Smart Grow Controller (SGC)

Version V1.0

Introduction

In the rapidly evolving landscape of agriculture and plant cultivation, the need for precise monitoring and control of growth conditions has become paramount. Our project aims to address this demand through the development of an innovative technical device—an advanced plant growth monitoring and control module.

Overview

The plant growth monitoring and control module is a sophisticated 220 cm high stand, seamlessly integrating sensors, motors, and cameras. This intelligent system is designed to provide comprehensive insights into the plant environment, facilitating centralized and automated control of growing conditions. The key features include:

- **Lighting Height Adjustment:** An electric motor enables horizontal movement of the lighting unit along the stand, coupled with a contact sensor to detect the maximum height.

- **Environmental Sensors:** Equipped with sensors measuring humidity, temperature, CO2 concentration, air pressure, and soil conditions, the module continuously collects data crucial for analyzing and optimizing growing conditions.

- **Camera Monitoring:** Three cameras capture video recordings of plants, which are then transmitted to a Raspberry Pi for in-depth analysis, offering valuable insights into the overall health and development of the plants.

- **Controllable Power Sockets:** The module incorporates power sockets with the ability to measure and control power consumption, providing an additional layer of control over the plant environment.

- **Real-time Data Access:** Home Assistant serves as the central hub for real-time data access. Users can effortlessly monitor key metrics such as humidity, temperature, CO2 concentration, air pressure, and soil conditions from the convenience of their Home Assistant dashboard.

- **Graphical Representation:** The collected data is not just displayed; it is presented in a visually intuitive manner through graphs and charts within the

Home Assistant interface. This graphical representation enhances the user experience, providing insightful trends and patterns in plant growth conditions over time.

- **Alerts and Notifications:** Home Assistant is configured to send alerts and notifications based on predefined thresholds or specific events. Users receive instant notifications on their devices, ensuring timely responses to any deviations from optimal growth conditions.

- **Remote Control:** The module's controllable power sockets and lighting height adjustment feature can be effortlessly controlled remotely through Home Assistant. Users can fine-tune the environment by adjusting lighting levels or modifying power consumption settings, all with a few clicks on the Home Assistant interface.

- **User-Friendly Interface:** Home Assistant offers an intuitive and user-friendly interface, ensuring that both novice and experienced users can navigate and utilize the platform effortlessly. The seamless integration of our module with Home Assistant reflects our commitment to providing an accessible and robust solution for plant growth monitoring and control.

Hardware Components

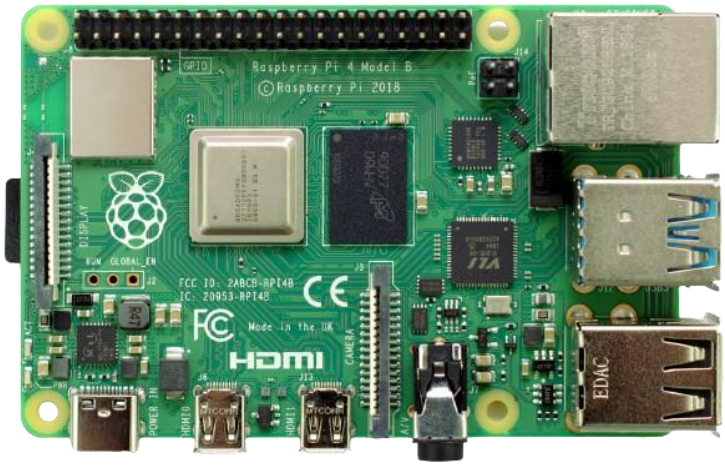
SL No.	Name	Description
1	Microcontroller	Espressif ESP32 WLAN Dev Kit Board Development Bluetooth and Wi-Fi
2	Air Pressure Sensor	BMP388 Digital Pressure Sensor
3	SCD-41	Adafruit SCD-41 - True CO2, Temperature and Humidity Sensor
4	Soil Moisture Sensor	Analog Waterproof Capacitive Soil Moisture Sensor
5	pH Sensor	SEN0161 DFrobot pH meter
6	Raspberry Pi	Raspberry Pi 4 Model B with 4GB RAM
7	Power Supply	DC 5V 3A Power Supply for Raspberry Pi
8	Camera Module	12MP IMX708 75°(D) Autofocus Pi Camera V3
9	Camera Adapter	Arducam Multi Camera Adapter Module V2.2 for Raspberry Pi 4B
10	7-Segment Display	3-Digit 7-Segment Display Common Cathode 3-Digit

		LED Display
11	Limit Switch	Micro Limit Switch Long Hinge Roller Momentary SPDT Snap Action
12	Power Control Switch	Rocker Switch ON-OFF SPST 2-Pin
13	Rotary Potentiometer	10K Ohm Linear Taper Adjustable Rotary Potentiometer
14	Motor Driver	BTS7960 High Power Double DC Motor Driver Module Board
15	DC Gear Motor	35W Mini DC Gear Motor Metal Speed Adjustable Large Torque Motor CW/CCW (12V 150rpm)
16	Energy Measurement Sensor	Adafruit INA260 High or Low Side Voltage, Current, Power Sensor
17	AC Energy Meter and Control Switch	Electricity Control Switch (Relay) & AC PZEM-004T Meter (Measure Power)
18	Light	Plant Growing Lamp for Indoor Plants Gardening
19	SMPS	Power Supply Unit for Motor Control
20	5V Adapter or DC to DC converter	Micro USB Power Supply 5V 3000mA / 3A Charger for Microcontroller & Sensor

Controllers and Sensors Information

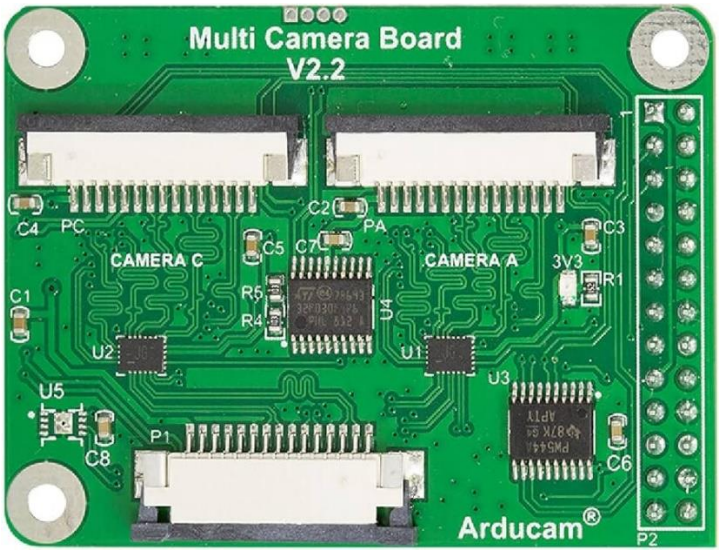
Raspberry Pi

Raspberry Pi is a series of small, affordable, single-board computers developed by the Raspberry Pi Foundation. These credit-card-sized computers are designed to promote computer science education and provide an accessible platform for hobbyists, makers, and enthusiasts to create a wide range of projects. The Raspberry Pi boards typically run on Linux-based operating systems and come equipped with GPIO pins, HDMI ports, USB ports, and networking capabilities.



