# Team 03 Test Plan

2025/06/05

## Top Down Test Plan v2.1

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| Date of Test: | *2025/06/25* |
| Tester: | *All* |

### Purpose

*To test the entire system against its requirements by performing a top-down test.*

### Equipment Needed

- System Equipment
  - *Populated Electrostatic Dust Analyzer PCB*
  - *9V Battery*
  - *USB-A to USB-C Cable*
- Test Equipment
  - *9V Battery*
  - *Arduino IDE*
  - *Laptop for Data Viewing*
  - *Dust Particles*
  - *Hollow Glass Pipe*
- Other Equipment
  - *N/A*

### Pre-Test Setup

1. Open the Arduino IDE on laptop intended for data viewing
2. Unscrew the battery compartment from the PCB enclosure
3. Connect laptop running the Arduino IDE to the QT PY via USB-A to USB-C Cable
4. Upload <EDA_CODE_FINAL> to the QT PY
5. Establish a WiFi connection between the QT PY and the laptop running the Arduino IDE (See user manual for how to establish this connection)
6. Open the website using the generated IP address for data observation
7. Disconnect the laptop from the QT PY
8. Reattach the battery compartment

### Test Steps

1. Insert the 9V battery into the battery compartment and connect it to the circuit via the battery port
2. Screw the lid back down onto the PCB enclosure
3. Insert dust particles into the hollow glass pipe
4. Position the hollow glass pipe above the faraday tube entrance (small hole on the lid)
5. Slowly pour a small amount of the dust particles out of the glass tube and let them fall into the

faraday tube entrance. Pause for about 2 seconds after about half a second of pouring to allow for the sensor to return to the noise floor, then pour for another half second. Repeat this process until there are no dust particles left in the tube

6. Observe the circuit output on the website
7. Voltage output, charge value, gain, charge sign, and estimated particle size should be observed on the server

## Post-Test Teardown

1. Lift the PCB enclosure up off of the testing surface
2. Brush the particles that fell through the sensor and onto the testing surface back into the container of dust particles.
3. Place the PCB enclosure back down and unscrew the lid
4. Disconnect the 9V battery from the device
5. Clean out any dust particles inside the enclosure

## Top-down Test Plan  Conclusions / Discussion

After running the test, we should observe that the output voltage changes depending on the electric charge measured at the input. Using this information, we should be able to determine the size and charge of the particles.

# Team 03 COATL Aircraft Particle Sensor

# First Test Cases using Dust (Version G Tests Created 6/5/25)

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| **Test Author: Felix Moss** | | | | |
| | **Test Case Name:** | Full Operation Test | **Test ID #:** | 001 |
| | **Description:** | To test the entire system against its requirements by performing a top-down test. | **Type:** | ✓ white box<br>□ black box<br>□ _____ |
| **Tester Information** | | | | |
| | **Name of Tester:** | Eisa Alsharifi | **Date:** | 6/05/2025 |
| | **HW/SW Version:** | Version G | **Time:** | 3:15 PM |
| | **Setup:** | 1. Insert the 9V battery into the battery compartment and connect it to the circuit via the battery port<br>2. Screw the lid back down onto the PCB enclosure<br>3. Insert dust particles into the hollow glass pipe<br>4. Position the hollow glass pipe above the faraday tube entrance (small hole on the lid)<br>5. Slowly pour a small amount of the dust particles out of the glass tube and let them fall into the faraday tube entrance. Pause for about 2 seconds after about half a second of pouring to allow for the sensor to return to the noise floor, then pour for another half second. Repeat this process until there are no dust particles left in the tube<br>6. Observe the circuit output on the website<br>7. Voltage output, charge value, gain, charge sign, and estimated particle size should be observed on the server | | |

| **TEST** | **INPUTS** | **EXPECTED OUTPUTS** | **PASS** | **FAIL** | **N/A** | **Comments** |
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| 1 | Slowly pour the standardized dust particles on the ramp and let them fall into the faraday tube entrance. Observe the circuit output on the website | Voltage output, charge value, gain, charge sign, and estimated particle size should be observed on the server. The range of the voltage should be between -4V and 5V, and the range of the charge should be in the 1.5fA to 1nA range. | ✓ | | | |
| | **Overall test result:** | | ✓ | | | |

