

# Quick Start Workshop Guide

## Step by Step Explanation for TwoStage\_Opamp (B. Razavi Fig\_9p25)

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Circuit diagrams used in this workshop guide are adapted & independently redrawn from examples presented in the Design of Analog CMOS Integrated Circuits by Behzad Razavi and are included solely for educational demonstration purposes. All rights in the referenced publication remain with the respective copyright owner(s).

Step 1: Select a Circuit from the Table that you want to practice.

1. Navigate below List of Circuits Preloaded in GenieLab
2. Browse available circuits
3. Choose a simple circuit
4. Here we are considering Sl. # 12 **Two Stage Op-Amp** project for this demonstration

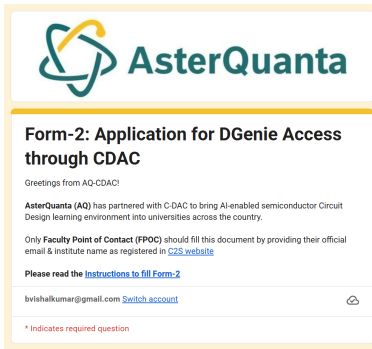
**Table :1 List of Circuits Pre-Loaded in GenieLab Project**

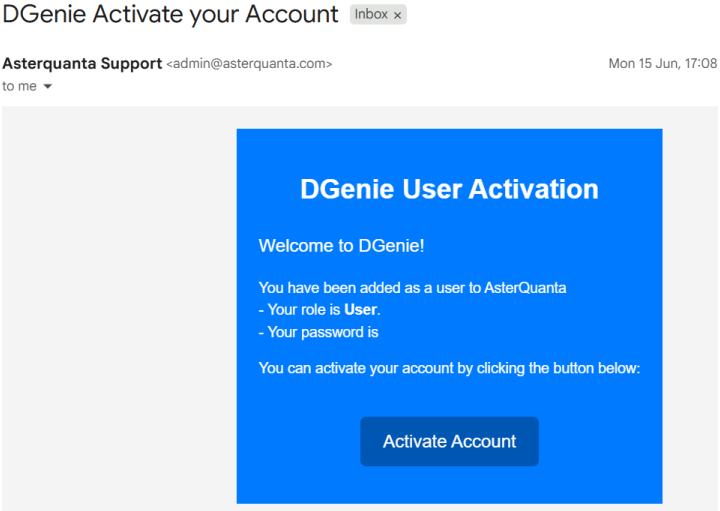
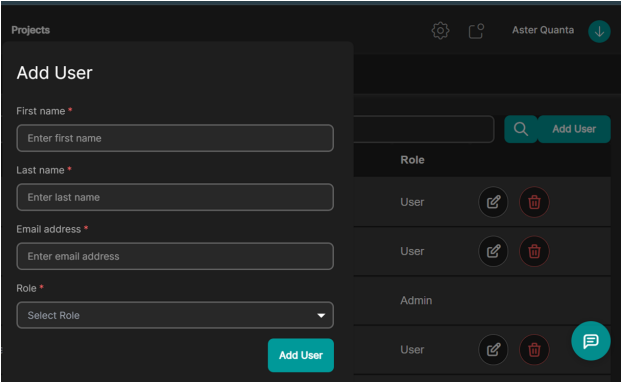
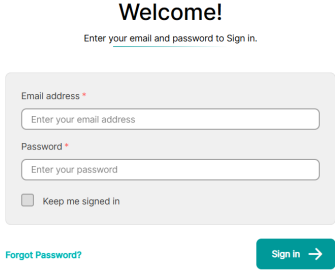
| S.No. | Circuit category                             | Circuit Name                                |
|-------|----------------------------------------------|---------------------------------------------|
| 1     | Single stage                                 | Common-Source Stage with Resistive Load     |
| 2     |                                              | CS Stage with Diode-Connected Load          |
| 3     |                                              | CS Stage with Current-Source Load           |
| 4     |                                              | Source Follower                             |
| 5     |                                              | Common-Gate Stage                           |
| 6     |                                              | Cascode Stage                               |
| 7     | Differential Amplifiers                      | Basic Differential Pair                     |
| 8     |                                              | Common-Mode Response of a differential pair |
| 9     |                                              | Differential Pair with MOS Loads            |
| 10    | Current Mirrors                              | Basic current mirror                        |
| 11    |                                              | Cascode Current Mirrors                     |
| 12    | OTA (Operational transconductance amplifier) | Two stage OpAmp (single ended output)       |
| 13    |                                              | Telescopic Op-amp                           |
| 14    |                                              | Folded Cascode amp                          |
| 15    | V2I                                          | V2I converter (feedback sensing)            |
| 16    | Comparators                                  | Two stage comparator                        |
| 17    | Switched Capacitors                          | Switched capacitor amplifier                |
| 18    |                                              | Switched capacitor integrator               |
| 19    | BGR and LDOs                                 | Bandgap reference                           |
| 20    |                                              | PMOS based LDO                              |

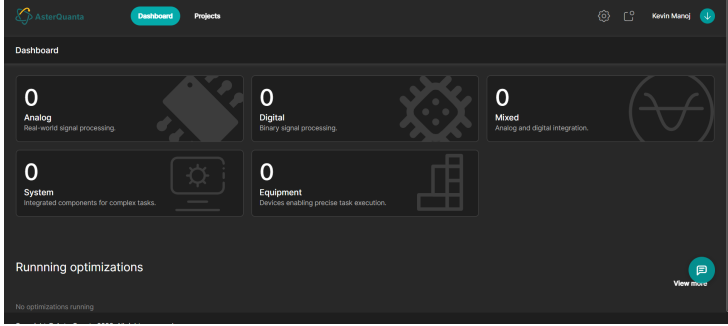
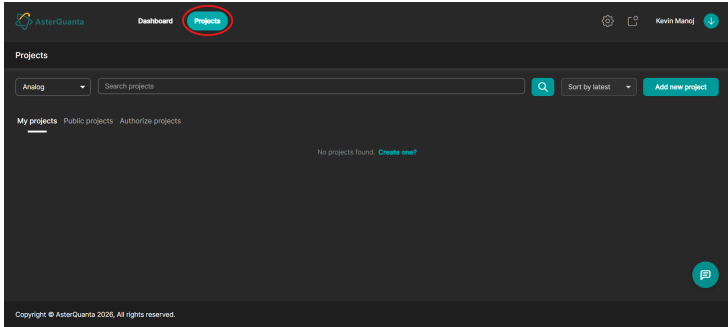
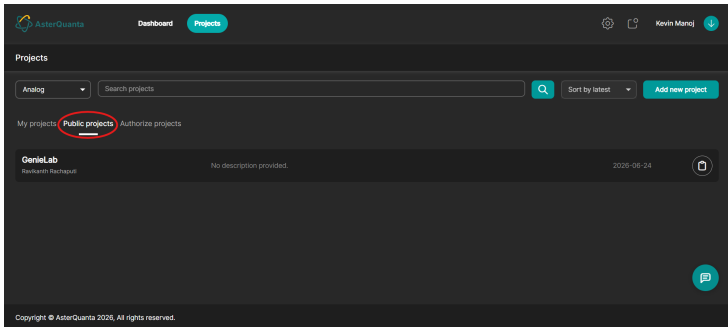
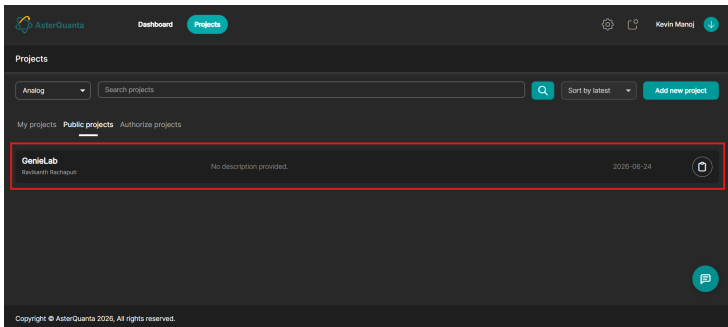
**Table 2: Summary of various Levels of Learning**

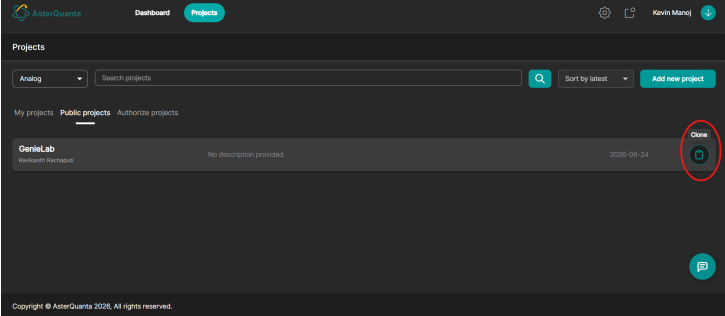
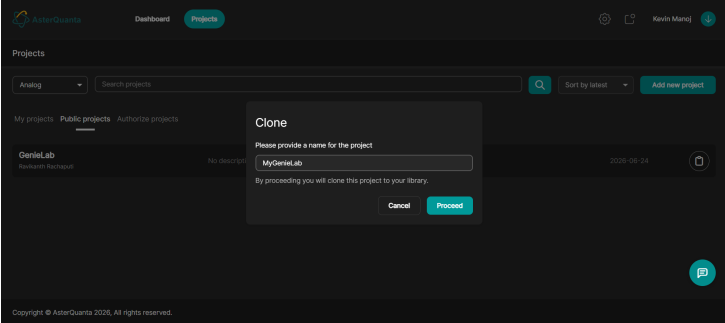
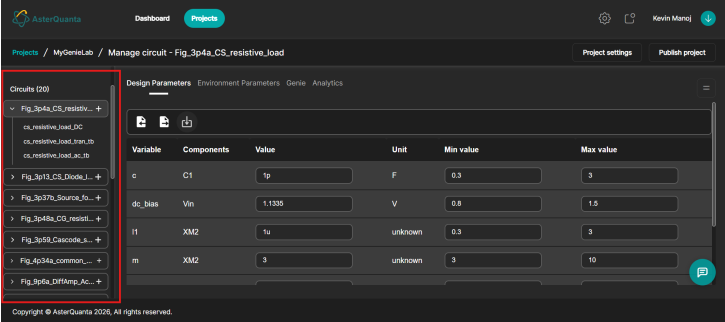
| SI No | User Learning Requirement                                                                                                                                                                                                                                                                                                   | People Involved | End-User Benefit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | <p><b>Getting Started with Analog Circuit Learning</b></p> <p>I am an ECE student.</p> <p>I am new to analog circuit design and want to understand how textbook circuits are implemented and simulated using DGenie. I want guided, hands-on learning with preloaded reference circuits before creating my own designs.</p> | EC Student      | <p>The student learns the complete analog circuit learning workflow by exploring preloaded educational circuits, understanding circuit structure, running DC, AC, and Transient simulations, interpreting schematics, netlists, graphs, design parameters, and simulation results, and connecting theoretical concepts from textbooks with practical circuit analysis in DGenie. The student builds confidence to independently explore additional circuits and simulations.</p> <p><a href="#">Click here to go to detailed learning</a></p> |
| 2     | <p><b>Learning AI-Driven Circuit Optimization</b></p> <p>I have a basic understanding of analog circuits and DGenie workflows.</p> <p>I want to learn how to define circuit measurements, visualize simulation data, set optimization targets, and use Genie AI to automatically optimize circuit performance.</p>          | EC Student      | <p>The student learns how to configure measurements and data capture, visualize simulation results, define performance targets using Genie, and perform AI-driven circuit optimization. By comparing target and simulated results and analyzing optimized design parameters, the student develops an understanding of how AI can automate analog circuit design and improve circuit performance while reducing manual design effort.</p> <p><a href="#">Click here to go to detailed learning</a></p>                                         |