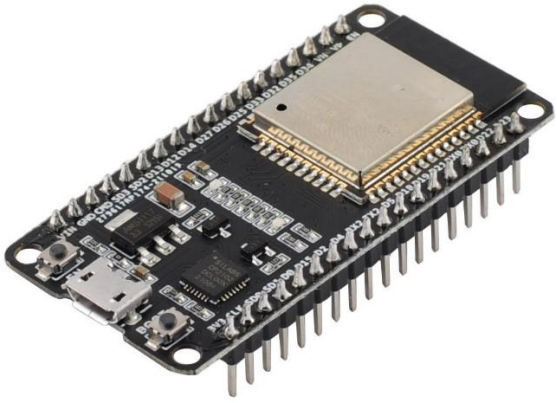
Arducam Camera Module

The Arducam 4 Camera Adapter for Raspberry Pi is a versatile accessory designed to enhance the imaging capabilities of the Raspberry Pi. This adapter allows users to connect up to four Arducam cameras simultaneously to a single Raspberry Pi, enabling multi-camera applications such as 360-degree panoramic photography, stereoscopic vision, or advanced computer vision projects. The adapter provides flexibility in camera positioning and synchronization, making it a valuable tool for projects requiring multiple perspectives or enhanced imaging capabilities. With easy integration and support for various Arducam camera modules, this adapter opens up a wide range of possibilities for creative and sophisticated Raspberry Pi-based imaging projects.



ESP32 Dev Module

The ESP32 is a versatile and widely used microcontroller and system-on-chip (SoC) that is part of the ESP (Espressif) family. It integrates both Wi-Fi and Bluetooth capabilities, making it a popular choice for IoT (Internet of Things) applications. Developed by Espressif Systems, the ESP32 features a dual-core processor, low-power modes, a variety of interfaces, and ample memory, enabling it to handle a range of tasks from simple sensor monitoring to more complex projects such as home automation and wearable devices.

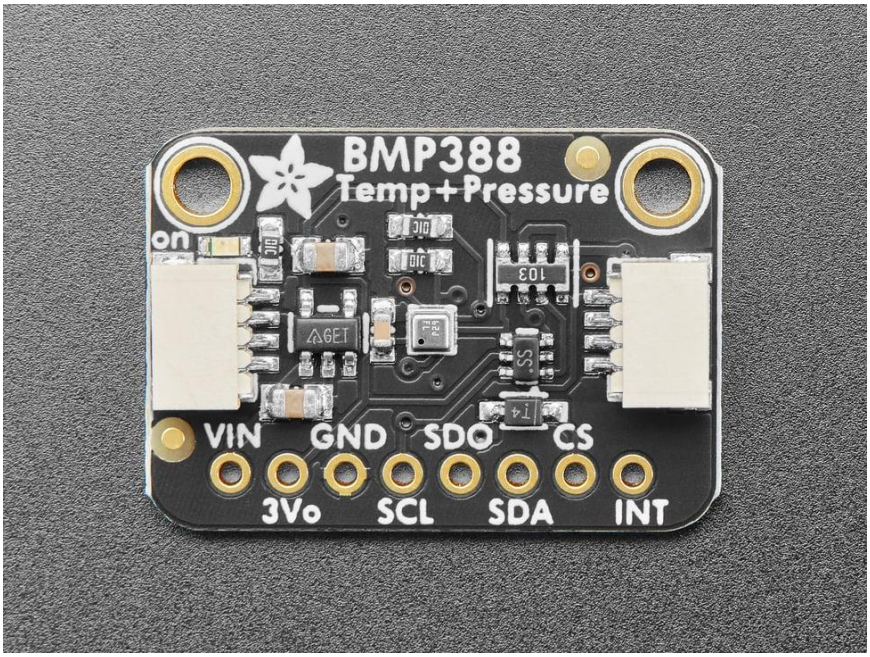


Air Pressure Sensor

BMP388 is a pressure and temperature measurement sensor. It offers lower power consumption, smaller size, higher resolution, and sampling rate compared with its predecessors BMP180, BMP280.

Barometric sensors are usually used to measure barometric pressure and temperature. But besides that, they can also measure altitude and relative floor height because there is a certain relationship between altitude and barometric pressure. Moreover, BMP388 enables accurate altitude tracking and is specifically suited for drone applications.

Based on Bosch's proven piezo-resistive pressure sensor technology, BMP388 features high EMC robustness, high accuracy, and low power. It offers an accuracy of ±8Pa, which is equivalent to about ±0.66m difference in altitude, and an absolute accuracy temperature of ±0.5℃ for a temperature range between 0℃ and 65℃.

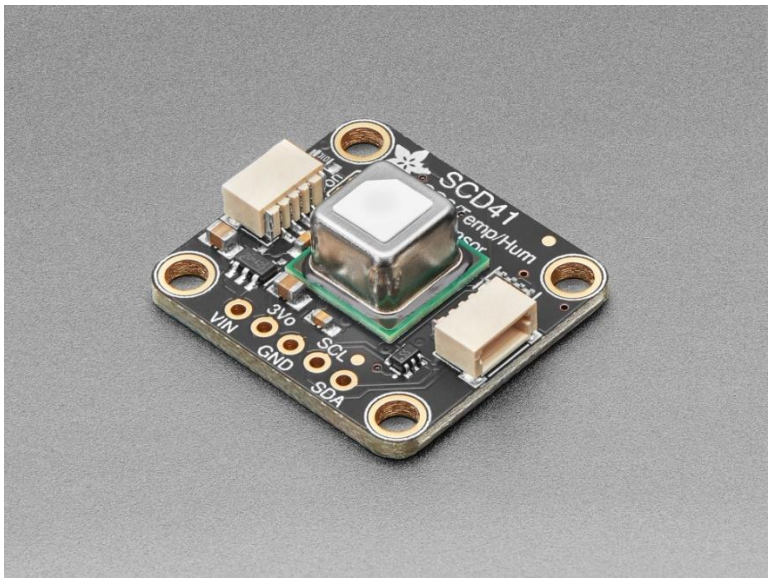


SCD-41 - True CO2 Temperature and Humidity Sensor

The SCD-41 is a photoacoustic 'true' CO2 sensor designed to measure the CO2 PPM (parts-per-million) composition of ambient air. Unlike some sensors that approximate CO2 levels from VOC gas concentration, the SCD-41 employs a precise measurement technique, providing accurate CO2 concentration data. Ideal for

environmental sensing, scientific experiments, air quality assessments, and ventilation studies, this sensor is larger and more expensive but offers authenticity in CO2 measurement. It operates over I2C, facilitating seamless integration with various microcontrollers or microcomputers. Available in two variants, the SCD-40 is cost-effective for indoor/outdoor air quality measurements, while the SCD-41, though pricier, is suitable for industrial or scientific CO2 measurements with a wider ppm range.

