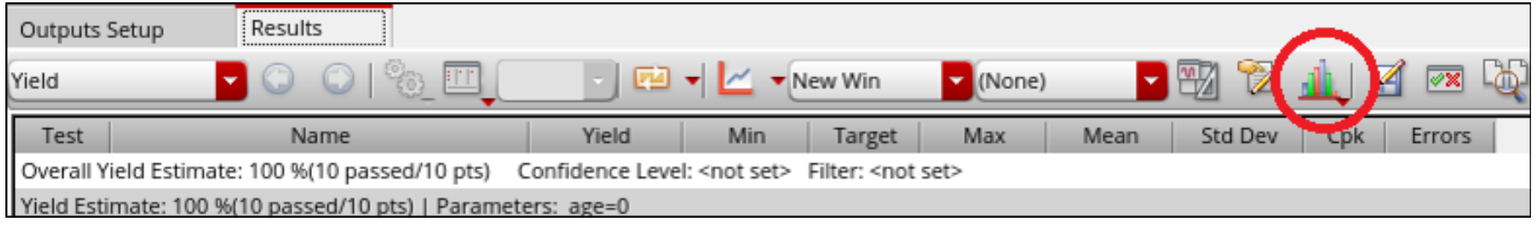
- After running the simulation, the results should look like this.



Test	Name	Yield	Min	Target	Max	Mean	Std Dev	Cpk	Errors
Yield Estimate: 100 %(10 passed/10 pts) | Parameters: age=0									
amplifier_common_source_testbench_1									
	Gain(summary)	100% (10/10)	16.16 dB	> 7.5	16.93 dB	16.55 dB	248.2 mdB	12.2	0
	Gain	100% (10/10)	16.16 dB	> 7.5	16.93 dB	16.55 dB	248.2 mdB	12.2	0
	Bandwidth(summary)	100% (10/10)	5.775 GHz	> 4G	6.44 GHz	6.155 GHz	212.5 MHz	3.38	0
	Bandwidth	100% (10/10)	5.775 GHz	> 4G	6.44 GHz	6.155 GHz	212.5 MHz	3.38	0
	Current Consumption(summary)	100% (10/10)	1.785 mA	< 2.5m	1.967 mA	1.872 mA	58.14 uA	3.6	0
	Current Consumption	100% (10/10)	1.785 mA	< 2.5m	1.967 mA	1.872 mA	58.14 uA	3.6	0
	Power Consumption(summary)	100% (10/10)	1.963 mW	< 2.75m	2.164 mW	2.059 mW	63.96 uW	3.6	0
	Power Consumption	100% (10/10)	1.963 mW	< 2.75m	2.164 mW	2.059 mW	63.96 uW	3.6	0
Yield Estimate: 40 %(4 passed/10 pts) | Parameters: age=3_yr									
amplifier_common_source_testbench_1									
	Gain(summary)	40% (4/10)	423.8 mdB	> 7.5	13.36 dB	6.951 dB	4.753 dB	-0.0385	0
	Gain	40% (4/10)	423.8 mdB	> 7.5	13.36 dB	6.951 dB	4.753 dB	-0.0385	0
	Bandwidth(summary)	100% (10/10)	5.883 GHz	> 4G	17.78 GHz	10.84 GHz	4.29 GHz	0.532	0
	Bandwidth	100% (10/10)	5.883 GHz	> 4G	17.78 GHz	10.84 GHz	4.29 GHz	0.532	0
	Current Consumption(summary)	100% (10/10)	875 uA	< 2.5m	1.026 mA	927.6 uA	50.98 uA	10.3	0
	Current Consumption	100% (10/10)	875 uA	< 2.5m	1.026 mA	927.6 uA	50.98 uA	10.3	0
	Power Consumption(summary)	100% (10/10)	962.5 uW	< 2.75m	1.128 mW	1.02 mW	56.07 uW	10.3	0
	Power Consumption	100% (10/10)	962.5 uW	< 2.75m	1.128 mW	1.02 mW	56.07 uW	10.3	0