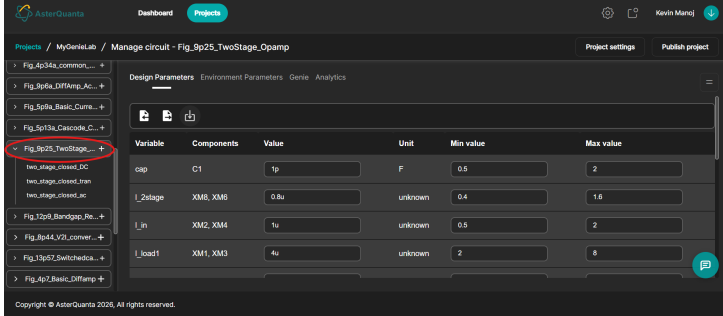
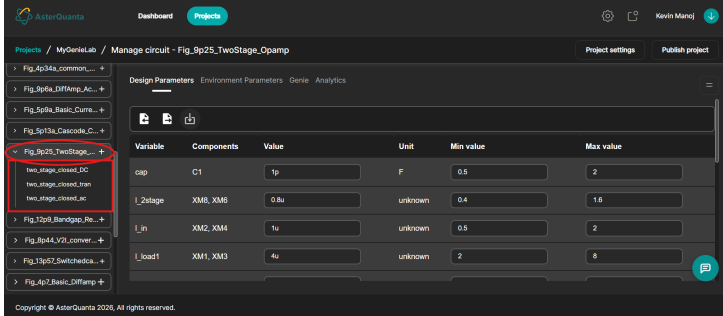
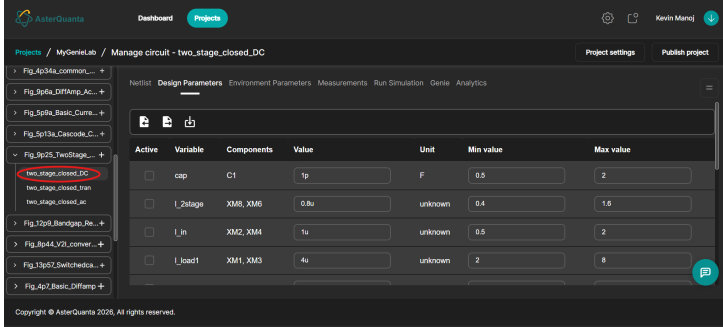
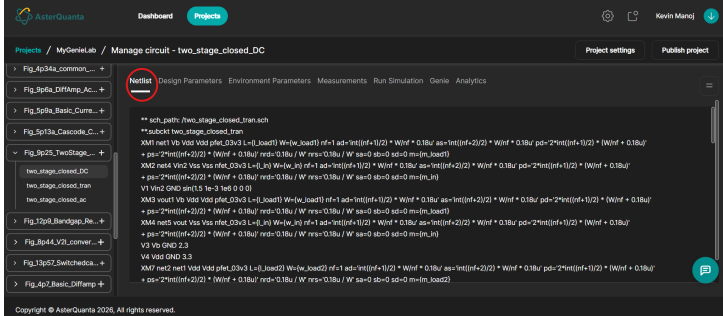
## Workshop Hands-on Steps-1

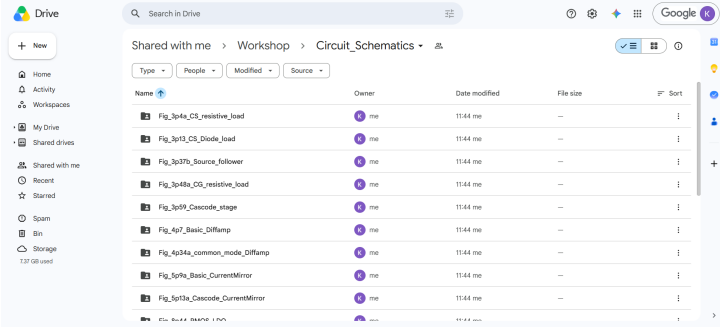
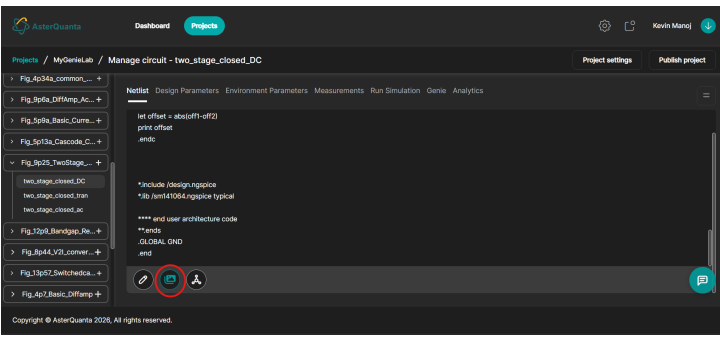
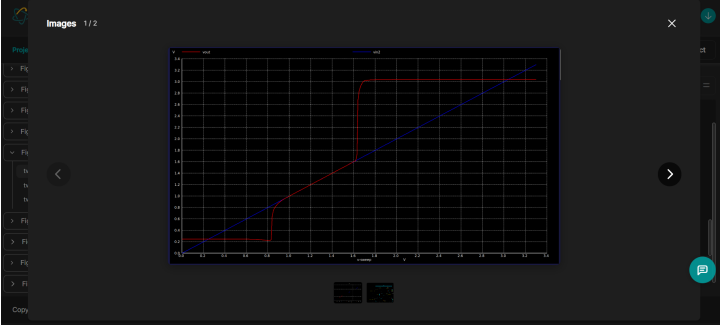
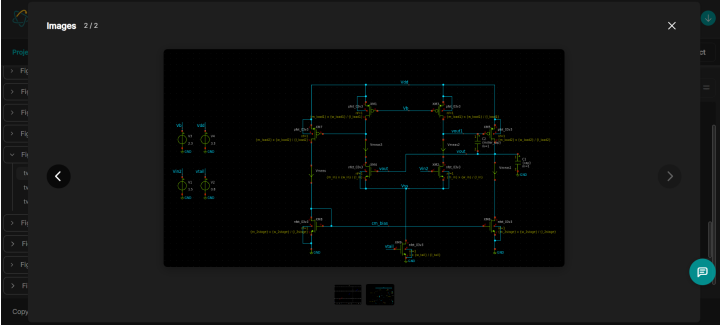
| Step | Activity                                                                                                             | Reference                                                                           |
|------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| i    | Register for the AQ Masterclass through the CDAC website.                                                            |   |
| ii   | Attend the Masterclass and understand how DGenie is used for circuit design, simulation, and AI-driven optimization. |                                                                                     |
| iii  | Save the DGenie access request form shared during the session.                                                       |  |
| iv   | Provide your name and official college email address to your faculty coordinator.                                    |                                                                                     |
| v    | Request access to DGenie through the faculty submission process.                                                     |                                                                                     |
| vi   | Wait for confirmation that your details have been added to the DGenie platform.                                      |                                                                                     |

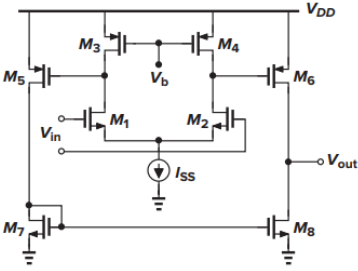
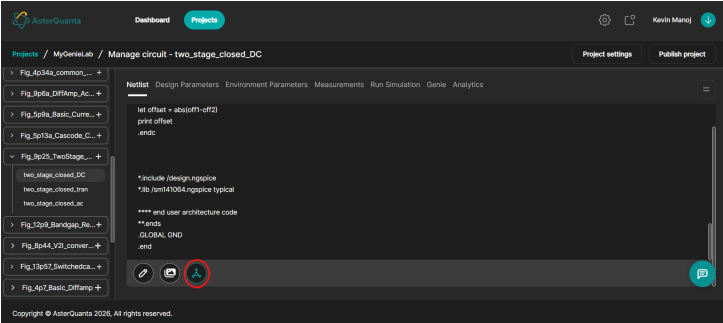
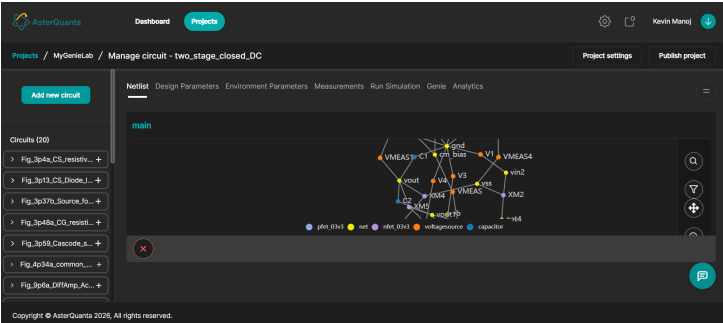
|      |                                                                                                                                                                                                                                                                    |                                                                                      |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| vii  | Check your inbox for the account activation email from AsterQuanta.                                                                                                                                                                                                |    |
| viii | Open the activation email and review the account information provided.                                                                                                                                                                                             |                                                                                      |
| ix   | Click the Activate Account button.                                                                                                                                                                                                                                 |                                                                                      |
| x    | Create a secure password and complete account activation.                                                                                                                                                                                                          |                                                                                      |
| xi   | <p>Faculty can provide access to their students</p> <p>Faculty log in to their account</p> <p>Click on Settings</p> <ul style="list-style-type: none"> <li>- Add User</li> <li>- Add Details</li> <li>- Select Role as “User”</li> <li>- Click Add User</li> </ul> |  |
| 1    | <p>Open the DGenie login page <a href="https://academy-genie.asterquanta.com">academy-genie.asterquanta.com</a></p> <p>Sign in using your registered email address and password.</p>                                                                               |  |