Technical details include a measurement range of 400 ppm to 5000 ppm, accuracy of ±(40 ppm + 5% of reading), and integrated temperature and humidity sensors. The sensor, in STEMMA QT form factor, features connectors compatible with SparkFun Qwiic I2C connectors, ensuring easy interfacing. A 3.3V regulator and level shifters enhance stability, accommodating a power supply range of 3.3V to 5V. The sensor's dimensions are 25.5mm x 22.8mm x 7.7mm, with a weight of 2.8g. Notably, the PCB underwent revisions, with a new silkscreen featuring Adafruit Pinguin, for improved visibility. The SCD-41 is a reliable choice for those seeking accurate and authentic CO2 measurements in diverse applications.



Waterproof Capacitive Soil Moisture Sensor

This is a new type of analog capacitive soil moisture sensor designed by DFRobot. Compared with the old soil moisture sensor, it has increased waterproof performance. Even if the sensor is fully immersed in water, it can still be used normally; the anti-corrosion performance is optimized and more Laminate design,

no longer need to worry about the sensors in the soil scratching the sensor panel, resulting in accelerated corrosion of the sensor; the length of the electrode plate is increased and the circuit performance is optimized, the measurement range is expanded, and the measurement value of the sensor is more accurate!

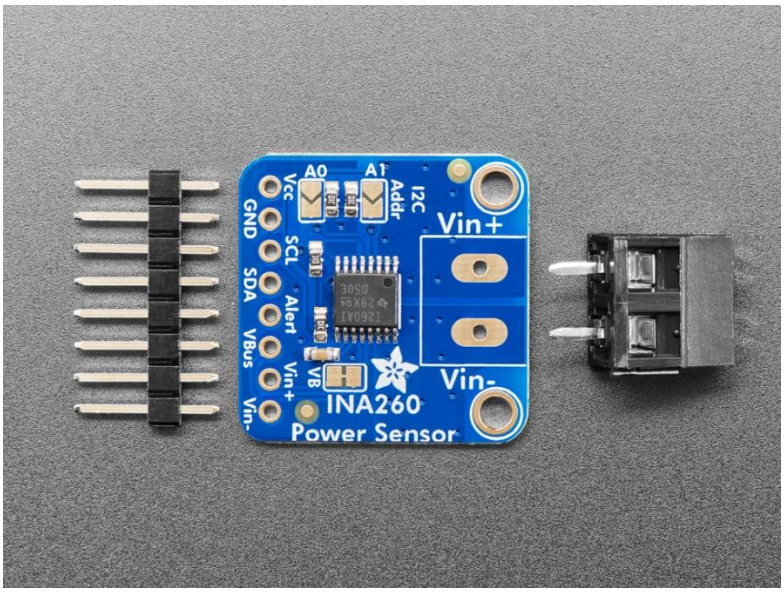
Analog pH Sensor / Meter

DFRobot analog pH meter, specially designed for Arduino controllers and has a convenient and practical "Gravity" connector and a bunch of features. Instant connection to your probe your Arduino to get pH measurements at ± 0.1pH (25 ℃). For most hobbyists, this great accuracy range and its low cost make this a great tool for bio robotics and other projects! It has an LED that works as the Power Indicator, a BNC connector, and a PH2.0 sensor interface. To use it, just connect the pH sensor with the BND connector, and plug the PH2.0 interface into the analog input port of any controller. If pre-programmed, you will get the pH value easily. Comes in a compact plastic box with foam for better mobile storage.

Adafruit INA260 High or Low Side Voltage, Current, Power Sensor

INA260 can do it with amazing precision and flexibility. With it you can measure high or low side DC current, the bus voltage, and have it automatically calculate the power. It can do so over impressive voltage, current, and temperature ranges with better than 1% accuracy, all while delivering the data in an easy-to-use format over I2C.

Most current-measuring devices operate with some notable constraints that limit what they can be used for. Many are low side only which can cause issues as the ground reference changes with current. Others, like its little sister the INA219B avoid this by measuring on the high side but need to change their shunt resistor to measure different current ranges. The INA260 avoids these limitations, and with its integrated precision shunt resistor it can be used to measure as much as +36V at up to 15A Continuous on either the high or low side.


A0
A1
I2C Addr
Vcc
GND
SCL
SDA
Alert
VBus
Vin+
Vin-
Vin+
Vin-
INA260
Power Sensor

Home Assistant Installation and Setup

The first step to getting started with Home Assistant is to install it on Raspberry Pi. There are many ways to run it for all kinds of scenarios. In this section, I will describe two scenarios that help to install and run Home Assistant on Raspberry Pi.

Let's explore the first Home Assistant available version. Home Assistant offers four different installation methods. I recommend using Home Assistant Operating System or Supervised. Other methods are available for experienced users for their specific needs, for example, running Home Assistant in a virtualized environment (e.g. Proxmox), or on top of an existing operating system (e.g. Windows, macOS, Linux):

Note that while these installation methods may provide some features for advanced users, they may also have some major limitations. For example, add-ons and other important Home Assistant features may not be available.

Home Assistant Versions

Home Assistant Container: Standalone container-based installation of Home Assistant Core (e.g. Docker).
Home Assistant Supervised: Manual installation of the Supervisor.
Home Assistant Core: Manual installation using Python virtual environment.