# Bottom Up Test Cases (Version F Tests Created 4/24/25)

| **Test Author: Felix Moss** | | | | | | |
|---|---|---|---|---|---|---|
| | **Test Case Name:** | Full Operation Test | **Test ID #:** | | | 001 |
| | **Description:** | To test the entire system against its requirements by performing a top-down test. | **Type:** | | | ✓ white box<br>□ black box<br>□ _____ |
| **Tester Information** | | | | | | |
| | **Name of Tester:** | Eisa Alsharifi | **Date:** | | | 4/24/2025 |
| | **HW/SW Version:** | Version F | **Time:** | | | 3:15 PM |
| | **Setup:** | Set 1 channel on the power supply to 9V and the other to 4.5V.<br>Connect power supply channels to the breadboard in the appropriate places.<br>Connect laptop running Arduino IDE to the QT PY<br>Connect oscilloscope probes to the op amp output<br>Double check all connections | | | | |
| **TEST** | **INPUTS** | **EXPECTED OUTPUTS** | **PASS** | **FAIL** | **N/A** | **Comments** |

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| 1 | Move source of static electricity close to input wire | As it gets closer to the wire, there is increased charge and deviations from the 4.5V. We should see voltage variations on the oscilloscope. | ✓ | | | Changes were observed on both the oscilloscope and the Arduino IDE |
| | **Overall test result:** | | ✓ | | | Our circuit works well |

| **Test Information** | | | | | | |
|---|---|---|---|---|---|---|
| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | | | **Date:** | |
| | **HW/SW Version:** | Version F | | | **Time:** | |
| | **Setup:** | *Connect power supply and oscilloscope to test points on the breadboard circuit. Probes for the oscilloscope are set at the frequency input and the output. Set Power supply to 9V and 0.1A. Set the function generator to a SQUARE wave with amplitude 20mVpp, offset 0, frequency 100Hz. (The current entering the coulomb-meter is about 20pA for these tests)* | | | | |
| **STEP** | **Action** | **Expected Result** | **PASS** | **FAIL** | **N/A** | **Comments** |
| 1 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | | | | |
| 2 | Turn on the power and function generator. | No shorts should be evident on the power supply | | | | |
| 3 | Probe the function generator output | A clear pulse wave (probes at function generator output) should be visible | | | | |
| 4 | Upload code to microcontroller via Arduino IDE | Code should be successfully uploaded to the microcontroller | | | | |
| 5 | Give the ADC a direct supply of voltage (0V - 10V in 1mV | We get matching ADC bit readings on the Arduino IDE. | | | | |

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| | increments) | | | | | |
| 6 | Give a 2.4V signal to the gates of the analog switch from the microcontroller | The output of the switch the output should match the input | | | | |
| 7 | Probe the amplified coulomb-meter output (LM662 op amp output) | A voltage reading of between 4V and 8V | | | | |
| | **Overall test result:** | | | | | |

# Breadboard Test Cases (Version A Tests from 2/19/25)

| **Test Author: Felix** | | | | | | |
|---|---|---|---|---|---|---|
| | **Test Case Name:** | Input Testing | | | **Test ID #:** | 1-1 |
| | **Description:** | *Imitating the charged particles entering the device via a pulse wave to produce an amplified voltage output.* | | | **Type:** | ✅ white box<br>□ black box<br>□ _____ |
| **Tester Information** | | | | | | |
| | **Name of Tester:** | Nathan Truong, Eisa Alsharifi | | | **Date:** | 2/19/25 |
| | **HW/SW Version:** | Version A | | | **Time:** | 2:38 PM |
| | **Setup:** | *Connect power supply and oscilloscope to test points on the breadboard circuit. Probes for the oscilloscope are set at the frequency input and the output. Set Power supply to 9V and 0.1A. Set the function generator to a PULSE wave with amplitude 10mV, offset 0, frequency 1kHz. (The current entering the coulomb-meter is about 20pA for these tests)* | | | | |
| **STEP** | **Action** | **Expected Result** | **PASS** | **FAIL** | **N/A** | **Comments** |
| 1 | Turn on the power and | No shorts should be evident on the power supply | ✅ | | | |

