# Team 03 Test Plan

2025/04/27

## Top Down Test Plan v1.0

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| Date of Test: | *2025/04/24* |
| Tester: | *Eisa Alsharifi* |

### Purpose

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

### Equipment Needed

- System Equipment
  - *Project Breadboard*
  - *MAX1032*
  - *LM662 Op Amp*
  - *QT PY Chip*
- Test Equipment
  - *Power Supply*
  - *Oscilloscope*
  - *Arduino IDE*
  - *Probes*
  - *DMM*
- Other Equipment
  - *N/A*

### Pre-Test Setup

1. Set 1 channel on the power supply to 9V and the other to 4.5V.
2. Connect power supply channels to the breadboard in the appropriate places.
3. Connect laptop running Arduino IDE to the QT PY
4. Connect oscilloscope probes to the op amp output
5. Double check all connections

### Top Down Test Steps

1. Turn on both power supply channels
2. Upload the code to the QT PY
3. Observe circuit output
   a. If we see a match between the Arduino IDE output voltage and the oscilloscope output voltage, this indicates a successful test.

### Post-Test Teardown

1. Turn off power supply channels
2. Unplug power supply connections
3. Unplug oscilloscope probes

4. Unplug QT PY from laptop

### Top-down Test Plan  Conclusions / Discussion

After running the test, we should observe that the output voltage should change 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 measure

# Team 03 COATL Aircraft Particle Sensor

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

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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:** | 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** |
|---|---|---|---|---|---|---|
| 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 increments) | We get matching ADC bit readings on the Arduino IDE. | | | | |
| 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 | A voltage reading of between 4V and 8V | | | | |

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| | op amp output) | | | | | |
| | **Overall test result:** | | | | | |

# Bottom Up Test Cases (Version F Tests on 5/20/25)

| **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:** | 5/20/2025 | | |
| | **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** |
|---|---|---|---|---|---|---|
| 1 | No inputs, only room noise | | | | | |

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|---|---|---|---|---|---|---|
| 2 | 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. | ✓ | | | |
| | **Overall test result:** | | ✓ | | | |

| **Test Information** | | | | | | |
|---|---|---|---|---|---|---|
| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | | | **Date:** | 5/20/2025 |
| | **HW/SW Version:** | Version F, Test 1 | | | **Time:** | 12:05PM |
| | **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 the power supply to 9V and 0.2A. Set the function generator to a SINE wave with amplitude 200mVpp, offset 0, frequency 1KHz.* | | | | |
| **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 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | | ✓ | | Virtual ground not working properly. Only getting 3.2V instead of the intended 4.5V. (Not getting the 4.5V at the schematic's ground) |
| 3 | Probe the function generator output | A clear pulse wave (probes at function generator output) should be visible | | | | |
| 4 | Upload code to microcontroller | Code should be successfully uploaded to the microcontroller | | | | |

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| | via Arduino IDE | | | | | |
| 5 | Give the ADC a direct supply of voltage (0V - 10V in 1mV increments) | We get matching ADC bit readings on the Arduino IDE. | | | | |
| 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:** | | | | | Taking out microcontroller to test PCB by itself. |

| **Test Information** | | | | | | |
|---|---|---|---|---|---|---|
| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | | | **Date:** | 5/20/2025 |
| | **HW/SW Version:** | Version F, Test 2 | | | **Time:** | 12:24PM |
| | **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 the power supply to 9V and 0.2A.* | | | | |
| **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 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | | ✓ | | Virtual ground not working properly. Only getting 3.2V instead of the intended 4.5V. (Not getting the 4.5V at the schematic's ground) |
| 3 | Probe the function generator | A clear pulse wave (probes at function generator output) | | | | |

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| | 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 increments) | We get matching ADC bit readings on the Arduino IDE. | | | | |
| 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:** | | | ✓ | | Checking all connections on the PCB, looking for potential shorts. |

| **Test Information** | | | | | | |
|---|---|---|---|---|---|---|
| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | | | **Date:** | 5/20/2025 |
| | **HW/SW Version:** | Version F, Test 3 | | | **Time:** | 12:40PM |
| | **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 the power supply to 9V and 0.2A.* | | | | |
| **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 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | | ✓ | | Virtual ground not working properly. Only getting 3.2V instead of the intended 4.5V. Went into the Capstone lab for a |