	HA OS[1]	Container[1]	Core[1]	Supervised[1]
Automations	✅	✅	✅	✅
Dashboards	✅	✅	✅	✅
Integrations	✅	✅	✅	✅
Blueprints	✅	✅	✅	✅
Uses container	✅	✅	❌	✅
Supervisor	✅	❌	❌	✅
Add-ons	✅	❌	❌	✅
Backups	✅	✅[2]	✅[2]	✅
Managed Restore	✅	❌[3]	❌[3]	✅
Managed OS	✅	❌	❌	❌

Home assistant available features in different version

We are going to design a user-attractive dashboard. In this case, we need some extra features such as supervisor, add-ons, integrations and others. So, we need Home Assistant OS or supervised version. Here we will discuss both OS and supervised versions of Home Assistant installation.

The differences between Home Assistant OS and Home Assistant Supervised, as well as instructions for installing each on a Raspberry Pi.

Home Assistant OS vs. Home Assistant Supervised

1. **Home Assistant OS**
   - Home Assistant OS is a dedicated operating system designed specifically for running Home Assistant.
   - It is an all-in-one solution, including the operating system and Home Assistant software.
   - It uses Docker containers for running Home Assistant and other services in isolation.

- It is recommended for users who want a hassle-free and more controlled environment.

2. **Home Assistant Supervised**
   - Home Assistant Supervised is a more flexible installation option that allows you to run Home Assistant on a generic Linux system.
   - It doesn't come with its own operating system; instead, it runs on top of an existing Linux distribution.
   - It provides more control over the underlying system and allows users to install additional software.
   - It is suitable for users who want more customization options and are comfortable managing a Linux system.

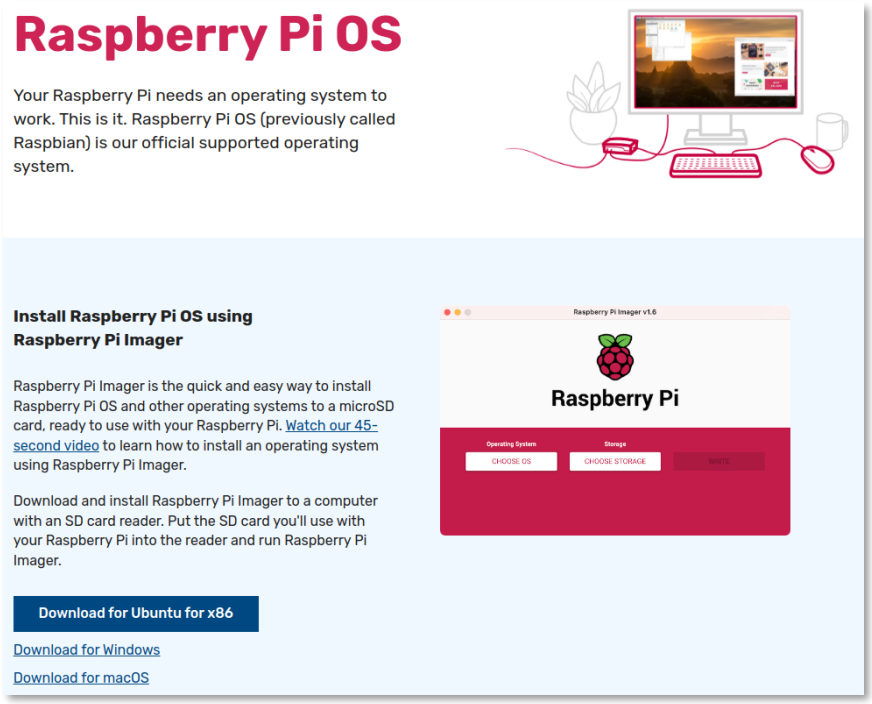
Home Assistant OS Installation on Raspberry Pi

This guide shows how to install the Home Assistant Operating system onto your Raspberry Pi using Raspberry Pi Imager.

*If Raspberry Pi Imager is not supported by your platform, you can use **Balena Etcher** instead. Follow method 2.*

Method 1:

1. Download and install the Raspberry Pi Imager on your computer as described under https://www.raspberrypi.com/software/.