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| | function generator. | | | | | |
| 2 | Probe the function generator output | A clear pulse wave (probes at function generator output) should be visible | ✅ | | | |
| 3 | Probe the amplified coulomb-meter output | A voltage reading of between 4V to 8V | | ❌ | | Oscilloscope displays nothing on the amplified coulomb-meter output |
| | **Overall test result:** | | | ❌ | | Oscilloscope displays nothing on the coulomb-meter output. Need to debug circuit and measurements. |

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| **Test Author: Felix** | | | | |
| | **Test Case Name:** | Input Testing | **Test ID #:** | 1-2 |
| | **Description:** | *Second attempt at imitating the charged particles entering the device via a square wave to produce an amplified voltage output. Changed to SQUAREwave and Increased the wave amplitude to 100mV* | **Type:** | ✅ white box<br>□ black box<br>□ _____ |
| **Tester Information** | | | | |
| | **Name of Tester:** | Nathan Truong, Eisa Alsharifi | **Date:** | 2/19/25 |

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|---|---|---|---|---|---|---|
| | **HW/SW Version:** | Version A | | | **Time:** | 2:55 PM |
| | **Setup:** | *Connect power supply and oscilloscope to test points on the breadboard circuit. Probes for the oscilloscope are set at the frequency input and the output. Set Power supply to 9V and 0.1A. Set the function generator to a SQUARE wave with amplitude 100mVpp, offset 0, frequency 100Hz. (The current entering the coulomb-meter is about 20pA for these tests)* | | | | |
| **STEP** | **Action** | **Expected Result** | **PASS** | **FAIL** | **N/A** | **Comments** |
| 1 | Turn on the power and function generator. | No shorts should be evident on the power supply | ✅ | | | |
| 2 | Probe the function generator output | A clear pulse wave (probes at function generator output) should be visible | ✅ | | | |
| 3 | Probe the amplified coulomb-meter output | A voltage reading of between 4V to 8V | | ❌ | | Oscilloscope displayed a straight line around 0.5V |
| | **Overall test result:** | | | ❌ | | Oscilloscope displayed a straight line around 0.5V. |

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| **Test Author: Felix** | | | | |
| | **Test Case Name:** | Input Testing | **Test ID #:** | 1-3 |
| | **Description:** | *Third attempt at imitating the charged particles entering the device via a SQUARE wave to produce an amplified voltage output.* | **Type:** | ✅ white box<br>□ black box<br>□ _____ |
| **Tester Information** | | | | |
| | **Name of Tester:** | Nathan Truong, Eisa Alsharifi | **Date:** | 2/19/25 |

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|---|---|---|---|---|---|---|
| | **HW/SW Version:** | Version A | | | **Time:** | 3:10 PM |
| | **Setup:** | *Connect power supply and oscilloscope to test points on the breadboard circuit. Probes for the oscilloscope are set at the frequency input and the output. Set Power supply to 9V and 0.1A. Set the function generator to a SQUARE wave with amplitude 100mVpp, offset 0, frequency 100Hz. (The current entering the coulomb-meter is about 20pA for these tests)* | | | | |
| **STEP** | **Action** | **Expected Result** | **PASS** | **FAIL** | **N/A** | **Comments** |
| 1 | Turn on the power and function generator. | No shorts should be evident on the power supply | ✅ | | | |
| 2 | Probe the function generator output | A clear pulse wave (probes at function generator output) should be visible | ✅ | | | |
| 3 | Probe the amplified coulomb-meter output | A voltage reading of between 4V to 8V | | ❌ | | Oscilloscope displayed a straight line around 0.5V |
| | **Overall test result:** | | | ❌ | | Oscilloscope displayed a straight line around 0.5V. Going to change oscilloscopes and test the virtual ground. |