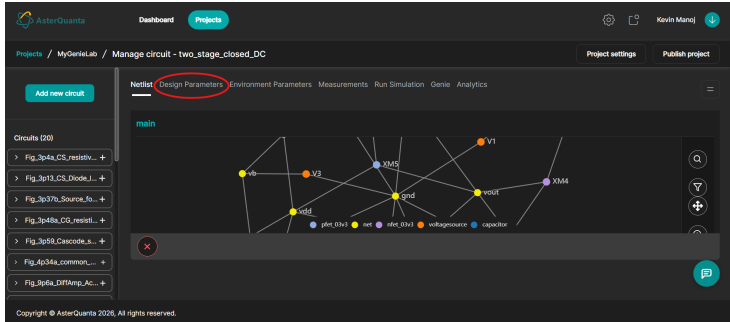
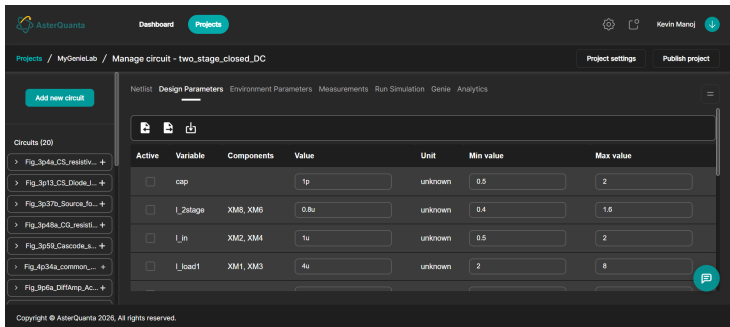
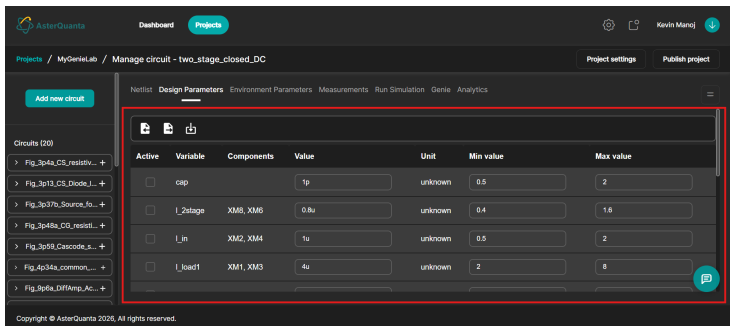
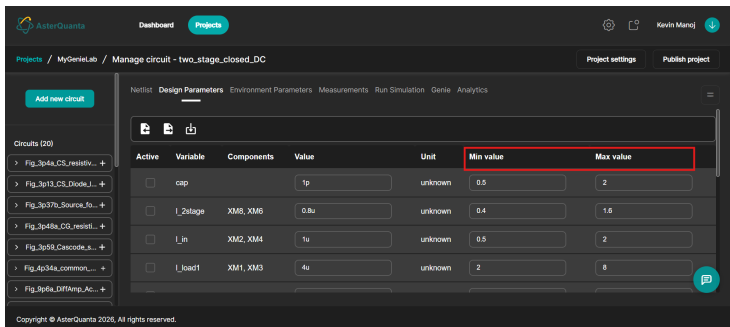
|     |                                                                               |                                                                                      |
|-----|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 1.1 | You are logged in                                                             |    |
| 2.  | Open the Projects section to explore available project resources.             |    |
| 3.  | Switch to the Public Projects tab and review the available learning projects. |   |
| 4.  | Locate the GenieLab project that contains pre-loaded educational circuits.    |  |

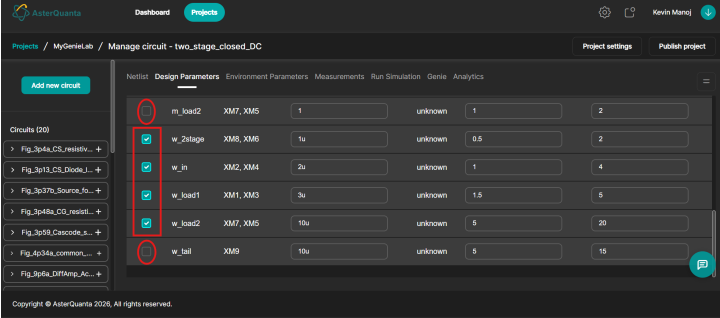
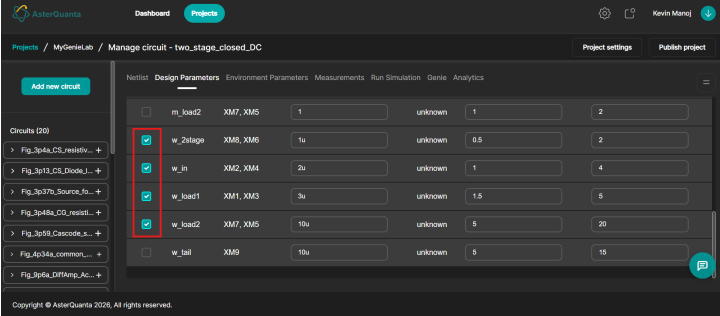
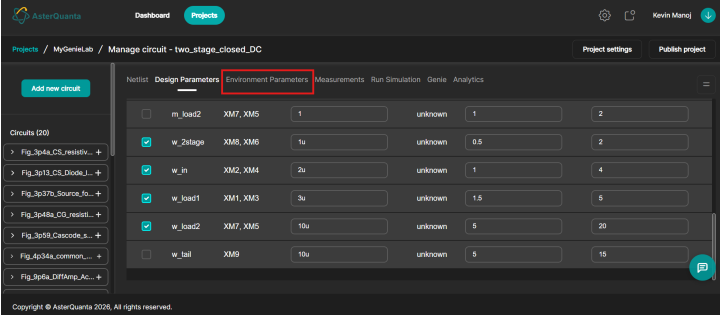
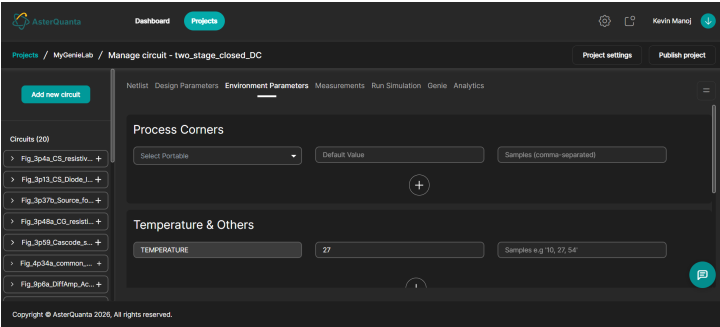
| 5.    | Clone the GenieLab project to create your personal workspace by clicking on the 'Clone' button on the right.                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------------------|--------------|---|--------------|-----------------------------------------|---|------------------------------------|---|-----------------------------------|---|-----------------|---|-------------------|---|---------------|---|-------------------------|-------------------------|---|---------------------------------------------|---|-----------------|----------------------------------|----|----------------------|----|--|-------------------------|----|---------------------------------------|----|----------------------------------------------|-------------------|----|--------------------|----|-----|----------------------------------|----|-------------|----------------------|----|---------------------|------------------------------|----|-------------------------------|----|--------------|-------------------|----|----------------|
| 6.    | Provide a meaningful project name and proceed with cloning.                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 7.    | Review the cloned project and observe the collection of circuits available for learning which are taken from Razavi. B textbook 2nd edition |  <table border="1"> <thead> <tr> <th>S.No.</th><th>Circuit category</th><th>Circuit Name</th></tr> </thead> <tbody> <tr><td>1</td><td rowspan="6">Single stage</td><td>Common-Source Stage with Resistive Load</td></tr> <tr><td>2</td><td>CS Stage with Diode-Connected Load</td></tr> <tr><td>3</td><td>CS Stage with Current-Source Load</td></tr> <tr><td>4</td><td>Source Follower</td></tr> <tr><td>5</td><td>Common-Gate Stage</td></tr> <tr><td>6</td><td>Cascode Stage</td></tr> <tr><td>7</td><td rowspan="2">Differential Amplifiers</td><td>Basic Differential Pair</td></tr> <tr><td>8</td><td>Common-Mode Response of a differential pair</td></tr> <tr><td>9</td><td rowspan="2">Current Mirrors</td><td>Differential Pair with MOS Loads</td></tr> <tr><td>10</td><td>Basic current mirror</td></tr> <tr><td>11</td><td rowspan="2"></td><td>Cascode Current Mirrors</td></tr> <tr><td>12</td><td>Two stage OpAmp (single ended output)</td></tr> <tr><td>13</td><td rowspan="2">OTA (Operational transconductance amplifier)</td><td>Telescopic Op-amp</td></tr> <tr><td>14</td><td>Folded Cascode amp</td></tr> <tr><td>15</td><td>V2I</td><td>V2I converter (feedback sensing)</td></tr> <tr><td>16</td><td>Comparators</td><td>Two stage comparator</td></tr> <tr><td>17</td><td rowspan="2">Switched Capacitors</td><td>Switched capacitor amplifier</td></tr> <tr><td>18</td><td>Switched capacitor integrator</td></tr> <tr><td>19</td><td rowspan="2">BGR and LDOs</td><td>Bandgap reference</td></tr> <tr><td>20</td><td>PMOS based LDO</td></tr> </tbody> </table> | S.No. | Circuit category | Circuit Name | 1 | Single stage | Common-Source Stage with Resistive Load | 2 | CS Stage with Diode-Connected Load | 3 | CS Stage with Current-Source Load | 4 | Source Follower | 5 | Common-Gate Stage | 6 | Cascode Stage | 7 | Differential Amplifiers | Basic Differential Pair | 8 | Common-Mode Response of a differential pair | 9 | Current Mirrors | Differential Pair with MOS Loads | 10 | Basic current mirror | 11 |  | Cascode Current Mirrors | 12 | Two stage OpAmp (single ended output) | 13 | OTA (Operational transconductance amplifier) | Telescopic Op-amp | 14 | Folded Cascode amp | 15 | V2I | V2I converter (feedback sensing) | 16 | Comparators | Two stage comparator | 17 | Switched Capacitors | Switched capacitor amplifier | 18 | Switched capacitor integrator | 19 | BGR and LDOs | Bandgap reference | 20 | PMOS based LDO |
| S.No. | Circuit category                                                                                                                            | Circuit Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 1     | Single stage                                                                                                                                | Common-Source Stage with Resistive Load                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 2     |                                                                                                                                             | CS Stage with Diode-Connected Load                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 3     |                                                                                                                                             | CS Stage with Current-Source Load                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 4     |                                                                                                                                             | Source Follower                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 5     |                                                                                                                                             | Common-Gate Stage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 6     |                                                                                                                                             | Cascode Stage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 7     | Differential Amplifiers                                                                                                                     | Basic Differential Pair                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 8     |                                                                                                                                             | Common-Mode Response of a differential pair                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 9     | Current Mirrors                                                                                                                             | Differential Pair with MOS Loads                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 10    |                                                                                                                                             | Basic current mirror                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 11    |                                                                                                                                             | Cascode Current Mirrors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 12    |                                                                                                                                             | Two stage OpAmp (single ended output)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 13    | OTA (Operational transconductance amplifier)                                                                                                | Telescopic Op-amp                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 14    |                                                                                                                                             | Folded Cascode amp                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 15    | V2I                                                                                                                                         | V2I converter (feedback sensing)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 16    | Comparators                                                                                                                                 | Two stage comparator                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 17    | Switched Capacitors                                                                                                                         | Switched capacitor amplifier                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 18    |                                                                                                                                             | Switched capacitor integrator                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 19    | BGR and LDOs                                                                                                                                | Bandgap reference                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |
| 20    |                                                                                                                                             | PMOS based LDO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |       |                  |              |   |              |                                         |   |                                    |   |                                   |   |                 |   |                   |   |               |   |                         |                         |   |                                             |   |                 |                                  |    |                      |    |  |                         |    |                                       |    |                                              |                   |    |                    |    |     |                                  |    |             |                      |    |                     |                              |    |                               |    |              |                   |    |                |