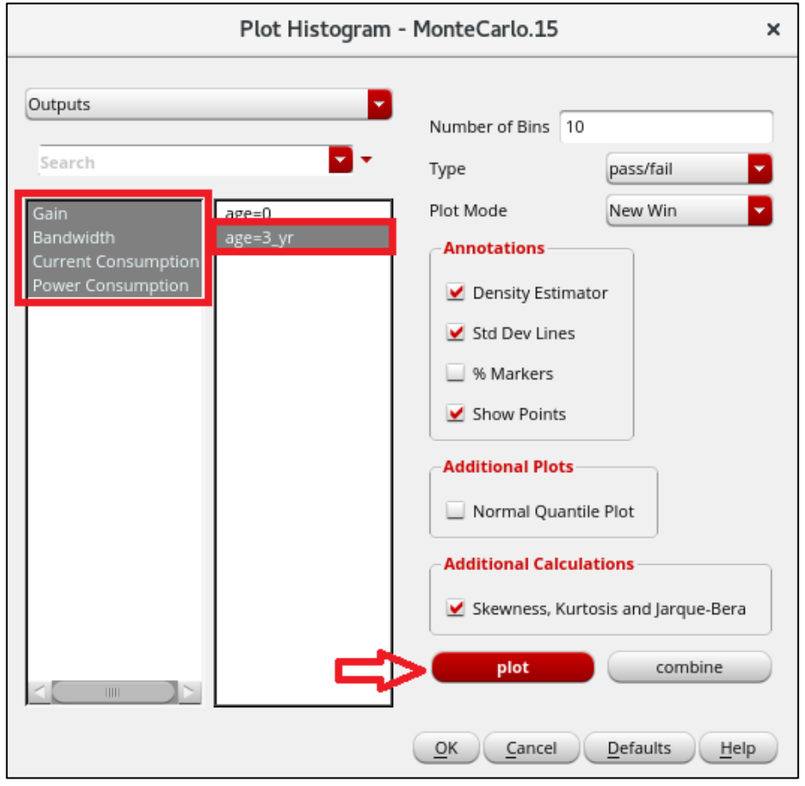
2.d. Reliability aging with Monte-Carlo *(continued)*

- Click on the **Histogram** icon in the Results tab.
- Select “amplifier_common_source_testbench_1” -> **Histogram**.



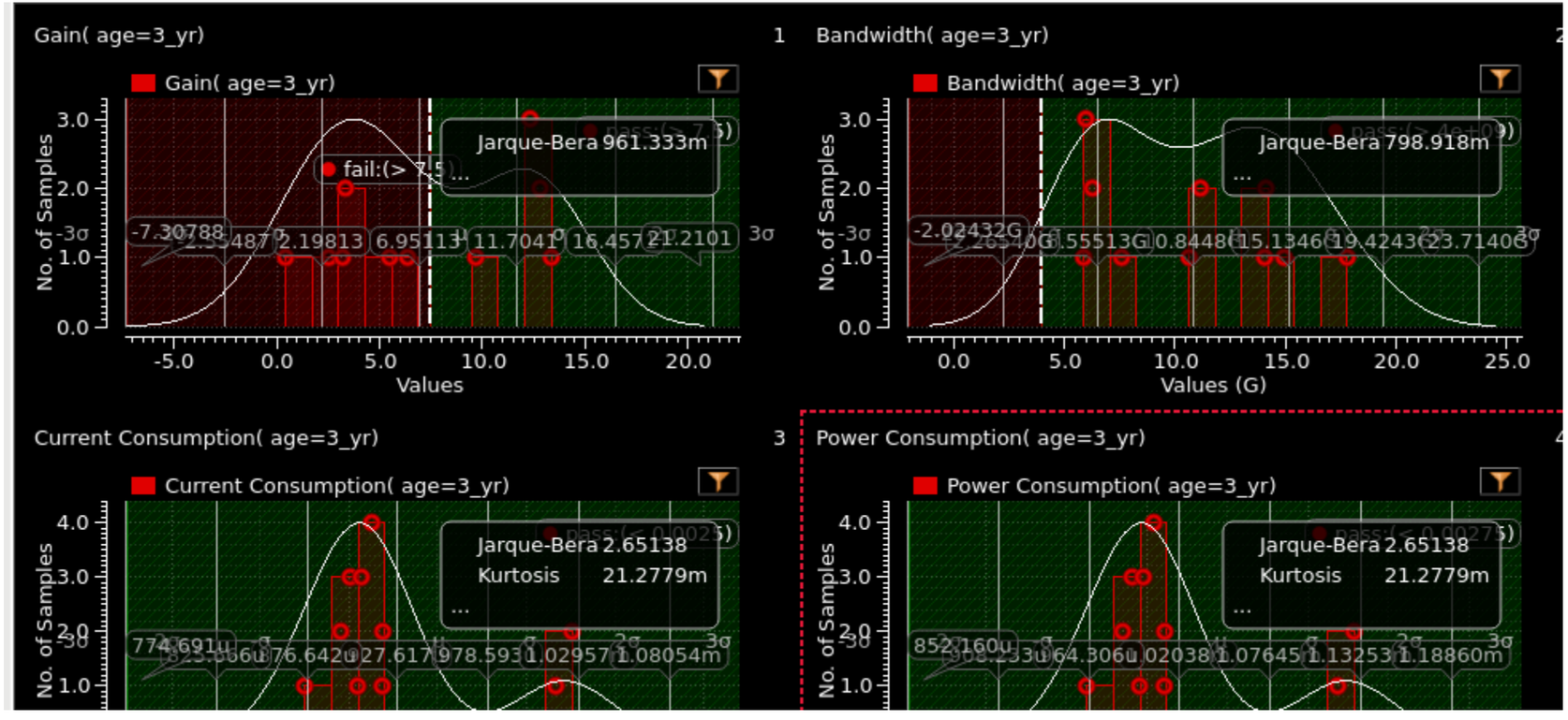
2.d. Reliability aging with Monte-Carlo *(continued)*

- Select “Gain”, “Bandwidth”, “Current Consumption”, and “Power Consumption”.
- Select on “age=3_yr” and then click on **Plot**.



