## Hardware Architecture

Three main hardware interfaces:

1. Customized PCB:

* Purpose:
  + The PCB offers power regulation, signal routing, and a stable platform for mounting the Raspberry Pi Zero, NFC sensor. Provisions are made to accommodate other devices to achieve flexibility. This ensures a structured, efficient hardware layout, facilitating clear connections and power distribution for the entire system.
* Interconnection:
  + Regulated 5VDC to supply power to Raspberry Pi, with 40-pin GPIOs from Pi to dedicated connectors.
  + Regulated 3.3VDC to supply power to NFC sensor.

1. Raspberry Pi Zero W:
   * Purpose:

* The Raspberry Pi acts as the central control unit, running software applications and managing data processing.
  + Interconnection:
    - GPIO 2 (SDA) and GPIO 3 (SCL) are brought from Pi to PCB connector (J12), which then connects to the NFC sensor.

1. Near Field Communication (NFC) sensor:
   * Purpose:
     + The NFC sensor facilitate contactless communication with external devices, enabling access control, data transfer, and authentication.
   * Interconnection:
     + Mounted to its dedicated 4-pin header on PCB.

In summary, the hardware architecture combines the computational power of the Raspberry Pi with the NFC sensor's contactless communication capabilities, all organized and interconnected through the customized PCB.

See the subsequent pages for PCB view and connector pinouts.

See Appendix A for PCB design details.

A close up of a circuit board

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Figure :PCB Top View

A close up of a circuit board

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Figure : PCB Side View

Table 1: PCB Connector Pinouts

|  |  |  |  |
| --- | --- | --- | --- |
| **PCB Connector Pinouts** | | | |
| **CONNECTOR** | **PIN#** | **DESCRIPTION** | **COMMENTS** |
| J1 | 1 | +12V | Max 2A, with 2.5A fuse protection |
| 2 | GND |
| J2 | 1 | +5V | Max 1A, with 1.5A fuse protection |
| 2 | GND |
| J3 | 1 | +3V3 | Max 0.5A, with 1.5A fuse protection |
| 2 | GND |
| J4 | 1 | +12V | 12VDC adaptor output (can use 9-12V source), J4 is connected to switch S1 to turn power on/off |
| 2 | GND |
| J5 | 1 | +5V | 12V-to-5V regulator output, 3A output load current |
| 2 | GND |
| J6 | 1 | +3V3 | 5V-to-3V3 regulator output, 1A output load current |
| 2 | GND |
| J7 | 1 | GPIO 12 | PWM0 |
| 2 | GND |
| J8 | 1 | GPIO 13 | PWM1 |
| 2 | GND |
| J9 | 1 | GPIO 26 | General purpose I/O |
| 2 | GND |
| J10 | 1 | +12V | Positive power terminal |
| 2 | GND | Negative power terminal |
| J12 | 1 | GND |  |
| 2 | +3V3 | 5V-to-3V3 regulator output |
| 3 | GPIO 2 | SDA |
| 4 | GPIO 3 | SCL |
| J13 | 1 | Reset | J13 is connected to switch S2: press S2 to reset Raspberry Pi |
| 2 |
| J14 | 1 | GPIO 2 | SDA, do not use simultaneously with J12 |
| 2 | GPIO 3 | SCL, do not use simultaneously with J12 |
| 3 | GPIO 17 | spi1 CS1 |
| 4 | GND |  |
| 5 | GPIO 10 | MOSI |
| 6 | GPIO 9 | MISO |
| 7 | GPIO 11 | SCLK |
| 8 | GND |  |
| 9 | GPIO 19 | PWM1, miso1 |
| 10 | GND |  |
| J15 | 1 | GPIO 14 | TXD |
| 2 | GPIO 15 | RXD |
| 3 | GPIO 18 | PWM0, spi1 CS0 |
| 4 | GND |  |
| 5 | GPIO 8 | SPI CS0 |
| 6 | GPIO 7 | SPI CS1 |
| 7 | GPIO 16 | spi1 CS2 |
| 8 | GPIO 20 | mosi1 |
| 9 | GPIO 21 | sclk1 |
| 10 | GND |  |
| J16 | 1 | +5V from Pi | Must remove jumper to connector J16 when Raspberry Pi is connected to USB |
| 2 | +5V from regulator |
| J11 | 1-40 | 40-pin GPIO (same pinouts as Raspberry Pi) | Raspberry Pi mounts to connector J11 |
| P1 | Raspberry Pi breakouts, do not use simultaneously with J7, J8, J9, J12, J14, J15 |
| Note: LED1, LED2, and LED3 indicate 12V, 5V, and 3.3V, respectively. | | | |

A black circuit board with many wires and wires

Description automatically generated with medium confidence

Figure : PCB Pinouts Diagram

## Test Plan 1: PCB Hardware Functionality Test

### Summary

**Story ID: PCB-TEST-1**

The hardware functionality test is designed to detect and confirm the proper functioning of the customized PCB. It aims to validate power distribution, signal routing, and component integrity, ensuring that the PCB provides stable voltage outputs, correct signal paths, and reliable operation. The test seeks to confirm that the PCB meets design specifications and performs as expected in supporting the Raspberry Pi Zero and NFC sensor integration, while maintaining safety measures under various conditions.