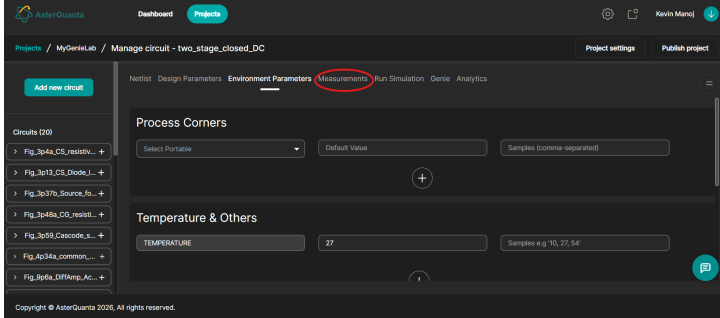
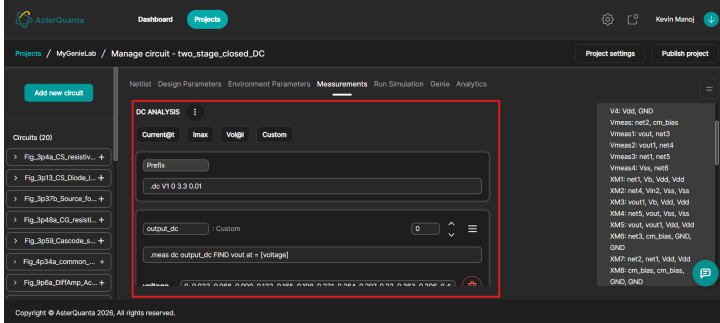
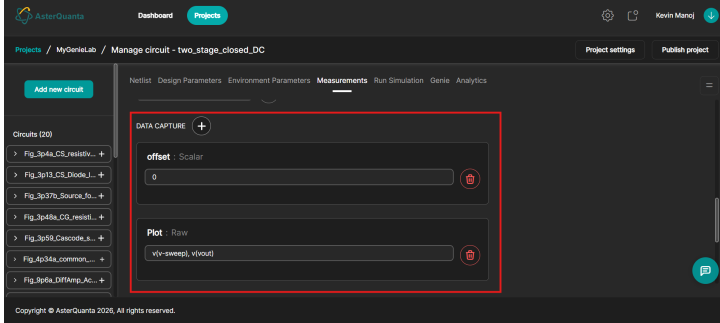
|     |                                                                                                         |                                                                                      |
|-----|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 8.  | Select the Two Stage Op-Amp circuit to begin your first hands-on exercise.<br>(Fig_9p25_TwoStage_Opmp)  |    |
| 9.  | Explore the circuit hierarchy and understand the relationship between design circuits and test benches. |    |
| 10. | Click on two_stage_closed_DC testbench (two_stage_closed_DC)                                            |   |
| 11. | Go to Netlist tab under two_stage_closed_DC                                                             |  |

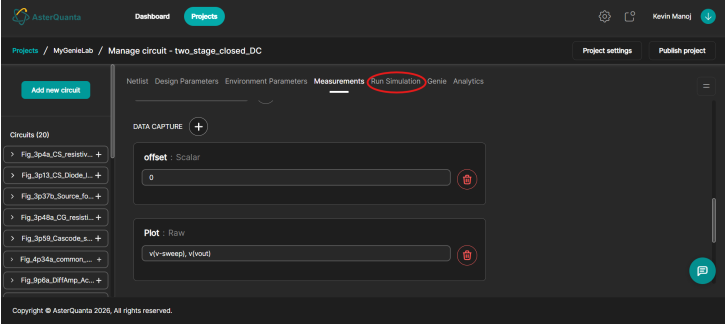
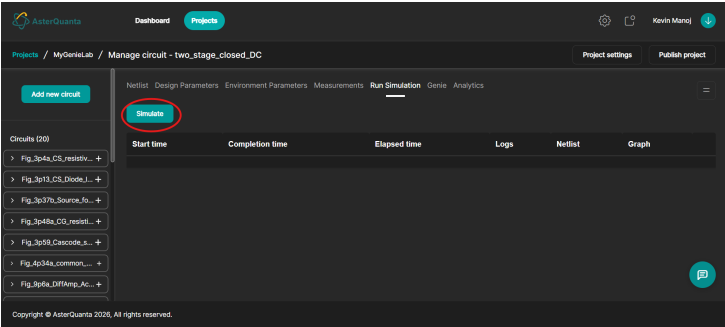
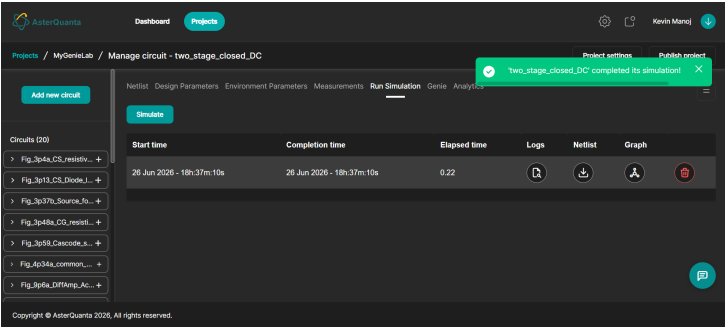
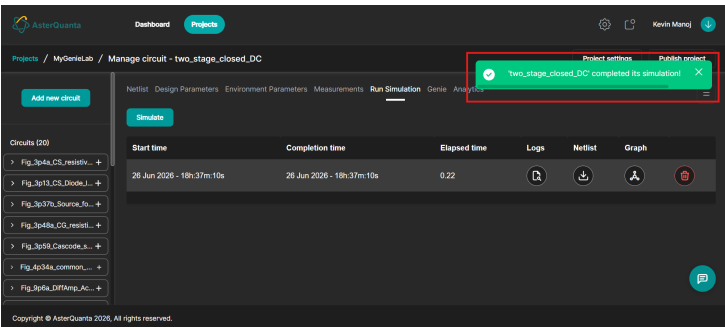
|     |                                                                                                                                                   |                                                                                                                                                                                                                                                                   |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12. | <p>The schematic for this circuit can be found here (<a href="#">Circuit_Schematics</a>)</p>                                                      |                                                                                                                                                                                 |
| 13. | <p>Click on the image icon at the bottom to view the image of the schematic, you can view both, the image of the schematic and the waveforms.</p> | <br><br> |

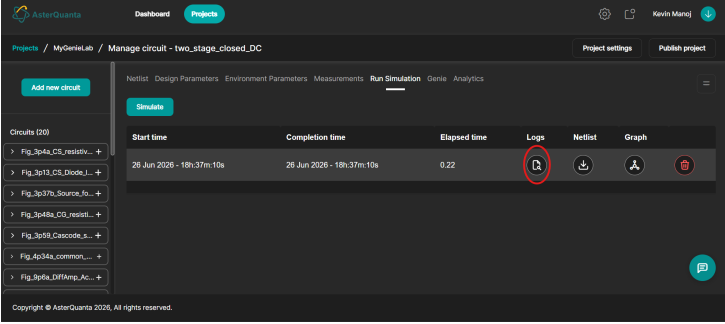
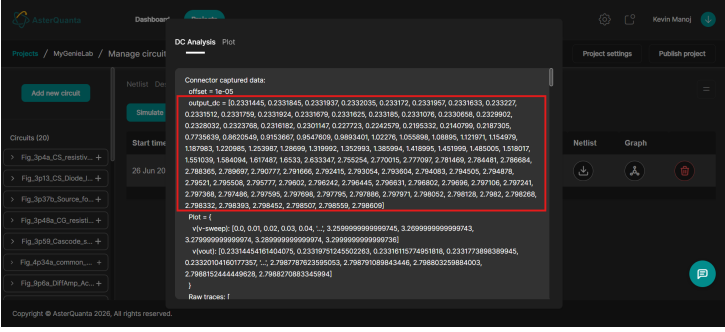
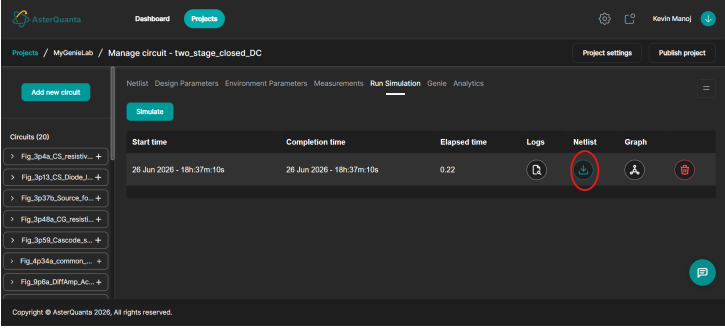
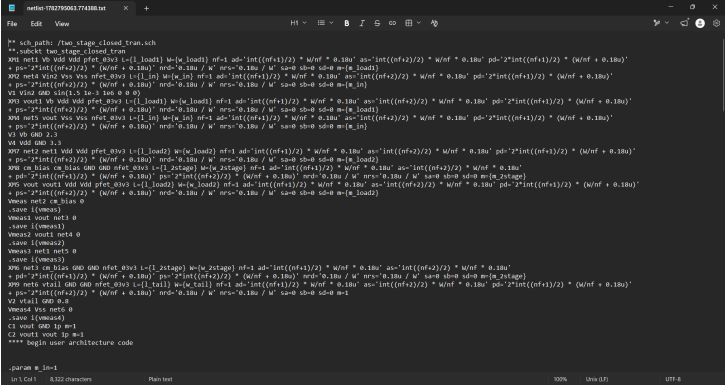
|             |                                                                                                                                                        |                                                                                                                                                                          |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>13.1</b> | <p>Compare the images with what you see in your textbook page number 362 and figure number 9.25</p>                                                    |  <p><b>Figure 9.25</b> Two-stage op amp with single-ended output.</p> <p>Copyright</p> |
| <b>14.</b>  | <p>Click on the graph icon at the bottom to view the generated graph of the netlist (skip this if you are not interested in the AI side of things)</p> |                                                                                        |
| <b>15.</b>  | <p>Inspect the graph.</p>                                                                                                                              |                                                                                      |
| <b>15.1</b> | <p>You will observe that the entire schematic (as represented in the netlist) is now transformed into a graph</p>                                      |                                                                                                                                                                          |
| <b>15.2</b> | <p>The components are represented as nodes and the connections represented as edges.</p>                                                               |                                                                                                                                                                          |