2.d. Reliability aging with Monte-Carlo *(continued)*

- The results will be plotted for each output expression.



AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- **Gradual aging**
- Run plan

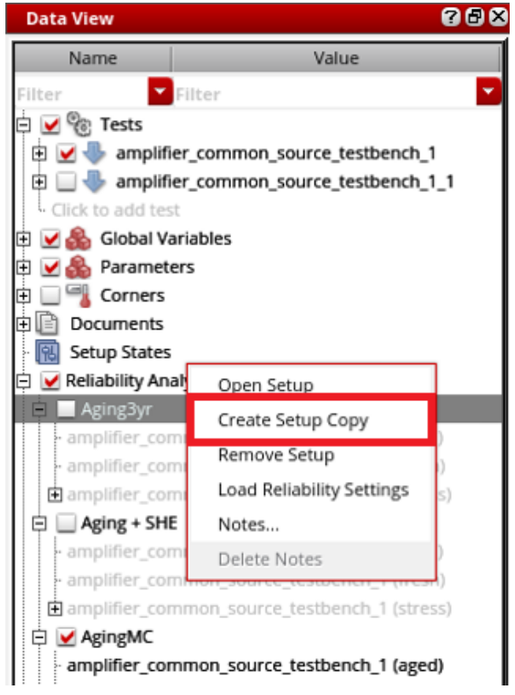
2.e. Gradual Aging Simulation

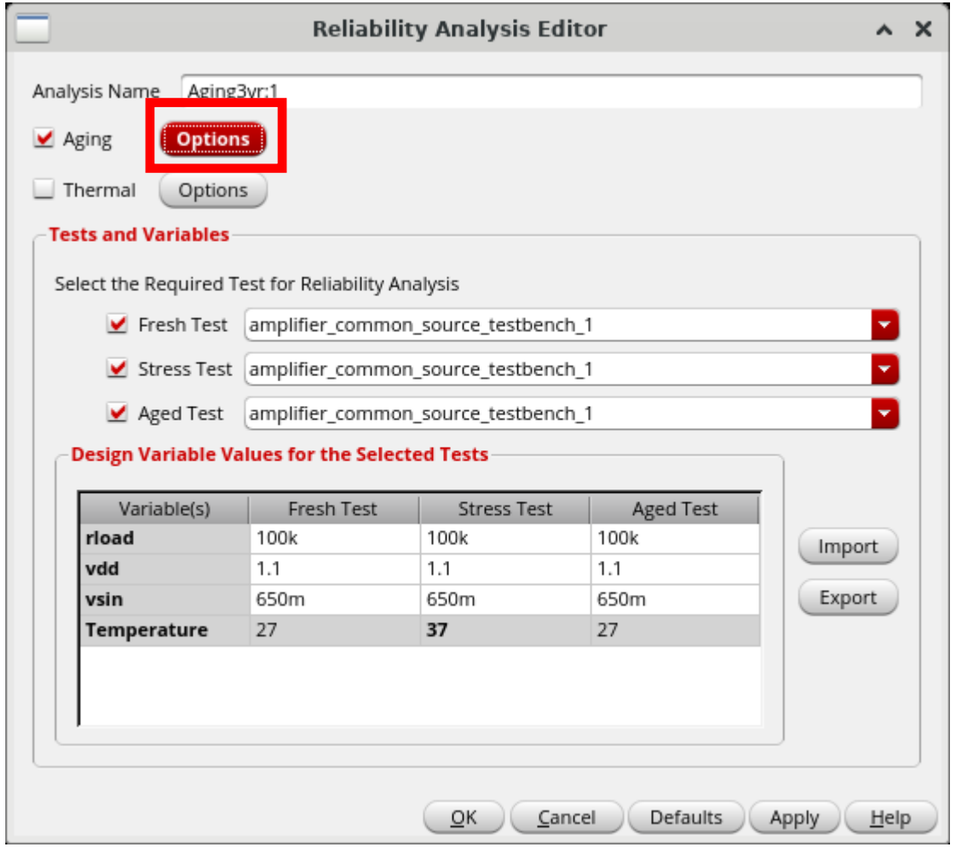
- Typically, aging simulations only run one stress simulation. The aging phase is divided into many periods using the gradual aging analysis.
- Although this produces better findings and is more accurate, it is more costly and calls for more simulations.