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| | | | | | | change of power supply to see if that was the issue but it was not. (Not getting the 4.5V at the schematic's ground) |
| 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 increments) | We get matching ADC bit readings on the Arduino IDE. | | | | |
| 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:** | | | ✓ | | Power supply was not the issue, going to continue to look for issues in the circuit. |

| **Test Information** | | | | |
|---|---|---|---|---|
| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | **Date:** | 5/20/2025 |
| | **HW/SW Version:** | Version F, Test 4 | **Time:** | 12:40PM |
| | **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 the power supply to 9V and 0.2A.* | | |

| **STEP** | **Action** | **Expected Result** | **PASS** | **FAIL** | **N/A** | **Comments** |
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|---|---|---|---|---|---|---|
| 1 | Turn on the power and function generator. | No shorts should be evident on the power supply | ✓ | | | |
| 2 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | | ✓ | | Virtual ground not working properly. Only getting 3.2V instead of the intended 4.5V. Went into the Capstone lab for a change of power supply to see if that was the issue but it was not. (Not getting the 4.5V at the schematic's ground) |
| 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 increments) | We get matching ADC bit readings on the Arduino IDE. | | | | |
| 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:** | | | ✓ | | Power supply was not the issue, going to continue to look for issues in the circuit. |

| **Test Information** | | | | |
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| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | **Date:** | 5/20/2025 |

| | HW/SW Version: | Version F, Test 5 | | | | Time: | 12:40PM |
|---|---|---|---|---|---|---|---|
| | **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 the power supply to 9V and 0.2A.* | | | | | |
| **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 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | | ✓ | | Virtual ground not working properly. Only getting 3.2V instead of the intended 4.5V. We are reading the 10k resistors in the voltage divider as 5k. This is because the resistors are mistakenly being connected in parallel. | |
| 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 increments) | We get matching ADC bit readings on the Arduino IDE. | | | | | |
| 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:** | | | ✓ | | Potential issue with the voltage divider was found. Going to test | |

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| | | | | | all individual connections on the PCB to completely rule out any missed connections. Going to switch out a resistors for fresh 10k |

| **Test Information** | | | | | | |
|---|---|---|---|---|---|---|
| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | | | **Date:** | 5/20/2025 |
| | **HW/SW Version:** | Version F, Test 6 | | | **Time:** | 1:25PM |
| | **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 the power supply to 9V and 0.2A.* | | | | |
| **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 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | | ✓ | | Virtual ground not working properly. Only getting 3.2V instead of the intended 4.5V. |
| 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 increments) | We get matching ADC bit readings on the Arduino IDE. | | | | |
| 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:** | | | ✓ | | Still not working. Going to change out the buffer for a new one since we identified that it was not getting enough input voltage. |

| **Test Information** | | | | | | |
|---|---|---|---|---|---|---|
| | **Name of Testers:** | Nathan Truong, Felix Moss, Annika Boyd, Eisa Alsharifi | | | **Date:** | 5/20/2025 |
| | **HW/SW Version:** | Version F, Test 6 | | | **Time:** | 2:53PM |
| | **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 the power supply to 9V and 0.2A.* | | | | |
| **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 | Test virtual ground | Both sides of the virtual ground should be around 4.5V | ✓ | | | Buffer was the issue! Virtual ground is working properly now. |
| 7 | Probe the amplified coulomb-meter output (LM662 op amp output) | A voltage reading of between 4V and 8V with responses to outside sources of charged particles | ✓ | | | We have a stable DC output of 4.5V and the output is affected by outside interference sources as intended. |
| | **Overall test result:** | | | ✓ | | The PCB is now functioning as intended. We believe the problem was that when a capacitor was popped, the buffer was burnt by |

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| | | | | | the surge of current. |