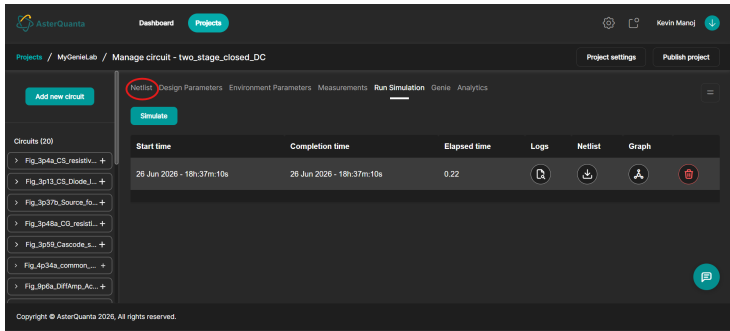
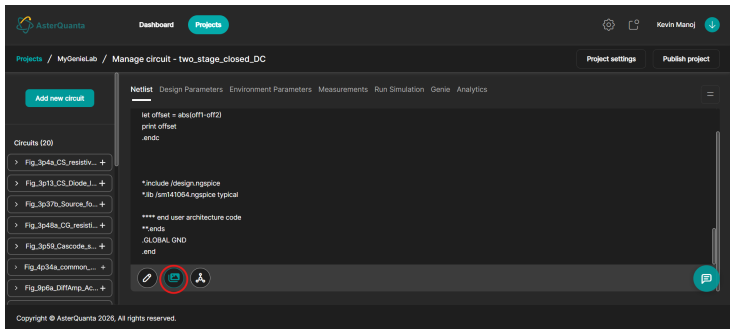
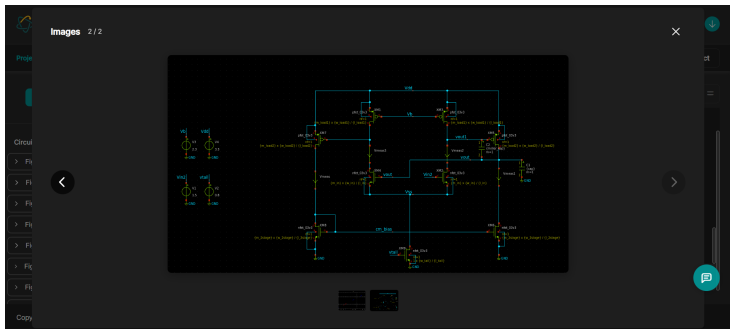
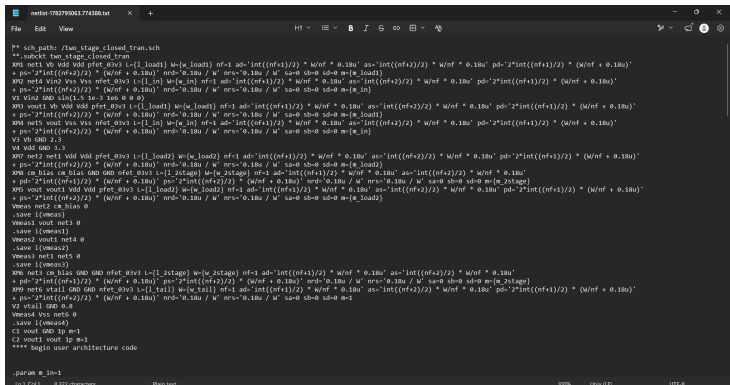
| 16.                      | Click on the Design Parameters tab                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |        |          |            |           |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|------------|-----------|------|-----------|-----------|--------------------------|-----|--|----|---------|-----|---|--------------------------|----------|----------|------|---------|-----|-----|--------------------------|------|----------|----|---------|-----|---|--------------------------|---------|----------|----|---------|---|---|
| 17.                      | Review the Design Parameters tab <b>without modifying</b> any values.                                                                                        |  <table><tr><th>Active</th><th>Variable</th><th>Components</th><th>Value</th><th>Unit</th><th>Min value</th><th>Max value</th></tr><tr><td><input type="checkbox"/></td><td>cap</td><td></td><td>1p</td><td>unknown</td><td>0.5</td><td>2</td></tr><tr><td><input type="checkbox"/></td><td>I_2stage</td><td>XM8, XM6</td><td>0.8u</td><td>unknown</td><td>0.4</td><td>1.6</td></tr><tr><td><input type="checkbox"/></td><td>I_in</td><td>XM2, XM4</td><td>1u</td><td>unknown</td><td>0.5</td><td>2</td></tr><tr><td><input type="checkbox"/></td><td>I_load1</td><td>XM1, XM3</td><td>4u</td><td>unknown</td><td>2</td><td>8</td></tr></table> | Active | Variable | Components | Value     | Unit | Min value | Max value | <input type="checkbox"/> | cap |  | 1p | unknown | 0.5 | 2 | <input type="checkbox"/> | I_2stage | XM8, XM6 | 0.8u | unknown | 0.4 | 1.6 | <input type="checkbox"/> | I_in | XM2, XM4 | 1u | unknown | 0.5 | 2 | <input type="checkbox"/> | I_load1 | XM1, XM3 | 4u | unknown | 2 | 8 |
| Active                   | Variable                                                                                                                                                     | Components                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Value  | Unit     | Min value  | Max value |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| <input type="checkbox"/> | cap                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1p     | unknown  | 0.5        | 2         |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| <input type="checkbox"/> | I_2stage                                                                                                                                                     | XM8, XM6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0.8u   | unknown  | 0.4        | 1.6       |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| <input type="checkbox"/> | I_in                                                                                                                                                         | XM2, XM4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1u     | unknown  | 0.5        | 2         |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| <input type="checkbox"/> | I_load1                                                                                                                                                      | XM1, XM3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4u     | unknown  | 2          | 8         |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| 18.                      | Observe that the circuit is prepopulated with the design parameters from the netlist.                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |          |            |           |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| 18.1                     | The corresponding components and their variables are assigned default values in this illustration.                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |          |            |           |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| 18.2                     | <b>Note:</b> When you are building something from scratch they may be assigned process node minimum values.                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |          |            |           |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |
| 19.                      | Observe that the minimum and maximum values are prepopulated. These are the design search space limits when the AI engine is trying to optimize the circuit. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |        |          |            |           |      |           |           |                          |     |  |    |         |     |   |                          |          |          |      |         |     |     |                          |      |          |    |         |     |   |                          |         |          |    |         |   |   |

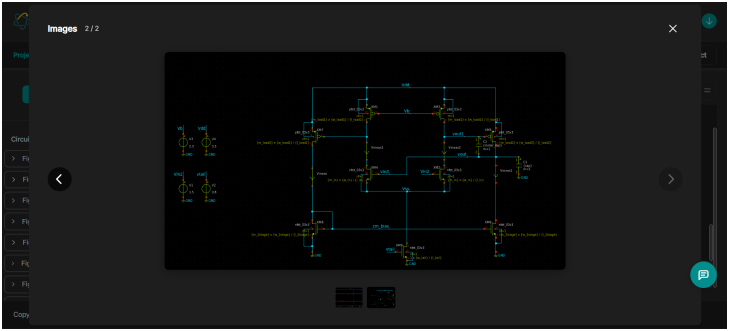
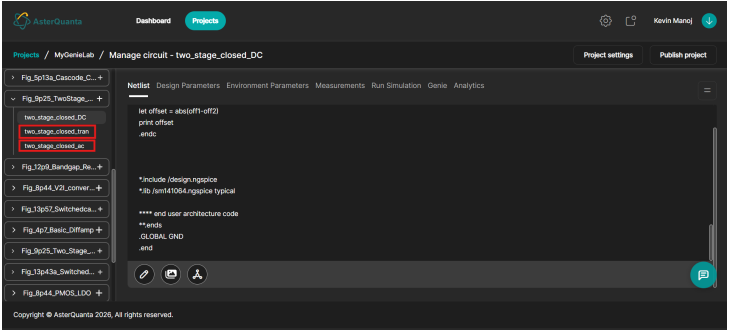
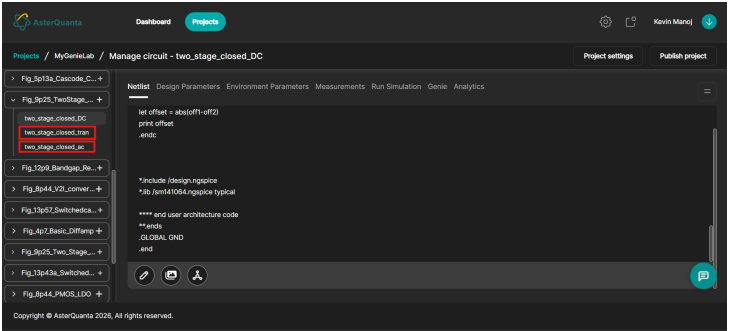
|      |                                                                                                                                                  |                                                                                      |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 20.  | Observe that some of the design parameters are selected and some are unselected.                                                                 |    |
| 20.1 | The ones that are selected are considered during AI optimization phases.                                                                         |    |
| 21.  | Click on Environment Parameters tab                                                                                                              |   |
| 21.1 | This section allows you to provide Process, Voltage, Temperature and other external parameters that can influence the performance of the circuit |  |
| 21.2 | We will not be using this section for this demonstration                                                                                         |                                                                                      |

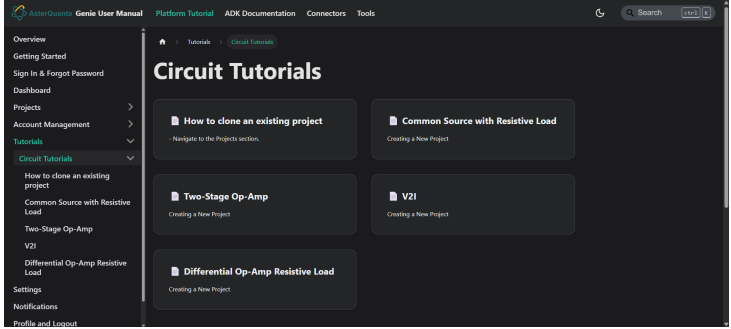
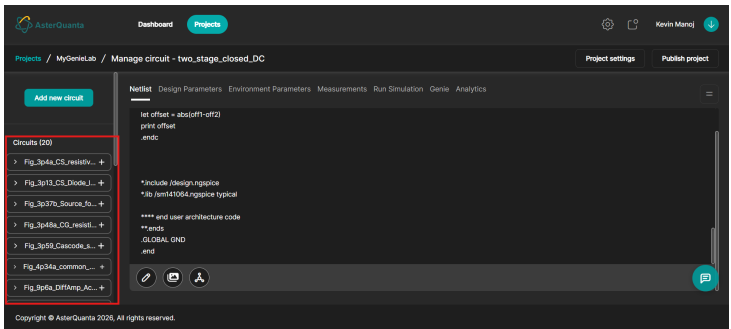
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|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 22.  | Click on Measurements tab                                                                                                                                                                                  |    |
| 22.1 | Observe types of Analysis. We are considering DC analysis here - This section allows you to define the measurements used to evaluate circuit performance during DC analysis.                               |    |
| 22.2 | DC Analysis (Direct Current Analysis) is a type of circuit simulation used to determine the steady-state voltages and currents in a circuit when all input sources are constant and do not vary with time. |                                                                                      |
| 22.3 | Data Capture is used to specify which signals or parameters should be extracted from the simulation results.                                                                                               |  |
| 22.4 | Measurements (.meas) are post-processing calculations that extract specific performance metrics from simulation results, enabling automated evaluation of circuit behavior.                                |                                                                                      |

|     |                                                          |                                                                                      |
|-----|----------------------------------------------------------|--------------------------------------------------------------------------------------|
| 23. | Open the Run Simulation section.                         |    |
| 24. | Start the simulation by clicking Simulate.               |    |
| 25. | Observe the simulation progress and wait for completion. |   |
| 26. | Confirm that the simulation completed successfully.      |  |