cadence

2.e. Gradual Aging Simulation (continued)

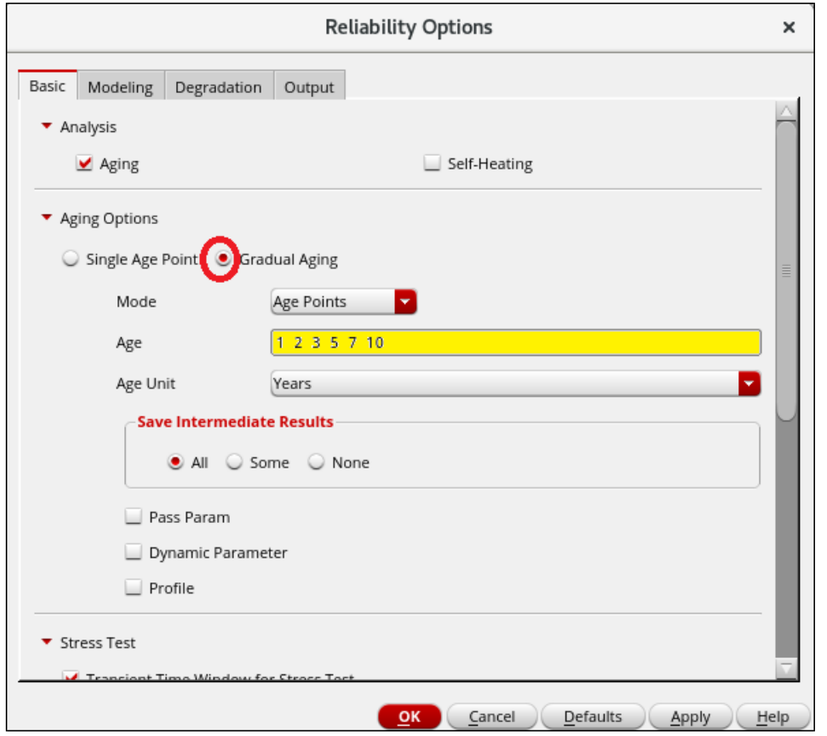
- Right click on `Aging3yr,` and select “create setup copy”.
- Open the new editor form and click on “options”.





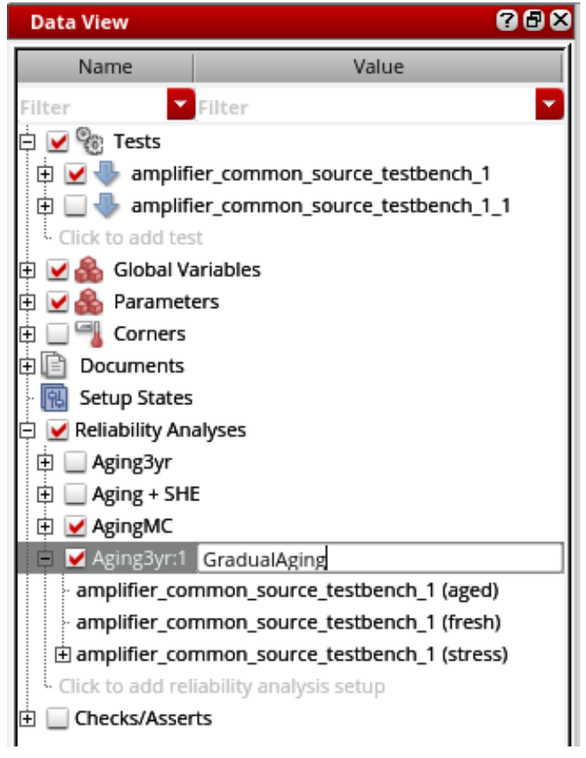
2.e. Gradual Aging Simulation (continued)

- Select **Gradual Aging** under **Aging options**.
- Select the mode as **Age Points**.
- Copy and paste the following in the **Age** field "`1 2 3 5 7 10`".
- Make sure **Pass param** and **Dynamic Parameter** options are not selected for now.
- Double check that under the Stress Test, Transient time window is selected with a **start time** of **0** and **stop time** of **10u**.
- Click OK to close Reliability Options form
- Click OK to close the Reliability Editor form