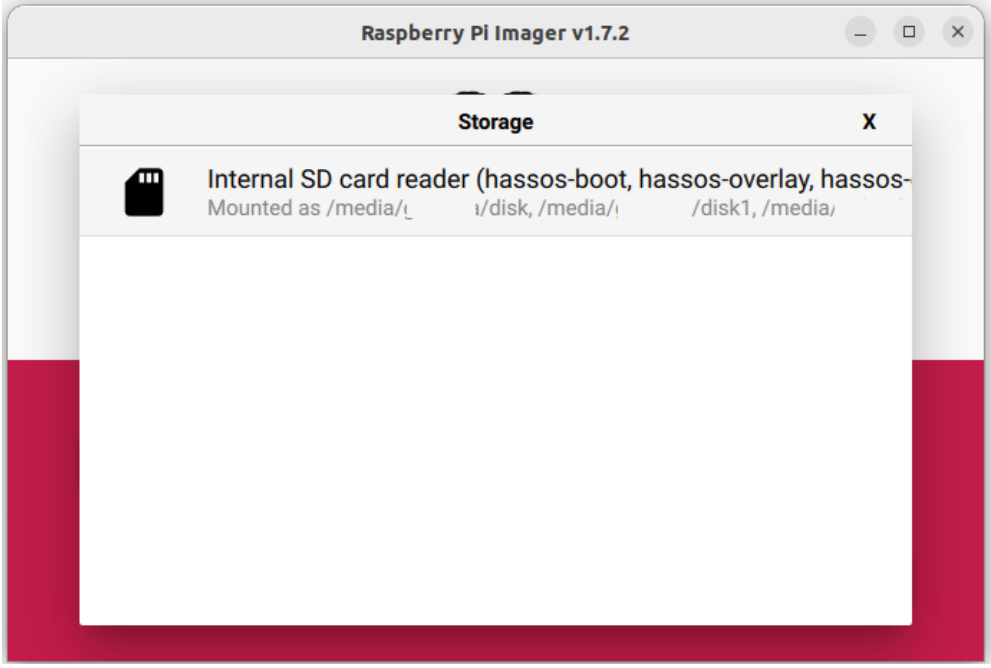


2. Open the Raspberry Pi Imager and select your Raspberry Pi device.

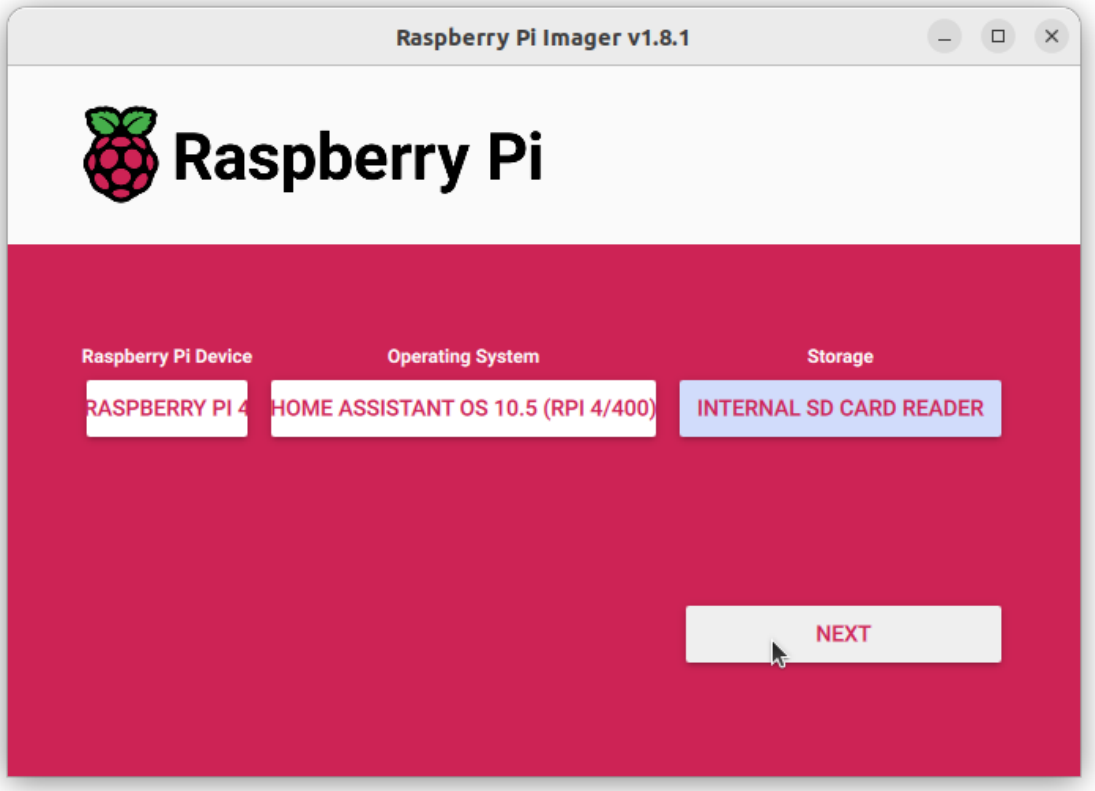
3. Choose the operating system:
   - Select **Choose OS**.

- Select **Other specific-purpose OS > Home assistants and home automation > Home Assistant.**
- Choose the Home Assistant OS that matches your hardware (RPi 3 or RPi 4).

4. Choose the storage:
   - Insert the SD card into the computer.
     Note: the contents of the card will be overwritten or need format it.
   - Select **your SD card**.



5. Write the installer onto the SD card:
   - To start the process, select **Next.**
   - Wait for the Home Assistant OS to be written on the SD card.



6. Eject the SD card.

7. Insert the SD card into your Raspberry Pi.
8. Plug in an Ethernet cable and make sure the Raspberry Pi is connected to the same network as your computer.
9. Connect the power supply to start up the device.

Access Home Assistant

Within a few minutes after connecting the Raspberry Pi, you will be able to reach your new Home Assistant. In the browser of your desktop system, enter homeassistant.local:8123.

- The time it takes for this page to become available depends on your hardware. On a Raspberry Pi 4, this page should be available within a minute.
- If it does not show up after 5 minutes on a Pi 4, maybe the image was not written properly.
- Try to flash the SD card again, possibly even try a different SD card.
- If this did not help, view the console output on the Raspberry Pi.
- To do this, connect a monitor via HDMI.

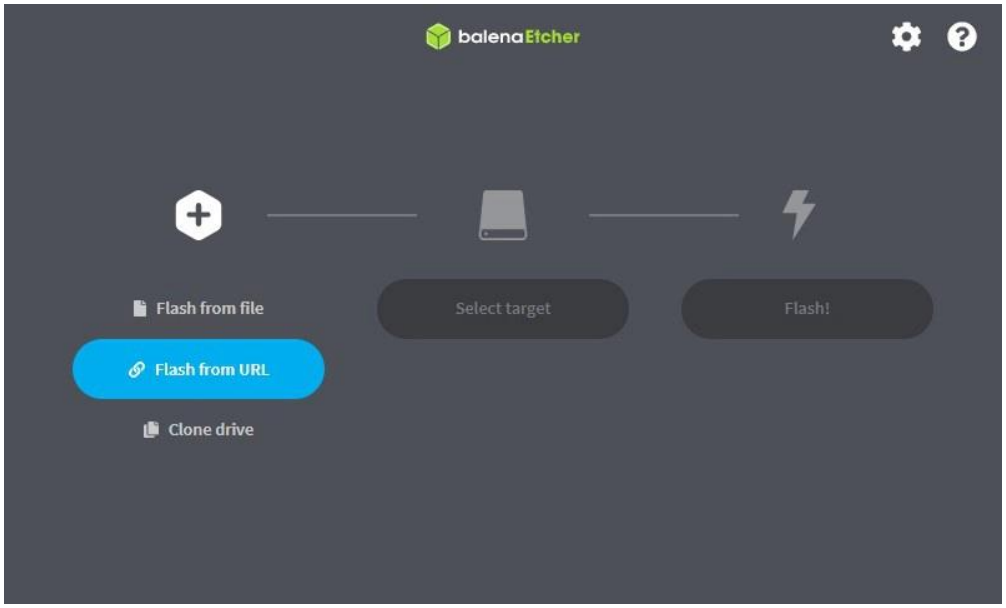
Congratulations! You finished the Raspberry Pi setup!

Method 2

Just like with Raspbian we are going to write the Home Assistant OS straight to the SD card. For this, we are going to use a free tool Balena Etcher. Make sure you download and install the tool before you continue.