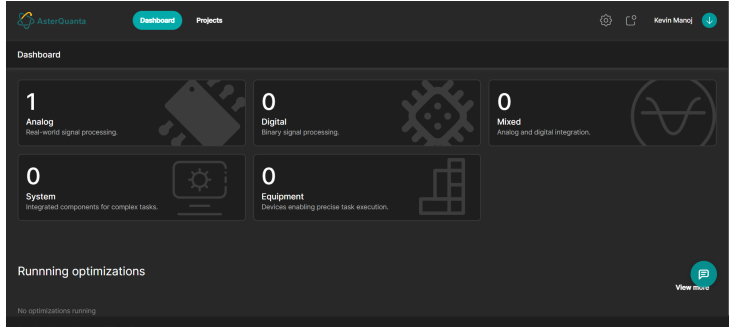
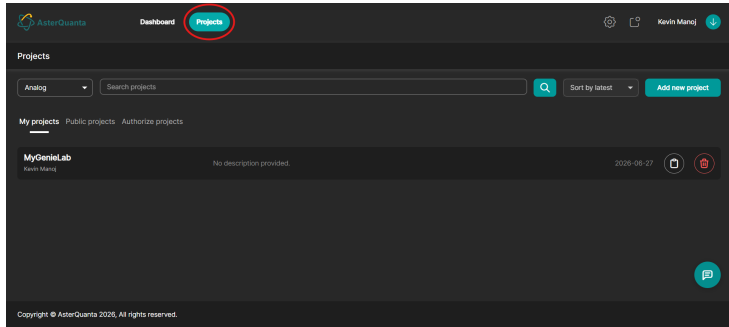
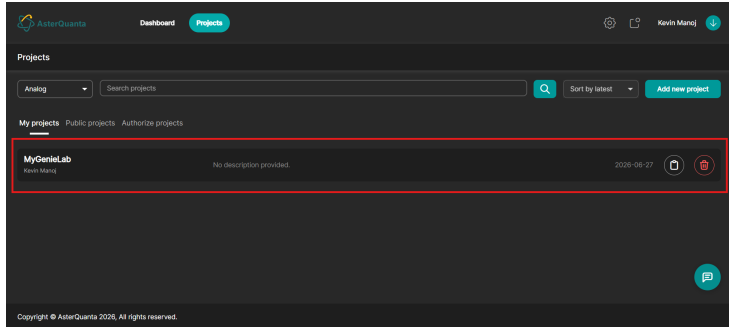
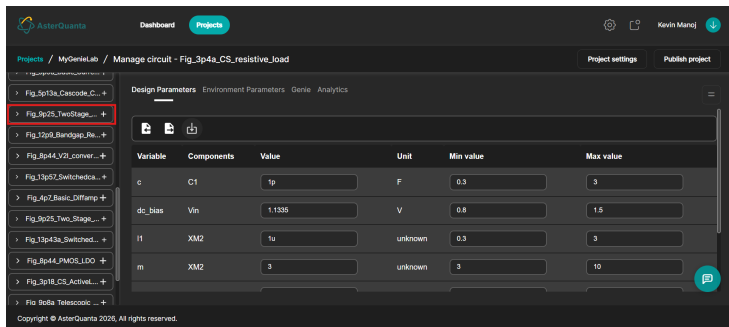
|      |                                                                                                                                     |                                                                                      |
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| 27.  | Open the simulation logs (under Logs icon).                                                                                         |    |
| 27.1 | Examine the output_dc values generated by the simulator.                                                                            |    |
| 28.  | Download and open the generated netlist file if you are interested in running the setup offline in your own simulation environment. |   |
| 29.  | Observe how the circuit is represented in simulator-readable format.                                                                |  |
| 29.1 | Observe the parameters and the measurement statements that are autogenerated in Spice format                                        |                                                                                      |
| 29.2 | Identify key components, connections, and parameters                                                                                |                                                                                      |

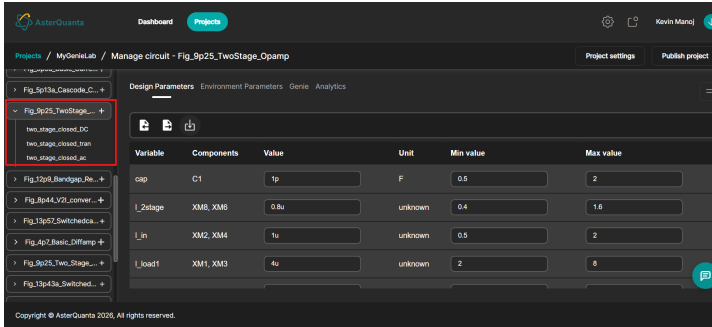
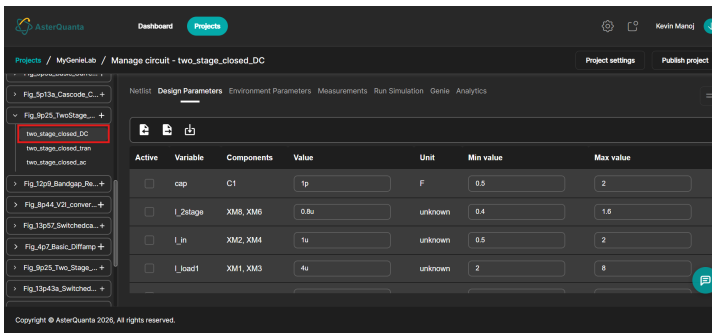
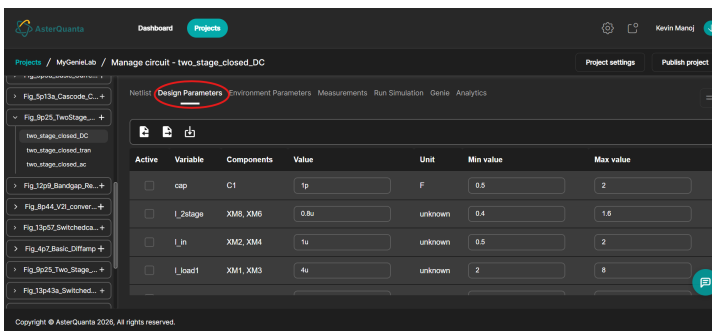
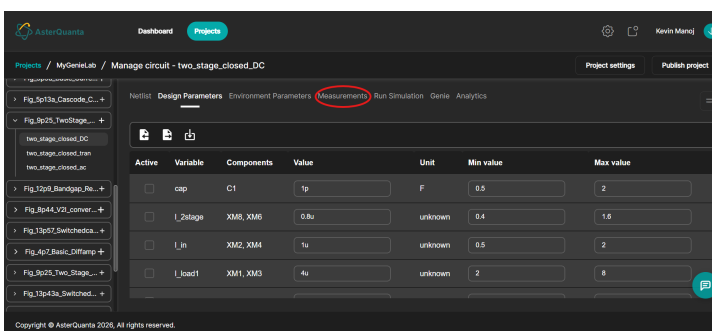
|                           | within the netlist.                                                                               |                                                                                                                                                                                                                                                                                                                                                                           |            |                 |              |      |         |       |                           |                           |      |  |  |  |
|---------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----------------|--------------|------|---------|-------|---------------------------|---------------------------|------|--|--|--|
| 20.                       | Return to the Netlist tab-<br>recheck the generated netlist<br>with the image of the<br>schematic |  <table><thead><tr><th>Start time</th><th>Completion time</th><th>Elapsed time</th><th>Logs</th><th>Netlist</th><th>Graph</th></tr></thead><tbody><tr><td>26 Jun 2026 - 19h:37m:10s</td><td>26 Jun 2026 - 19h:37m:10s</td><td>0.22</td><td></td><td></td><td></td></tr></tbody></table> | Start time | Completion time | Elapsed time | Logs | Netlist | Graph | 26 Jun 2026 - 19h:37m:10s | 26 Jun 2026 - 19h:37m:10s | 0.22 |  |  |  |
| Start time                | Completion time                                                                                   | Elapsed time                                                                                                                                                                                                                                                                                                                                                              | Logs       | Netlist         | Graph        |      |         |       |                           |                           |      |  |  |  |
| 26 Jun 2026 - 19h:37m:10s | 26 Jun 2026 - 19h:37m:10s                                                                         | 0.22                                                                                                                                                                                                                                                                                                                                                                      |            |                 |              |      |         |       |                           |                           |      |  |  |  |
| 30.1                      | Open the View Images option.                                                                      |                                                                                                                                                                                                                                                                                         |            |                 |              |      |         |       |                           |                           |      |  |  |  |
| 30.2                      | Examine the schematic<br>representation of the circuit.                                           |                                                                                                                                                                                                                                                                                       |            |                 |              |      |         |       |                           |                           |      |  |  |  |
| 30.3                      | Compare the schematic with<br>the netlist representation.                                         |                                                                                                                                                                                                                                                                                       |            |                 |              |      |         |       |                           |                           |      |  |  |  |

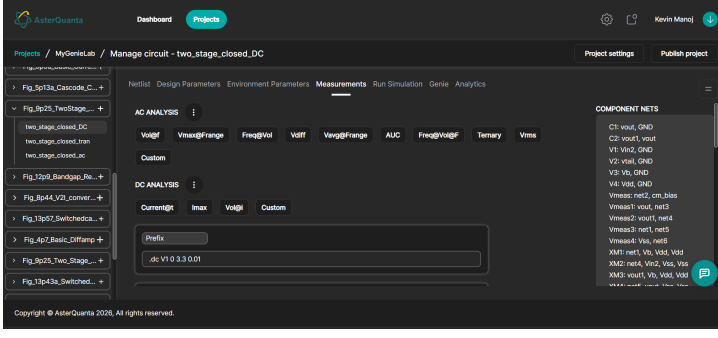
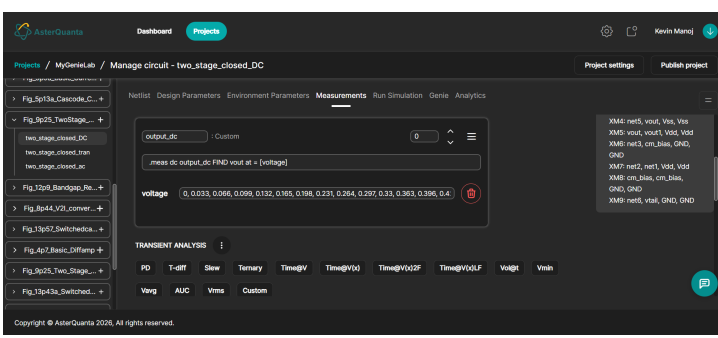
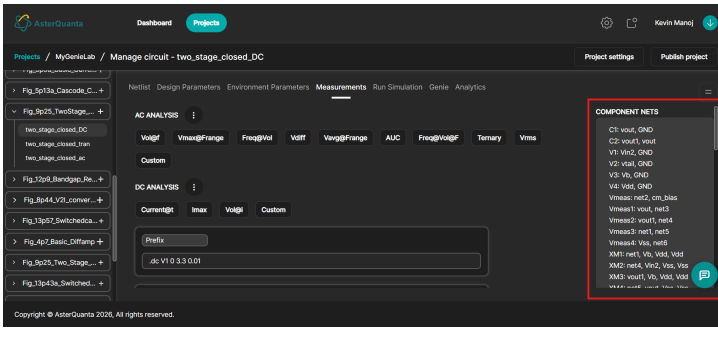
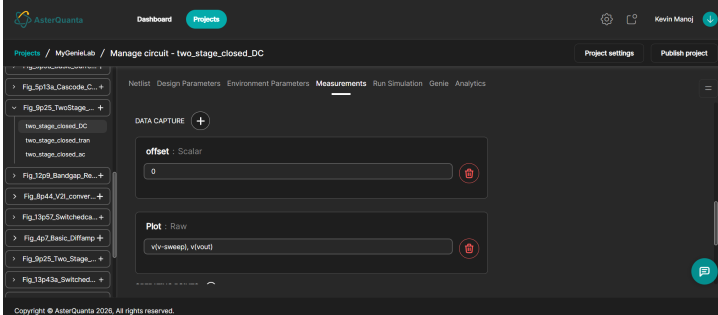
|      |                                                                                  |                                                                                      |
|------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|      |                                                                                  |    |
| 31.  | Identify the individual transistors and connections within the Two Stage Op-Amp. |                                                                                      |
| 31.1 | Connect the observed topology with concepts learned in textbooks.                |                                                                                      |
| 31.2 | Compare simulation results with theoretical expectations.                        |                                                                                      |
| 32.  | Congratulations - You have simulated your first circuit in DGenie!               |                                                                                      |
| 33.  | Repeat the same process and steps with the associated/sister testbenches         |                                                                                      |
| 33.1 | two_stage_closed_tran                                                            |  |
| 33.2 | two_stage_closed_ac                                                              |  |
| 34.  | Develop an understanding of                                                      |                                                                                      |