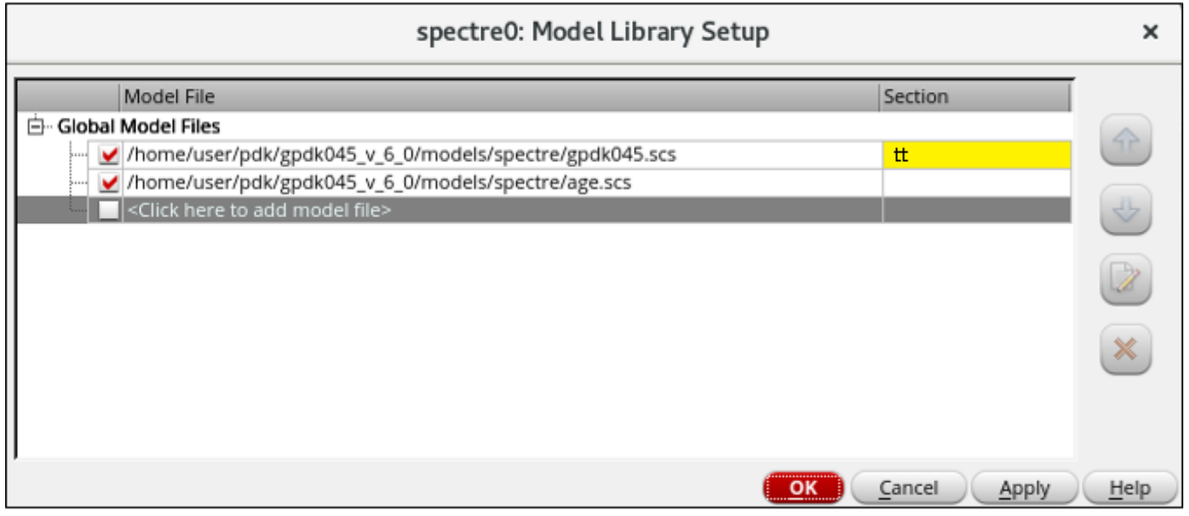
2.e. Gradual Aging Simulation (continued)

- Double click on `Aging3yr:1` and rename it to `GradualAging`.
- Uncheck AgingMC.



2.e. Gradual Aging Simulation (continued)

- Before running the simulation, head over to **ADE Explorer** by clicking on the blue arrow next to “amplifier_common_source_testbench_1” under **Tests**.
- In the upper menu bar, click on Setup -> Model Libraries…
- Change the section to **tt.**

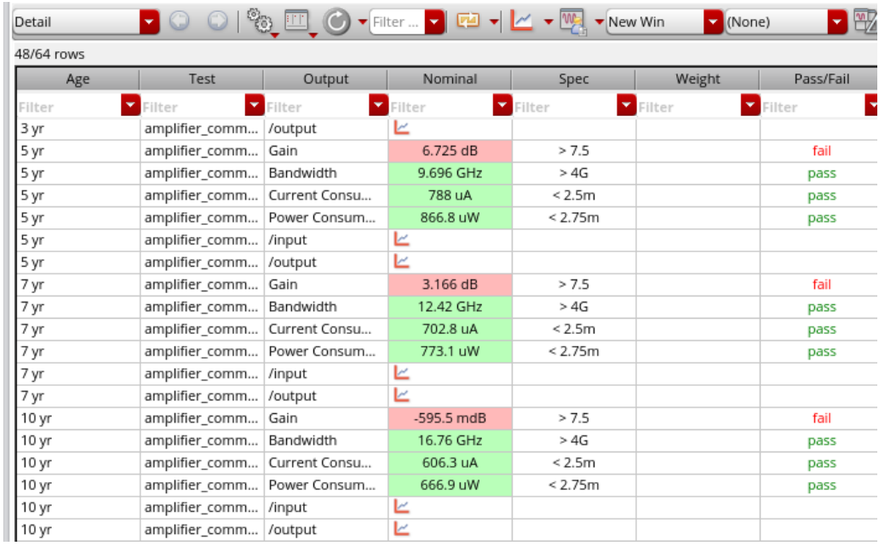


AMERICAN UNIVERSITY OF BEIRUT

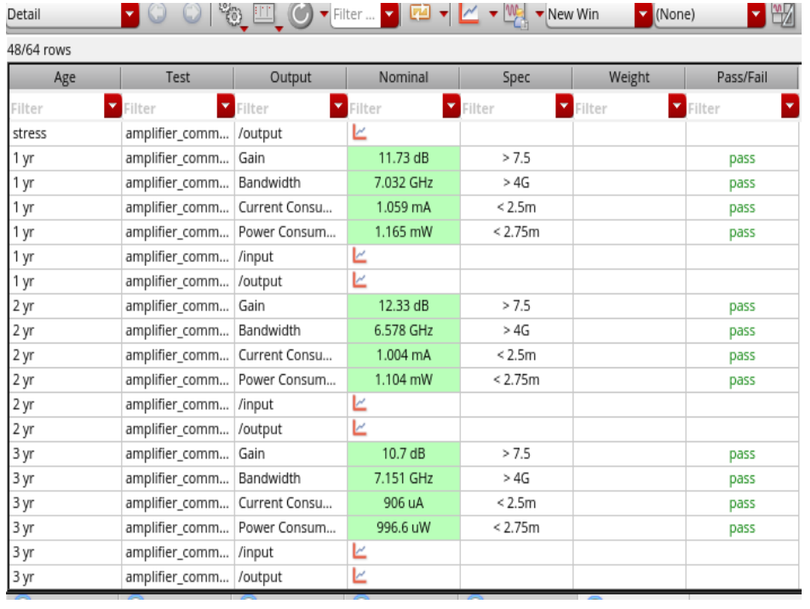
- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- **Gradual aging**
- Run plan