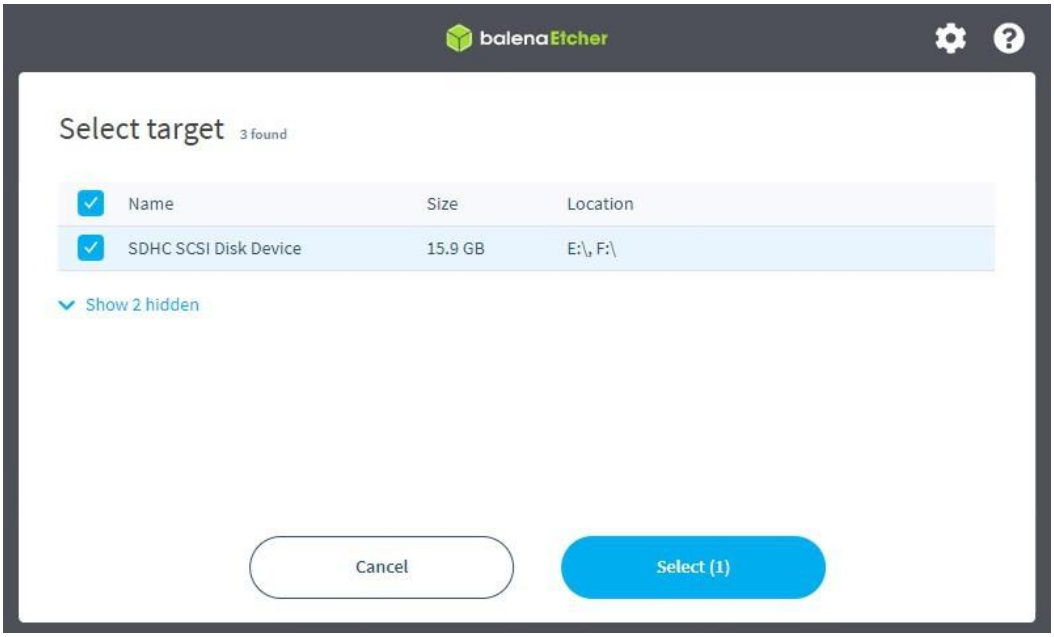
Make sure that you have inserted your SD Card into your computer.

1. Open Ether and click Flash from URL



2. Enter the URL for your Pi.
   https://github.com/home-assistant/operating-system/releases/download/6.5/haos_rpi4-64-6.5.img.xz

3. **Select target.**
   Select **your SD Card**, keep in mind that everything on it will be overwritten.



4. Click **Flash to start the process**.
5. You might get a warning for User Account Control. Just click **Yes**.
6. Wait for the process to finish.

7. Insert the SD card into your Raspberry Pi.
8. Plug in an Ethernet cable and make sure the Raspberry Pi is connected to the same network as your computer.
9. Connect the power supply to start up the device.

Access Home Assistant

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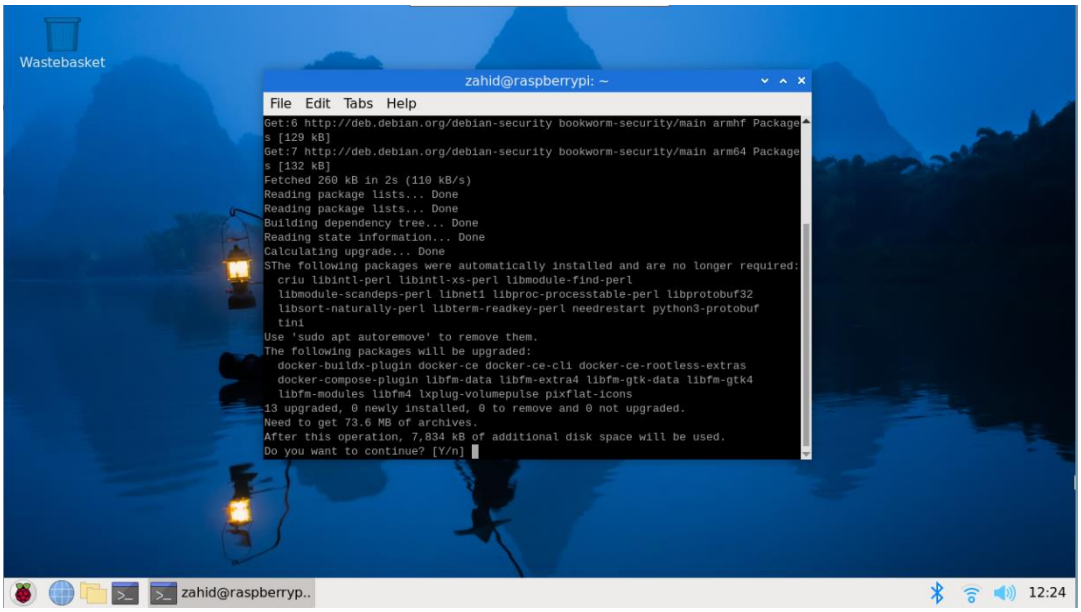
- Try to flash the SD card again, possibly even try a different SD card.
- If this did not help, view the console output on the Raspberry Pi.
- To do this, connect a monitor via HDMI.

Congratulations! You finished the Raspberry Pi setup using Balena Etcher!

Home Assistant Supervised Installation on Raspberry Pi

This is a little bit complicated task. If you have installed the Raspbian OS in your raspberry pi and don't want to uninstall it, then you can follow these steps. Otherwise, I will suggest you install Home Assistant OS on your Raspberry Pi.

1. Prepare the system and update the system and install required dependencies:



Command:

```
sudo apt-get update
sudo apt-get upgrade
sudo apt-get install -y software-properties-common apparmor-utils apt-transport-https avahi-daemon ca-certificates curl dbus jq network-manager
```

2. Add the Docker GPG key and repository

Command:

```
curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /usr/share/keyrings/docker-archive-keyring.gpg
echo "deb [signed-by=/usr/share/keyrings/docker-archive-keyring.gpg] https://download.docker.com/linux/ubuntu $(lsb_release -cs) stable" | sudo tee /etc/apt/sources.list.d/docker.list > /dev/null
```

3. Install Docker and Docker Compose.

   Command:

   ```
   sudo apt-get update
   sudo apt-get install -y docker-ce docker-ce-cli containerd.io docker-compose
   ```

4. Download and run the Home Assistant Supervised installation script.

   Command:

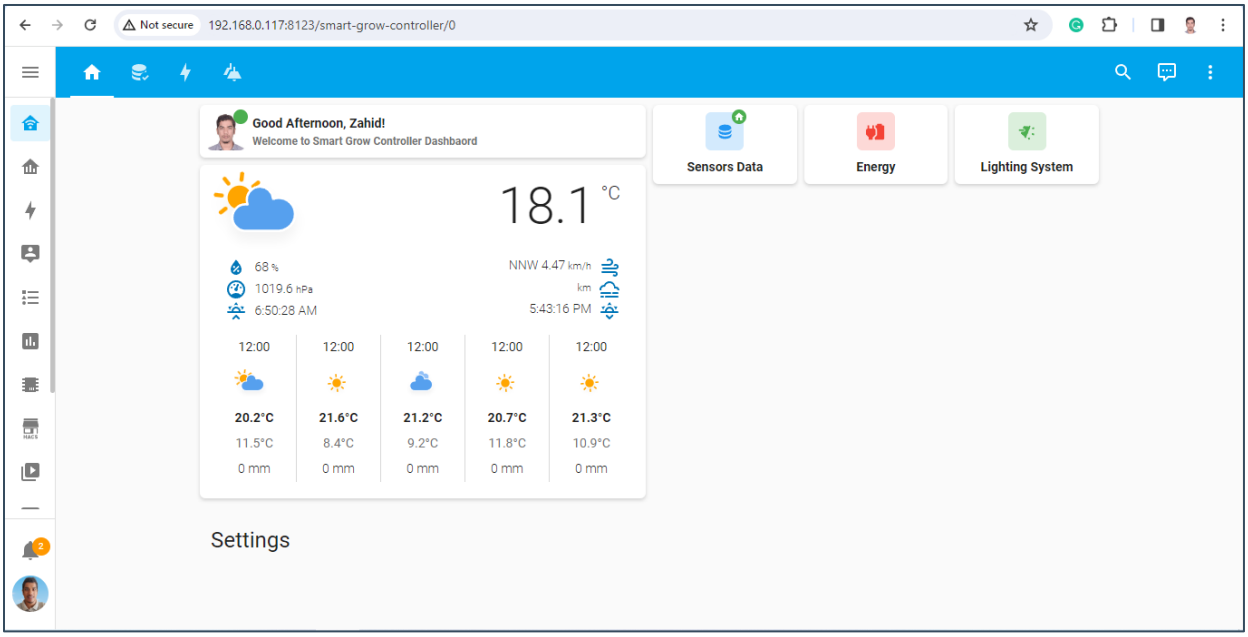
   ```
   sudo -i
   curl -sL "https://raw.githubusercontent.com/home-assistant/supervised-installer/master/installer.sh" | bash -s
   ```

5. Access Home Assistant:
   Once the installation is complete, access Home Assistant by navigating to http://homeassistant.local:8123 in your web browser. And then create an account on your server.

   Congratulations! You finished Home Assistant Supervised installation.

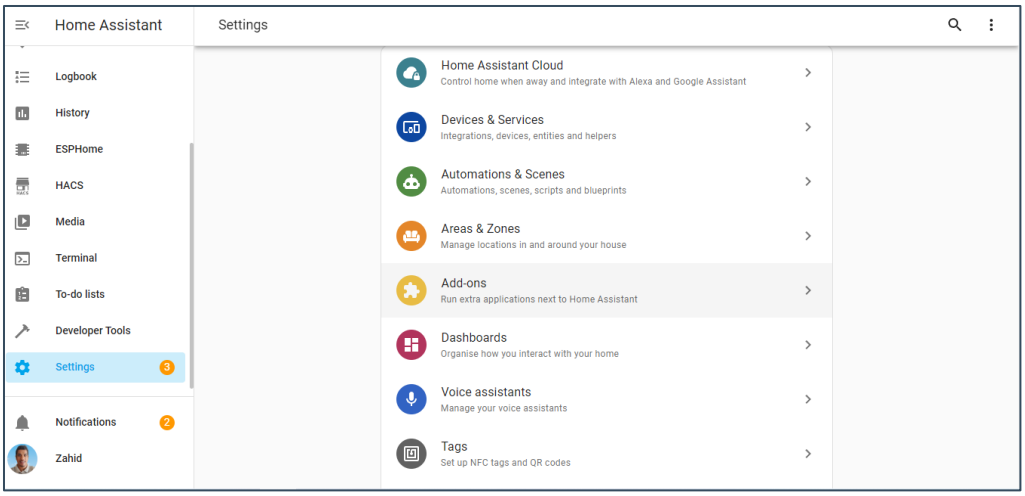
Troubleshoot Note

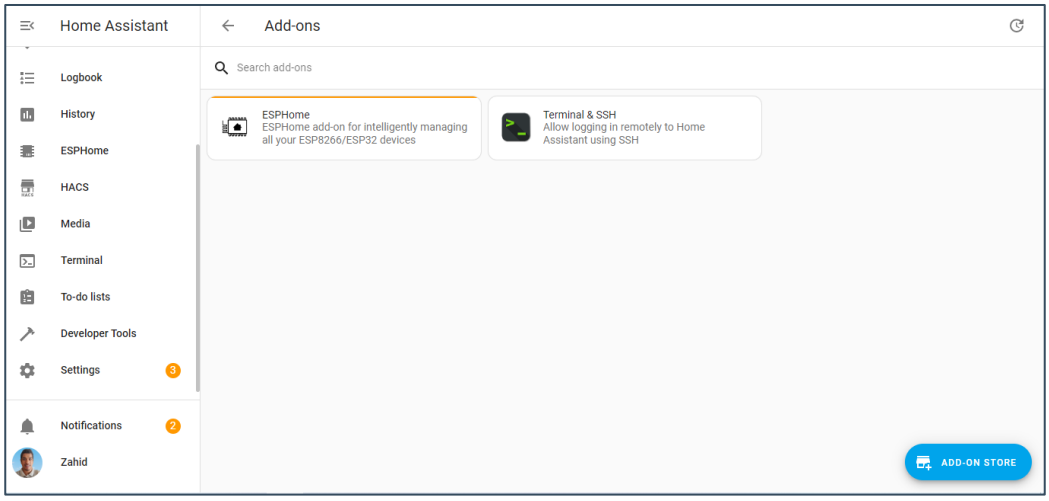
If you encounter issues accessing Home Assistant at http://homeassistant.local:8123, it might be due to various reasons such as network configuration or Bonjour service not working as expected. In such cases, you can find the Raspberry Pi's IP address and access Home Assistant through that. In my case, http://192.168.0.117:8123 where 192.168.0.117 is my raspberry pi address.