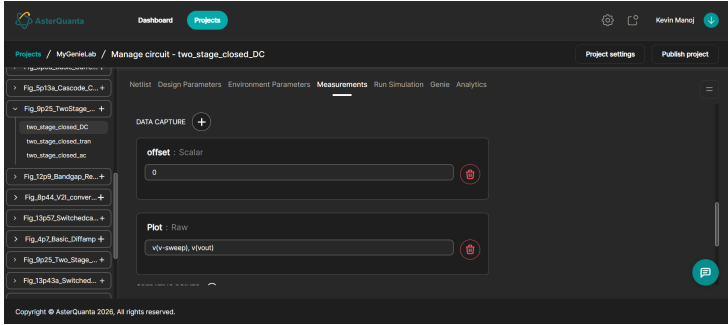
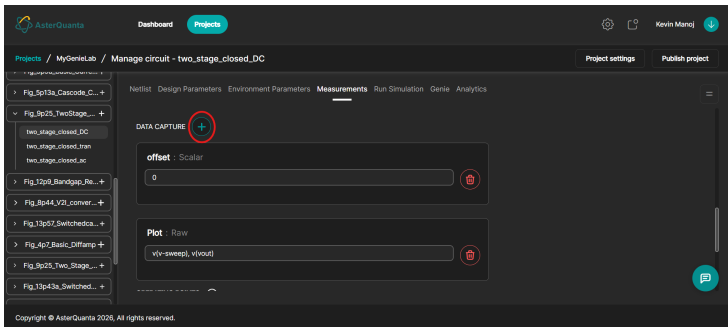
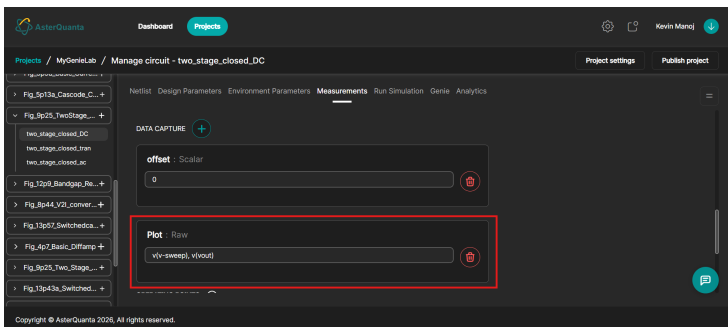
|     |                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                    |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|     | how DGenie bridges theory and practical circuit analysis.                                                                                                                                                                                                                                                                                                                                  |                                                                                    |
| 35. | <p>For a deeper understanding refer to the circuit tutorials page of Two-stage-Opamp</p> <p><a href="https://asterquanta.github.io/documentation/docs/category/circuit-tutorials">https://asterquanta.github.io/documentation/docs/category/circuit-tutorials</a></p>                                                                                                                      |  |
| 36. | Return to the project circuit list.                                                                                                                                                                                                                                                                                                                                                        |  |
| 37. | <p>You have completed your first DGenie learning cycle.</p> <p>Now you can prepare to explore advanced platform capabilities by doing the following:</p> <ol style="list-style-type: none"> <li>1. Select another circuit that interests you.</li> <li>2. Repeat the simulation workflow independently.</li> <li>3. Compare the behavior of multiple circuits and test benches.</li> </ol> |                                                                                    |

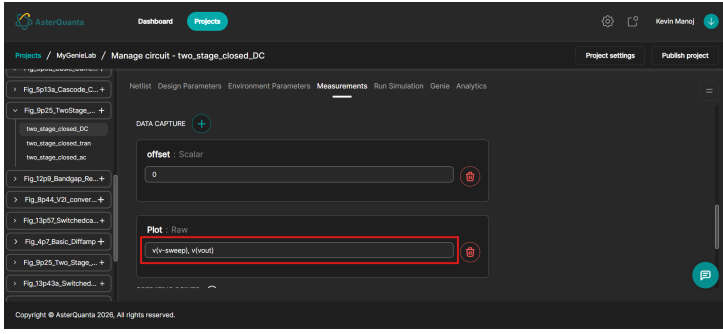
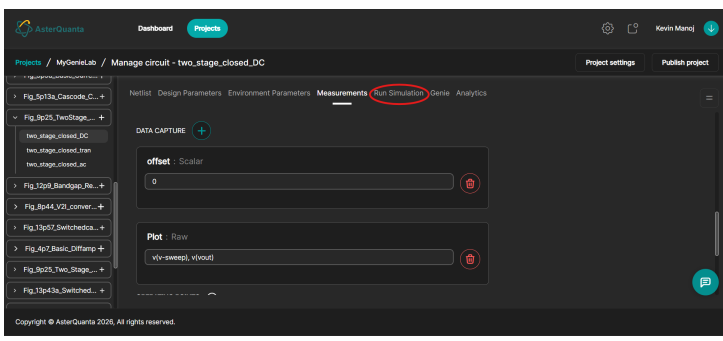
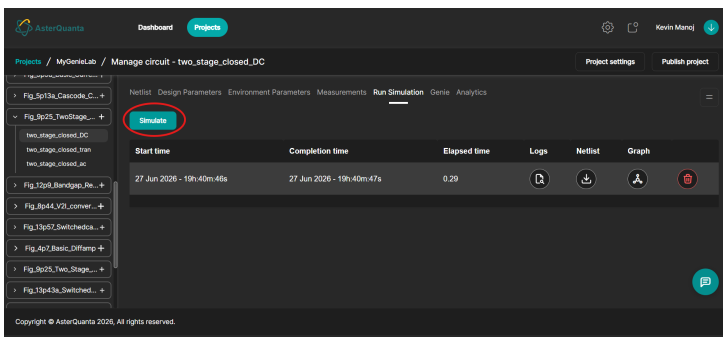
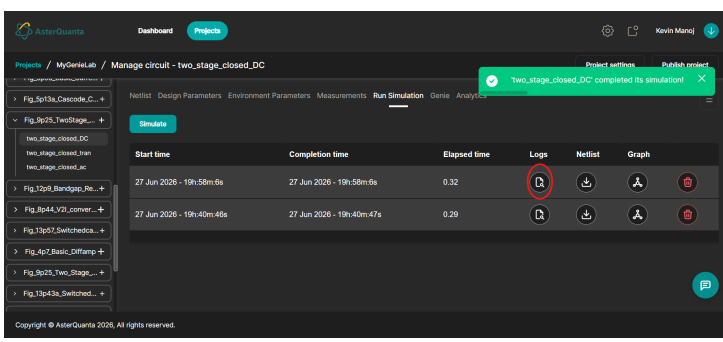
## Workshop Hands-on Steps-2

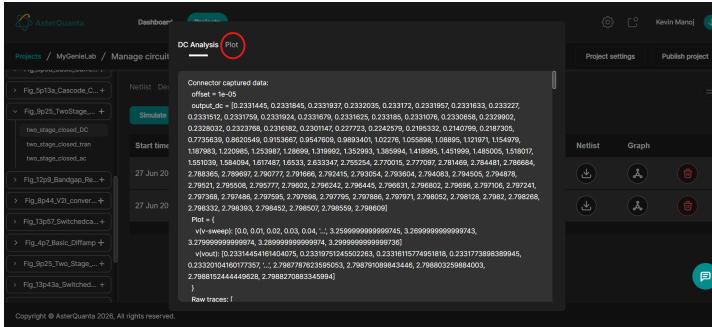
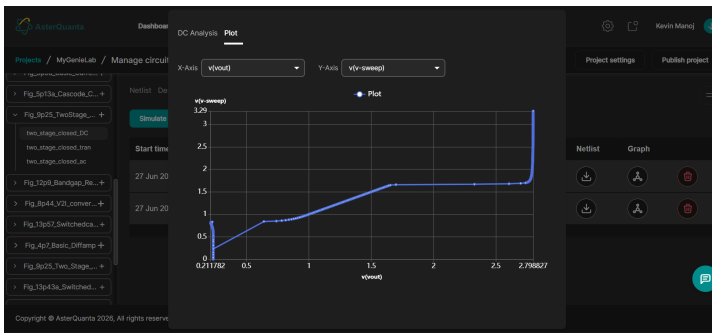
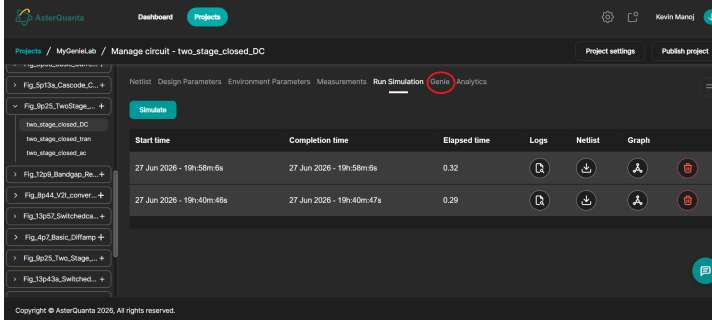
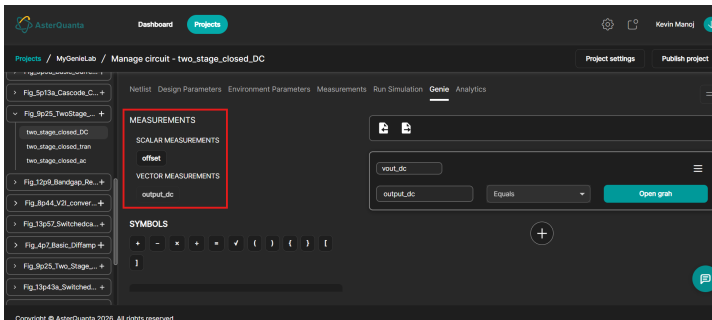
| Step     | Activity                                                                                                                  | Reference                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |          |            |           |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
|----------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------------|-----------|------|-----------|-----------|---|----|----|---|-----|---|---------|-----|--------|---|-----|-----|----|-----|----|---------|-----|---|---|-----|---|---------|---|----|
| 0.       | You have completed Workshop Hands-on Steps-1                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |          |            |           |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| 1.       | Return to the Dashboard                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |          |            |           |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| 2.       | Open the Projects section                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |            |           |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| 3.       | Under My projects, click on the cloned copy of GenieLab that you had saved and worked on previously                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |          |            |           |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| 4.       | Scroll down on the list of available circuits on the left hand side of your screen until you find Fig_9p25_TwoStage_Opamp |  <table><thead><tr><th>Variable</th><th>Components</th><th>Value</th><th>Unit</th><th>Min value</th><th>Max value</th></tr></thead><tbody><tr><td>C</td><td>C1</td><td>1p</td><td>F</td><td>0.3</td><td>3</td></tr><tr><td>dc_bias</td><td>Vin</td><td>1.1335</td><td>V</td><td>0.8</td><td>1.5</td></tr><tr><td>It</td><td>XM2</td><td>1u</td><td>unknown</td><td>0.3</td><td>3</td></tr><tr><td>m</td><td>XM2</td><td>3</td><td>unknown</td><td>3</td><td>10</td></tr></tbody></table> | Variable | Components | Value     | Unit | Min value | Max value | C | C1 | 1p | F | 0.3 | 3 | dc_bias | Vin | 1.1335 | V | 0.8 | 1.5 | It | XM2 | 1u | unknown | 0.3 | 3 | m | XM2 | 3 | unknown | 3 | 10 |
| Variable | Components                                                                                                                | Value                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Unit     | Min value  | Max value |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| C        | C1                                                                                                                        | 1p                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | F        | 0.3        | 3         |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| dc_bias  | Vin                                                                                                                       | 1.1335                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | V        | 0.8        | 1.5       |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| It       | XM2                                                                                                                       | 1u                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | unknown  | 0.3        | 3         |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |
| m        | XM2                                                                                                                       | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | unknown  | 3          | 10        |      |           |           |   |    |    |   |     |   |         |     |        |   |     |     |    |     |    |         |     |   |   |     |   |         |   |    |