### Test Cases

|  |  |  |
| --- | --- | --- |
| Test Case: 3.1 | | |
| Pre-Condition:  *Unpopulated PCB Board* | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Measure resistance between the test point 12V and GND  2. Measure resistance between the test point 5V and GND  3. Measure resistance between the test point 3.3V and GND  4. Measure resistance between the test point 12V and 5V  5. Measure resistance between the test point 12V and 3.3V  6. Measure resistance between the test point 5V and 3.3V | **> 1MΩ**  **> 1MΩ**  **> 1MΩ**  **> 1MΩ**  **> 1MΩ**  **> 1MΩ** | **As expected**  **As expected**  **As expected**  **As expected**  **As expected**  **As expected** |
| Result:  Pass | | |

|  |  |  |
| --- | --- | --- |
| Test Case: 3.2 | | |
| Pre-Condition:  *Power connector J10 and power switch S1 soldered on board, connected to power supply.* | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Turn on power switch S1  2. Measure the voltage between test point 12V and GND | **12V ± 2V** | **12.6V (as expected)** |
| Result:  Pass | | |

|  |  |  |
| --- | --- | --- |
| Test Case: 3.3 | | |
| Pre-Condition:  *12-to-5V regulator U1, 680uF capacitor C1, 220uF capacitor C2, Schottky diode D1, power inductor L1, LED1, LED2, 1k*Ω resistor R1, and 300Ω resistor R2 *soldered on board* | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Connect 12V power supply via input connector J10    2. Measure voltage at 12V and 5V test points | **12V test point = 12V**  **5V test point = 5V ± 0.1V** | **12V test point = 12V (as expected)**  **5V test point = 5.06V (as expected)** |
| Result:  Pass | | |

|  |  |  |
| --- | --- | --- |
| Test Case: 3.4 | | |
| Pre-Condition:  *5-to 3.3V regulator U2, 2.2uF capacitor C3 & C5, 10nF capacitor C4, LED3, 130*Ω resistor R3 soldered on board*.* | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Power on PCB    2. Measure voltage at 3.3V test point | **3.3V test point = 3.3V± 0.1V** | **3.3V test point = 3.3V (as expected)** |
| Result:  Pass | | |

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| --- | --- | --- |
| Test Case: 3.5 | | |
| Pre-Condition:  *Apply 3.3V to GPIO 22 to enable MOSFET Q1; connect 6*Ω load at J1 (12V output) | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Put the current meter in series with *6*Ω load    2. Measure rise in PCB temperature in 30 mins (affected by MOSFET Q1) | **I = 2A ± 0.1A**  **T < 50 °C** | **I = 2A (as expected)**  **T = 35 °C (as expected)** |
| Result:  Pass | | |

|  |  |  |
| --- | --- | --- |
| Test Case: 3.6 | | |
| Pre-Condition:  *Apply 3.3V to GPIO 23 to enable MOSFET Q2; connect 3.33*Ω load at J2 (5V output) | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Put the current meter in series with 3.33Ω load    2. Measure rise in PCB temperature in 30 mins (affected by MOSFET Q2) | **I = 1.5A ± 0.1A**  **T < 50 °C** | **I = 1.5A (as expected)**  **T = 45 °C (as expected)** |
| Result:  Pass | | |

|  |  |  |
| --- | --- | --- |
| Test Case: 3.7 | | |
| Pre-Condition:  *Apply 3.3V to GPIO 24 to enable MOSFET Q3; connect 6.67*Ω load at J3 (3.3V output) | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Put the current meter in series with 6.67Ω load    2. Measure rise in PCB temperature in 30 mins (affected by MOSFET Q3) | **I = 0.5A ± 0.1A**  **T < 50 °C** | **I = 0.5A (as expected)**  **T = 45 °C (as expected)** |
| Result:  Pass | | |

|  |  |  |
| --- | --- | --- |
| Test Case: 3.8 | | |
| Pre-Condition:  *Connect oscilloscope to 5V regulator output to measure AC ripple component.* | | |
| Steps: | **Expected Results** | **Actual Results** |
| 1. Measure output ripple with no load  2. Measure output ripple with 0.5A load (10Ω resistance)  3. Measure output ripple with 1A load (5Ω resistance)  4. Measure output ripple with 2A load (2.5Ω resistance) | **Δ increases in ripple with respect to baseline (ripple caused by external power supply) < 50mV** | **Δ increases in ripple < 50mV (as expected)** |
| Result:  Pass | | |

Note: see Appendix A for test results

# Appendix A:

A diagram of a computer

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Figure : PCB Schematic Design (IO Expansion)

A diagram of a circuit

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Figure : PCB Schematic Design (Power Management)

A green circuit board with different components

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Figure : PCB 3D Model

A computer circuit board with many wires

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Figure : PCB Layout

Table : PCB Bill of Materials (BOM)



A screen shot of a computer

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Figure : test case 1.8 (no load)

A screen shot of a computer

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Figure : test case 1.8 (0.5A load)

A screen shot of a computer

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Figure : test case 1.8 (1A load)

A screen shot of a computer

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Figure : test case 1.8 (2A load)