2.e. Gradual Aging Simulation (continued)

- Head back to ADE Explorer by clicking again on the blue arrow.
- Make sure that the Run mode is set to “Single Run, Sweeps and Corners”.
- Run the simulation.
- We will obtain results for the years 1, 2, 3, 5, 7, and 10.



Age	Test	Output	Nominal	Spec	Weight	Pass/Fail
3 yr	amplifier_comm...	/output				
5 yr	amplifier_comm...	Gain	6.725 dB	> 7.5		fail
5 yr	amplifier_comm...	Bandwidth	9.696 GHz	> 4G		pass
5 yr	amplifier_comm...	Current Consu...	788 uA	< 2.5m		pass
5 yr	amplifier_comm...	Power Consum...	866.8 uW	< 2.75m		pass
5 yr	amplifier_comm...	/input				
5 yr	amplifier_comm...	/output				
7 yr	amplifier_comm...	Gain	3.166 dB	> 7.5		fail
7 yr	amplifier_comm...	Bandwidth	12.42 GHz	> 4G		pass
7 yr	amplifier_comm...	Current Consu...	702.8 uA	< 2.5m		pass
7 yr	amplifier_comm...	Power Consum...	773.1 uW	< 2.75m		pass
7 yr	amplifier_comm...	/input				
7 yr	amplifier_comm...	/output				
10 yr	amplifier_comm...	Gain	-595.5 mdB	> 7.5		fail
10 yr	amplifier_comm...	Bandwidth	16.76 GHz	> 4G		pass
10 yr	amplifier_comm...	Current Consu...	606.3 uA	< 2.5m		pass
10 yr	amplifier_comm...	Power Consum...	666.9 uW	< 2.75m		pass
10 yr	amplifier_comm...	/input				
10 yr	amplifier_comm...	/output				



Age	Test	Output	Nominal	Spec	Weight	Pass/Fail
stress	amplifier_comm...	/output				
1 yr	amplifier_comm...	Gain	11.73 dB	> 7.5		pass
1 yr	amplifier_comm...	Bandwidth	7.032 GHz	> 4G		pass
1 yr	amplifier_comm...	Current Consu...	1.059 mA	< 2.5m		pass
1 yr	amplifier_comm...	Power Consum...	1.165 mW	< 2.75m		pass
1 yr	amplifier_comm...	/input				
1 yr	amplifier_comm...	/output				
2 yr	amplifier_comm...	Gain	12.33 dB	> 7.5		pass
2 yr	amplifier_comm...	Bandwidth	6.578 GHz	> 4G		pass
2 yr	amplifier_comm...	Current Consu...	1.004 mA	< 2.5m		pass
2 yr	amplifier_comm...	Power Consum...	1.104 mW	< 2.75m		pass
2 yr	amplifier_comm...	/input				
2 yr	amplifier_comm...	/output				
3 yr	amplifier_comm...	Gain	10.7 dB	> 7.5		pass
3 yr	amplifier_comm...	Bandwidth	7.151 GHz	> 4G		pass
3 yr	amplifier_comm...	Current Consu...	906 uA	< 2.5m		pass
3 yr	amplifier_comm...	Power Consum...	996.6 uW	< 2.75m		pass
3 yr	amplifier_comm...	/input				
3 yr	amplifier_comm...	/output				

cadence

3. Creating reliability analyses in run plan

AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- **Run plan**

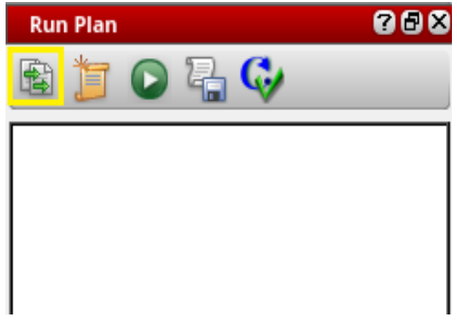
3. Creating reliability analyses in run plan