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| **Test Author: Felix** | | | | |
| | **Test Case Name:** | Input Testing | **Test ID #:** | 1-4 |
| | **Description:** | *Fourth attempt at imitating the charged particles entering the device via a square wave to produce an amplified voltage output. Changed to different oscilloscope for quicker debugging and tested virtual ground, changed amplitude to 20mVpp.* | **Type:** | ✅ white box<br>□ black box<br>□ _____ |
| **Tester Information** | | | | |
| | **Name of Tester:** | Nathan Truong, Eisa Alsharifi | **Date:** | 2/19/25 |

| | HW/SW Version: | Version A | | | | Time: | 3:25 PM |
|---|---|---|---|---|---|---|---|
| | **Setup:** | *Connect power supply and oscilloscope to test points on the breadboard circuit. Probes for the oscilloscope are set at the frequency input and the output. Set Power supply to 9V and 0.1A. Set the function generator to a SQUARE wave with amplitude 20mVpp, offset 0, frequency 100Hz. (The current entering the coulomb-meter is about 20pA for these tests)* | | | | | |
| **STEP** | **Action** | **Expected Result** | **PASS** | **FAIL** | **N/A** | **Comments** | |
| 1 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | ✅ | | | Both sides of the ground were operating within acceptable ranges. | |
| 2 | Turn on the power and function generator. | No shorts should be evident on the power supply | ✅ | | | | |
| 3 | Probe the function generator output | A clear pulse wave (probes at function generator output) should be visible | ✅ | | | | |
| 4 | Probe the amplified coulomb-meter output | A voltage reading of between 4V to 8V | | ❌ | | Oscilloscope displayed nothing | |
| | **Overall test result:** | | | ❌ | | The Oscilloscope displayed nothing. Need to check all connections in accordance with the circuit schematic and continue debugging. | |

| **Test Author: Felix** | | | | |
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| | **Test Case Name:** | Input Testing | **Test ID #:** | 1-5 |
| | **Description:** | *Fifth attempt at imitating the charged particles entering the device via a square wave to produce an amplified voltage output. After checking connections, we discovered there is too little current coming in from the* | **Type:** | ✅ white box<br>□ black box |

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| | | *circuit being used to generate a small current. The resistor value was changed from 67M to 1G.* | | □ _____ |

**Tester Information**

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| | **Name of Tester:** | Nathan Truong, Eisa Alsharifi | **Date:** | 2/19/25 |
| | **HW/SW Version:** | Version A | **Time:** | 4:12 PM |
| | **Setup:** | *Connect power supply and oscilloscope to test points on the breadboard circuit. Probes for the oscilloscope are set at the frequency input and the output. Set Power supply to 9V and 0.1A. Set the function generator to a SQUARE wave with amplitude 20mVpp, offset 0, frequency 100Hz. (The current entering the coulomb-meter is about 20pA for these tests)* | | |

| STEP | Action | Expected Result | PASS | FAIL | N/A | Comments |
|---|---|---|---|---|---|---|
| 1 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | ✅ | | | Both sides of the ground were operating within acceptable ranges. |
| 2 | Turn on the power and function generator. | No shorts should be evident on the power supply | ✅ | | | |
| 3 | Probe the function generator output | A clear pulse wave (probes at function generator output) should be visible | ✅ | | | |
| 4 | Probe the amplified coulomb-meter output | A voltage reading of between 4V and 8V | ✅ | | | Oscilloscope displayed the expected wave output with a mean peak to peak voltage of about 4.5V |
| | **Overall test result:** | | ✅ | | | Oscilloscope displayed the expected wave output with a mean peak to peak voltage of about 4.5V |