1. Block Diagram of the entire system

2. AC to DC Converter: Rectifier Circuit in the Power Module

Firstly, the transformer steps the wall power down to a lower AC voltage value. From here, the AC power passes through a 4-diode full-wave bridge rectifier to become a more stable DC voltage value.

Afterwards, the DC power goes through a few small value resistors. Also, a capacitor is utilized in parallel, to smooth out the DC value for one more time, and a fly-back diode is used to prevent any current flow in a wrong direction. Across the
resistor load is the voltage output, and a connector with be used at this point to connect to the power distribution board input, in sequence.

3. Calculation for a desired motor

In order to find out an appropriate motor for rotating the brush, we need to find out how much torque is required by finding out the friction between the brush and the blackboard.

After testing, we find out when we apply around 11.5N on two erasers, it is sufficient to clean the board.

Eraser contact surface area: 5cm * 12.5cm * 2 = 125cm^2 = 0.0125m^2

Pressure: F/A = 4.5N/0.0125m^2 = 360Pa

We plan to use a brush 0.5m long and have a contact width of 0.02m,

Brush contact surface area: 0.5m * 0.02m = 0.01m^2

Friction between brush and board: 0.01m^2 * 360Pa = 3.6 N

Our brush is 6~8cm in radius, thus the torque required is: 3.6N*0.08m = 0.29Nm
Since the brush has a narrower contact width, we might need to increase pressure in order to clean the board. Also, using a different board might lead to change in friction. We want to overkill the calculated torque to compromise these uncertainties. We want to look for a motor with 0.6Nm to 1.2Nm torque.

4. Graph based on our experiment of friction needed to clean the blockboard

![Friction Coefficient Test](image)

5. Control Module Detailed Description

Control Module:

- **Input:**
  - Power input: 5V from power distribution board.
  - Signal input:
    - Image processing module: “Command” info from the board
- Motion sensor: For self-shutdown when no one is using
- Backup button: Manually push a button to clean if faults
- Encoders on rails: Keeps sending motor information back to the MCU

- Output:
  - Signal output:
    - To motor controller module: Command content instruction
    - Power distribution board: 为啥

- Internal: The control board receives signals from image processing module, motion sensor, backup button, and encoders. It uses its own microcontroller to keep track of brush position and determine when the brush should move or stop.
  - “ALL ERASE”: If a presenter wants to erase the entire blackboard, just write “ALL ERASE” anywhere on the board
  - “ERASE”: Presenter can write “ERASE” as a cleaning boundary mark on the board. The brush will then move from the side to the “ERASE” mark, and only cleans part of the board.
  - “CONFIDENTIAL/ANNOUNCEMENT”: When IP module sends a signal indicating the content of the board is “confidential”, control will clean the board when motion sensor detects no motion for 5 mins. A board is default to be “confidential”, one can stop auto clean by writing “ANNOUNCEMENT” on the board. When IP module sends signal indicating the content is “announcement”, control do not clean the board until “ALL ERASE” or “ERASE” is triggered.

- Backup Whole-Clean Button: Located at the left side of the track, if for some reasons, the image-processing module is not responding to
the cleaning command, you can still manually push the Whole-clean button to clean the blackboard.

- Emergency Stop Button: Push when you need a sudden stop or you need to shut the system down when it is malfunctioning.

6. Requirements and Verifications for the Control Module

<table>
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<tr>
<th>Requirements</th>
<th>Verification</th>
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<tbody>
<tr>
<td>Sensors send appropriate signals back to control module.</td>
<td>Use LEDs to indicate if the sensors are sending signals to control.</td>
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<tr>
<td>Control module correctly recognize sensor signals and trigger corresponding functions.</td>
<td>Use switches to simulate sensor signals and use LEDs to indicate which function is triggered.</td>
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<tr>
<td>Emergency Stop Button cut off power when pushed</td>
<td>Set control to execute cleaning the board and then push the Emergency Stop Button see if power is cut off.</td>
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7. Safety concerns:

- This product can be particularly dangerous because it is directly connected to the wall power. Therefore, we will design the power converter boards with extra care and extra safety-oriented.

- Another concern is the functionality of the brush itself. In the case of system no response, or system can not terminate actions, we design a safety board consists of two buttons: One Back-up cleaning button for cases where there are faults in the system and it is not responding to the commands on the backboard; Also one Emergency stop button which cuts the power source off to turn off the entire system in unusual circumstances.