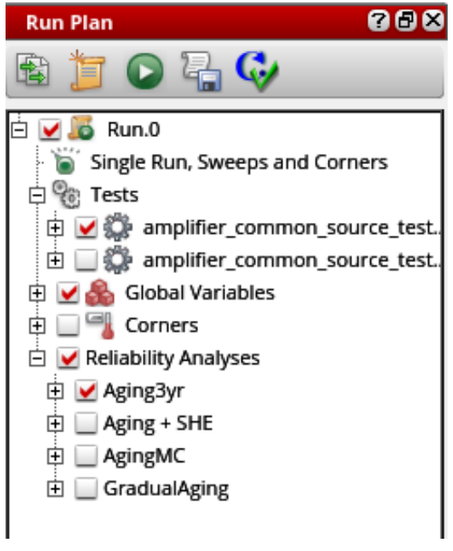
- In this section, we will dive into setup up **Reliability analysis in run plan.**
- With this assistance, we can set up a reliable verification flow for reliability simulation employing all the features of the run plan, such as:
  - Conditional run
  - Running several run modes simultaneously
  - pre-run/post-run scripts to change the setup prior to simulation, etc.

cadence

3. Creating reliability analyses in run plan

- Start by Enabling the **Aging3yr** analysis and disabling all the rest of the Reliability setups.
- From the Menu bar, select **Window > Assistants > Run plan**.
- The new Run plan window should pop up on the right side in **ADE Assembler.**
- Click on **Create new from active setup**.
- Expand the **Run.0** run plan setup.
- Create two more runs similarly, **Run.1** and **Run.2**.



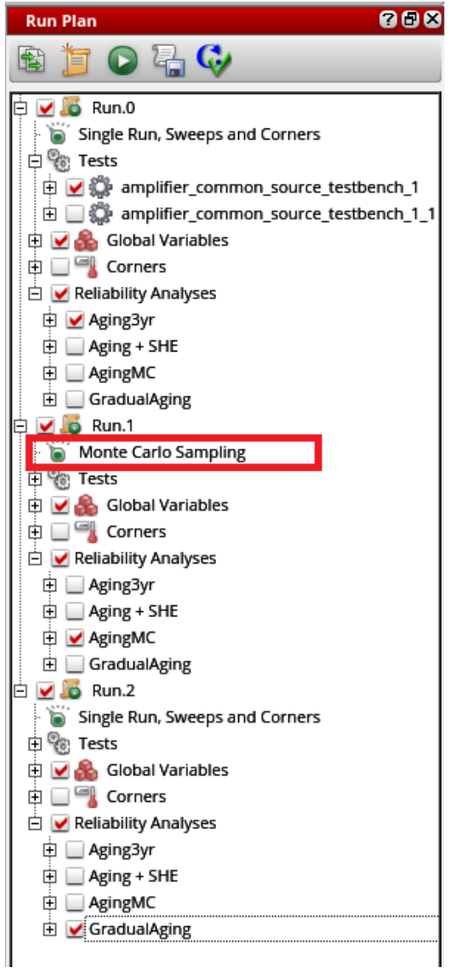


AMERICAN UNIVERSITY OF BEIRUT

- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

3. Creating reliability analyses in run plan

- For Run.0, select **Aging3yr** as the setup for Reliability.
- For Run.1 select **Aging_MC** as the Reliability setup.
- For Run.2 select **Gradual_aging** as the Reliability setup.
- Make sure to expand Run.1 and double click on **Single Run, sweeps and corners**.
- Select **Monte Carlo sampling** instead.