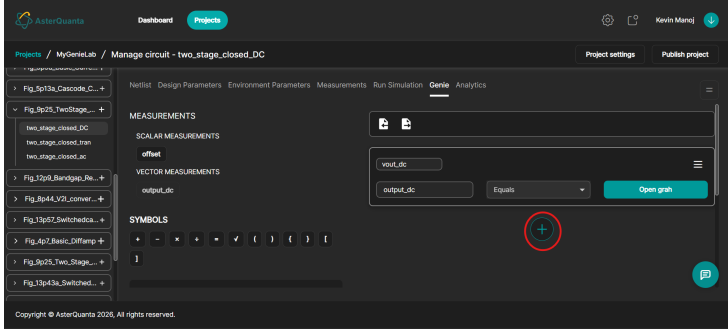
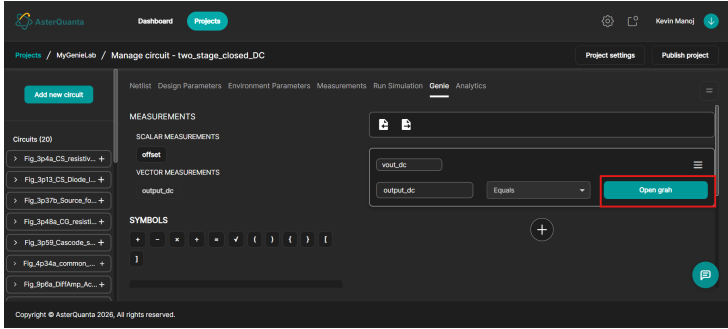
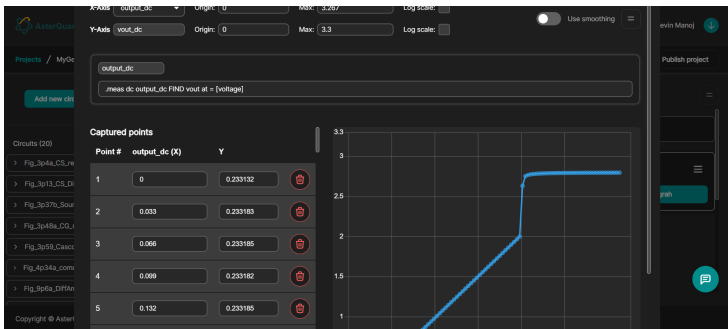
|    |                                                                                                                                           |                                                                                      |
|----|-------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 5. | Click on and open the Fig_9p25_TwoStage_Opamp circuit                                                                                     |    |
| 6. | Click on and open the two_stage_closed_DC test bench circuit seen under the Fig_9p25_TwoStage_Opamp main circuit                          |    |
| 7. | You will automatically land upon the Design Parameters tab under the two_stage_closed_DC test bench circuit under Fig_9p25_TwoStage_Opamp |   |
| 8. | Click on Measurements tab                                                                                                                 |  |

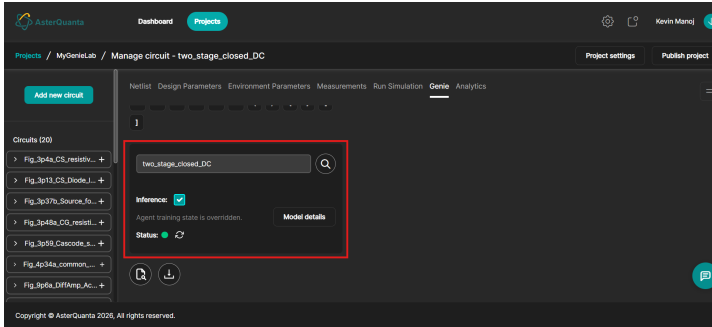
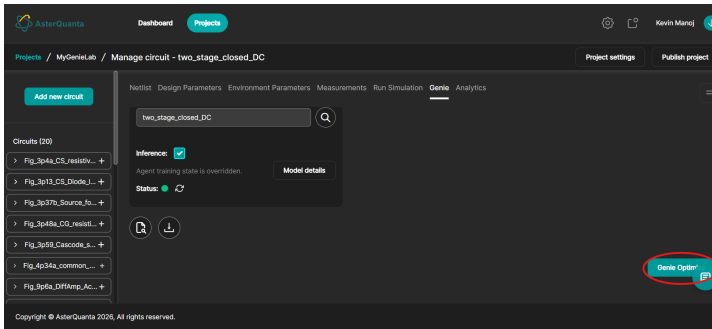
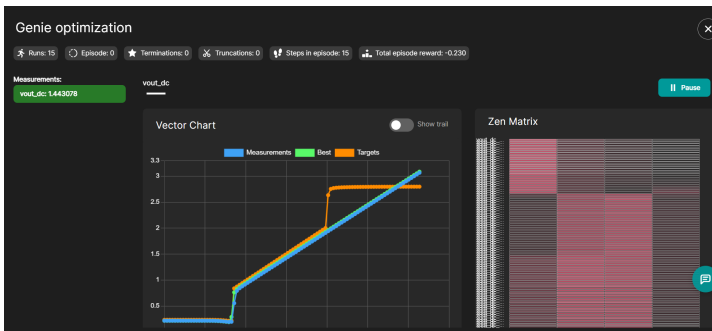
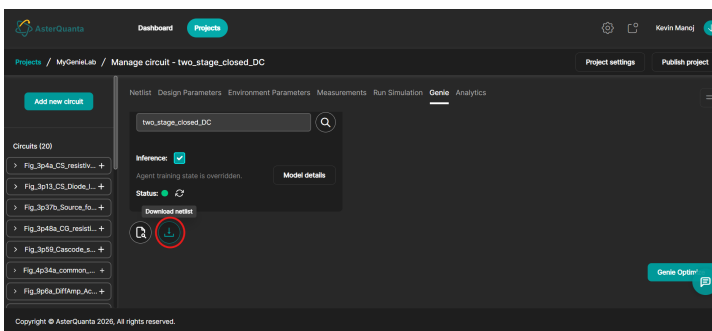
|                   |                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                       |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>8.1</b></p> | <p>Overview - The Measurements page allows users to define the outputs and performance metrics that should be extracted from simulation results.</p> <p>We are measuring multiple voltages on the net "vout"</p> <p>A label called "output_dc" is assigned to the measurements</p> <p>The analysis is a DC sweep on voltage source V1</p> |   |
| <p><b>9.</b></p>  | <p>Located on the right side of the page is the Component Nets Panel.</p> <p>This panel displays all component connections and circuit nets extracted from the schematic or netlist.</p> <p>Examples: vout, Vdd, GND.</p> <p>Users can reference these nets while creating measurements.</p>                                              |                                                                                    |
| <p><b>10.</b></p> | <p>Data Capture</p>                                                                                                                                                                                                                                                                                                                       |                                                                                   |
| <p><b>11.</b></p> | <p>The Data Capture section allows users to define values that can be extracted from simulation outputs, <b>directly from the netlist</b>.</p> <p>Example shown: offset : Scalar</p> <p>Data Capture is primarily used to expose</p>                                                                                                      |                                                                                                                                                                       |

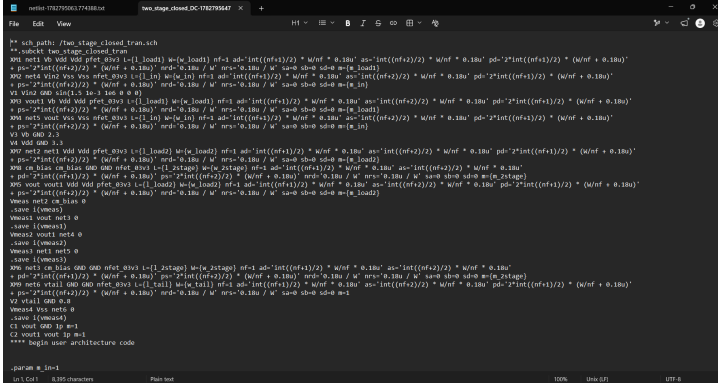
|      |                                                                                                                                                         |                                                                                      |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|      | simulation values that are defined in netlist directly. These may be referenced later in measurements, operating points, analytics, or Genie workflows. |                                                                                      |
| 12.  | In case you have used a vector measurement, you can use the plot feature to plot the output of your measurement in the Run Simulation page              |                                                                                      |
| 12.1 | Scroll down till you find Data Capture                                                                                                                  |    |
| 12.2 | We clicked on the plus icon (+) to Add Data Entry                                                                                                       |   |
| 12.3 | We have selected 'Raw' in the dropdown menu, we have used 'Plot' here, and clicked on 'Add entry'                                                       |  |

|             |                                                                                                                                                                                                                                                                          |                                                                                      |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>12.4</b> | <p>In the 'Enter raw data' field, we mentioned the nets that have been measured, and the vector label we have used in the measurement statement</p> <p>The first term would be v(v-sweep) indicating it is a DC sweep: Ex- v(v-sweep), v(vout) for plotting net vout</p> |    |
| <b>13.</b>  | <p>Go to 'Run Simulation'</p>                                                                                                                                                                                                                                            |    |
| <b>13.1</b> | <p>Then click on 'Simulate'</p>                                                                                                                                                                                                                                          |   |
| <b>13.2</b> | <p>Then click on 'Logs' on the latest simulation</p>                                                                                                                                                                                                                     |  |

|      |                                                                                                                             |                                                                                      |
|------|-----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 13.3 | Open 'Plot'                                                                                                                 |    |
| 13.4 | You will be able to see the vector plot after putting x-axis and y-axis appropriately                                       |    |
| 13.5 | Click out of the box                                                                                                        |                                                                                      |
| 14.  | Click on Genie                                                                                                              |  |
| 14.1 | <p>You will see the measurement tags</p> <p>You will be able to select these tags and define the required specification</p> |  |

|      |                                                                                                                                                                                                                                                                                          |                                                                                      |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 15.  | Click on the plus icon, you'll get an expression box                                                                                                                                                                                                                                     |    |
| 16.  | Change the expression name how you want                                                                                                                                                                                                                                                  |                                                                                      |
| 17.  | Click on the 'Enter Expression' box and select the measurement tag that you want to assign the targets to                                                                                                                                                                                |                                                                                      |
| 18.  | Then select the function from the dropdown menu                                                                                                                                                                                                                                          |                                                                                      |
| 19.  | If it is scalar, enter target value<br>If it is vector, change into graph mode                                                                                                                                                                                                           |                                                                                      |
| 19.1 | Click on 'Open Graph'                                                                                                                                                                                                                                                                    |  |
| 19.2 | Enter the X-Axis, you can enter target values directly or import a CSV file<br><br>To import a CSV file, click the menu on the top right<br><br>You can also perform math function to generate targets like sine waves<br><br>You can view target, and current measurements in the chart |  |
| 20.  | Click out of the pop-up                                                                                                                                                                                                                                                                  |                                                                                      |

|     |                                                                                                                  |                                                                                      |
|-----|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 21. | Next we select the AI Agent, which has already been pre-selected (two_stage_closed_DC)                           |    |
| 22. | Click on 'Genie Optimize'                                                                                        |    |
| 23. | Let optimization run for a while and then stop optimization; click on 'Chart' to see details during optimization |   |
| 24. | Download the updated netlist from below the model to see updated design parameters                               |  |

|     |                                                                                                           |                                                                                    |
|-----|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|     |                                                                                                           |  |
| 25. | Congratulations! You have just set up the workflow for AI optimization on Genie, and run an optimization! |                                                                                    |

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## 3. References

Razavi, B. Design of Analog CMOS Integrated Circuits. New York, NY, USA: McGraw-Hill, 2001 and Razavi, B., Design of Analog CMOS Integrated Circuits, 2nd Edition, McGraw-Hill Education, 2017

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