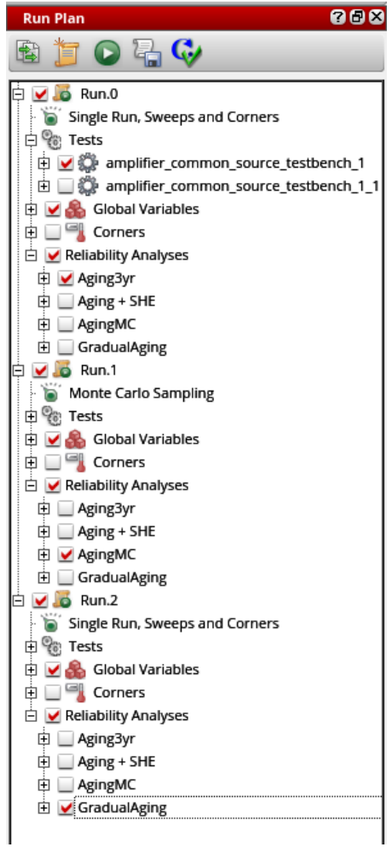
cadence

AMERICAN UNIVERSITY OF BEIRUT

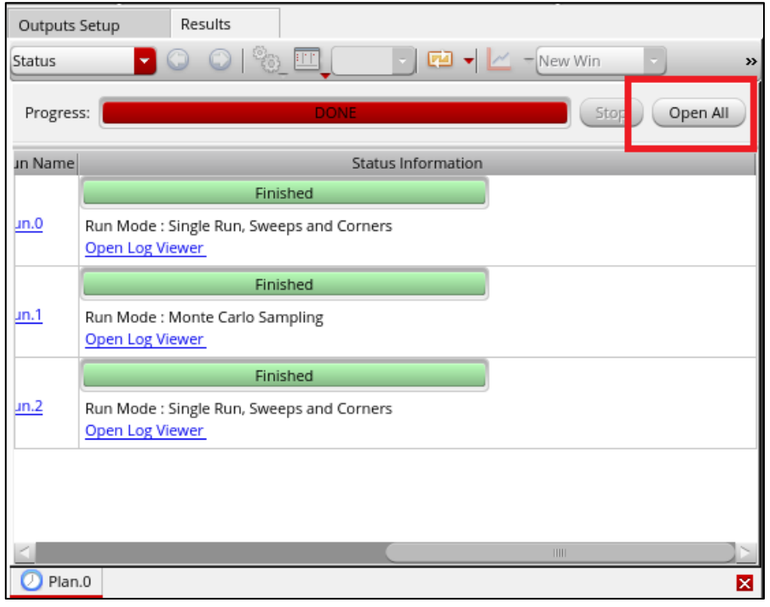
- Introduction to Reliability
- Reliability setup
- Configuring Aging Simulation
- Configuring Aging with Self Heating
- Reliability aging with Monte-Carlo
- Gradual aging
- Run plan

3. Creating reliability analyses in run plan

- The **Run Plan** window should now look like the figure on the left.
- Click on the green button to execute plan.

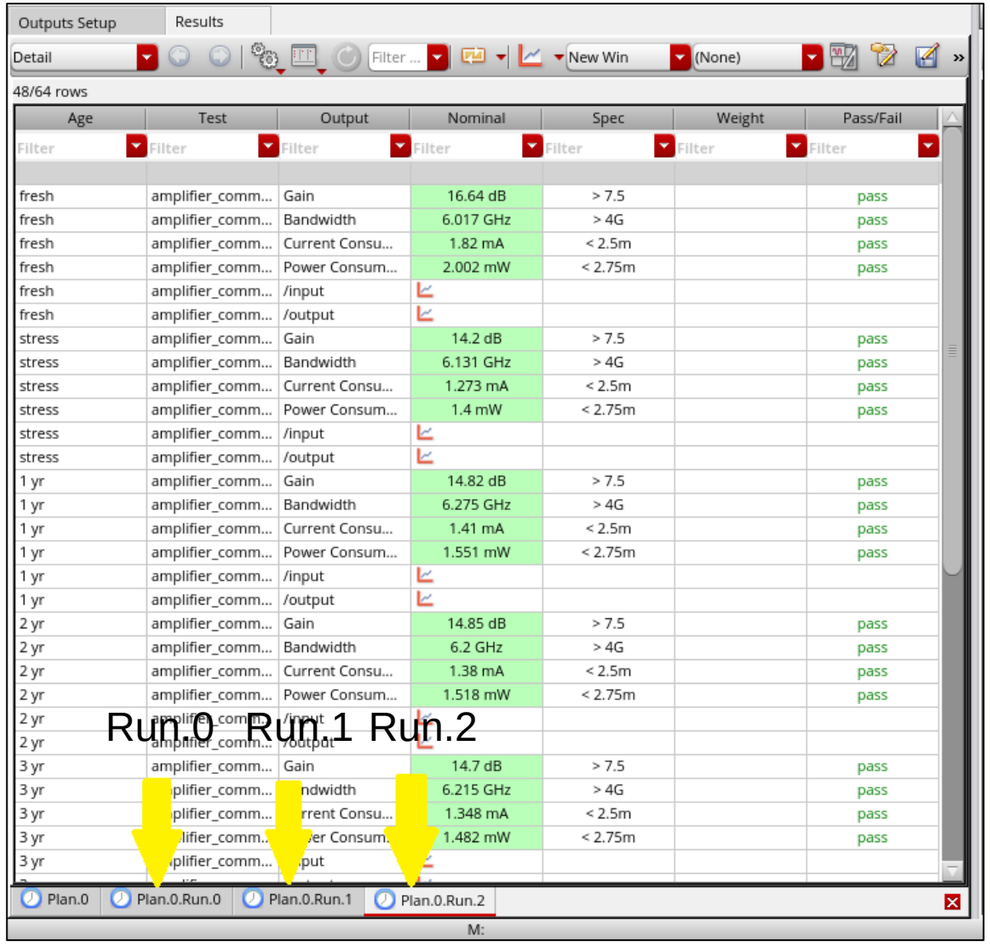


- After the run plan is finished, the results tab should look like this. Click on the Open all button.



cadence

3. Creating reliability analyses in run plan



- The advantage of having support for reliability analyses built into the run plan is that it allows us to run various reliability setups on various run modes inside a single simulation.