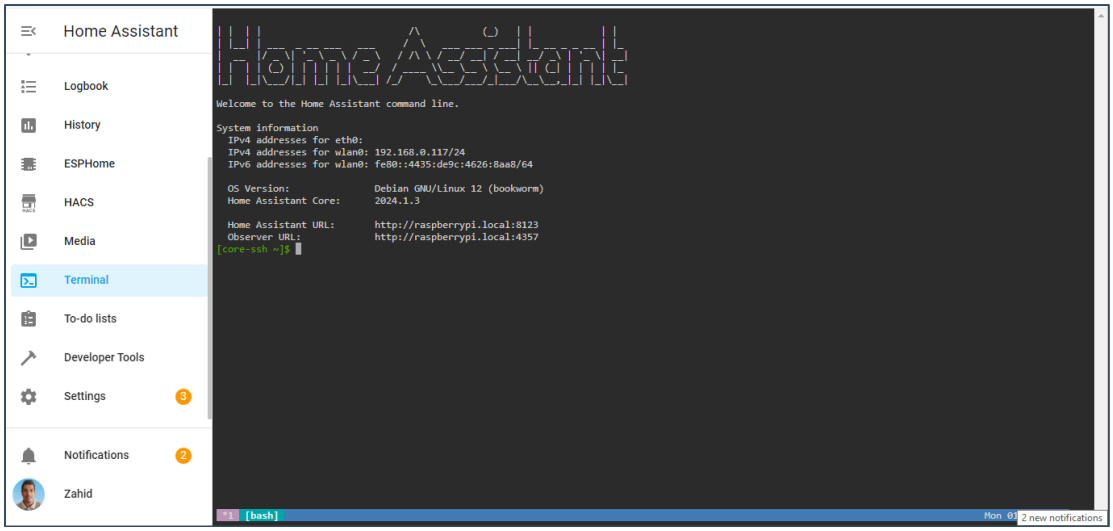
Home Assistant Dashboard Configuration

- **Add New Add-ons**
  To Add new add-ons, go to **Settings > Add-ons > ADD-ON-STORE.** Then, search for **Terminal & SSH** and install it. Similarly, install the **ESPHome**.





- **Home Assistant Community Store (HACS) Configuration**
  - To configure HACS, you may need to restart the Home Assistant and then you will get the **Terminal & SSH** on the left side bar. Now, open it and you will get the following window.



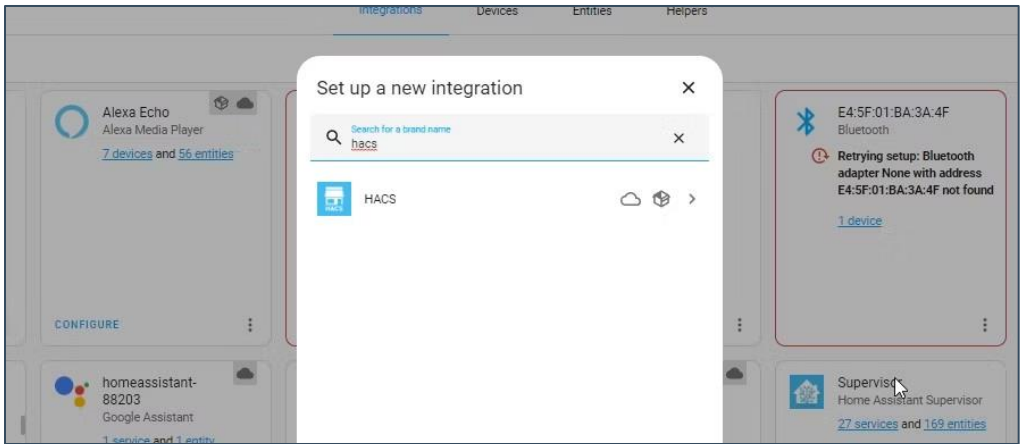
In the terminal window, enter the following commands:

```
cd /config
wget -O - https://get.hacs.xyz | bash -
```

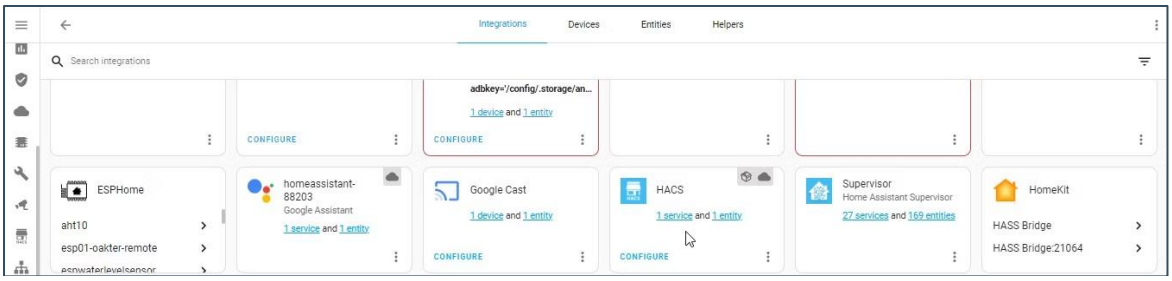
This will download HACS in the config directory.

- Then, Go to **Developer Tools** and click **Restart** to reboot the Home Assistant Server.

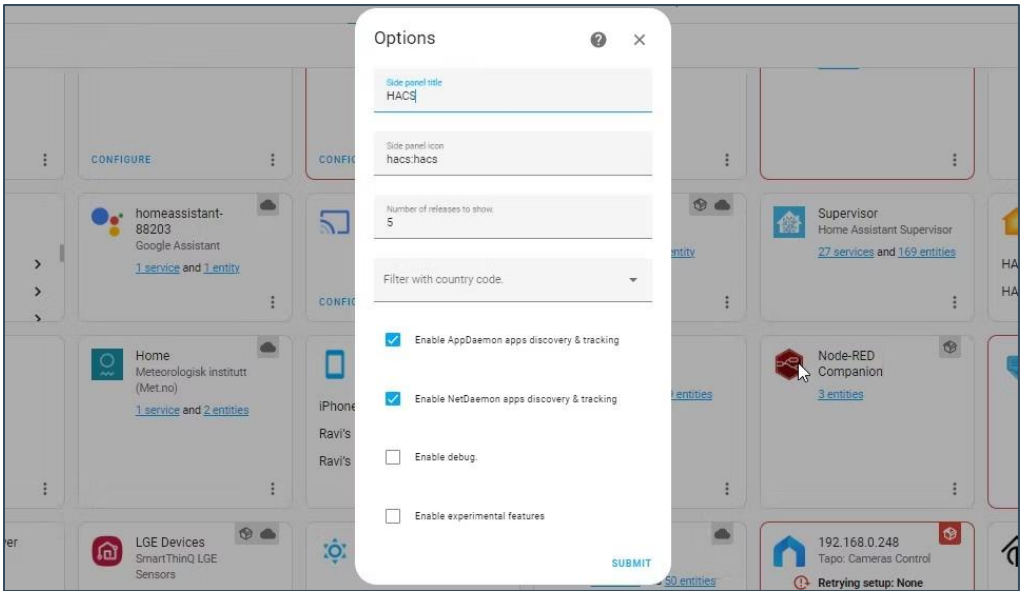
- After the reboot, go to **Settings > Devices & Services** and click the **ADD INTEGRATION** button.
- Search for **HACS** and click on it.



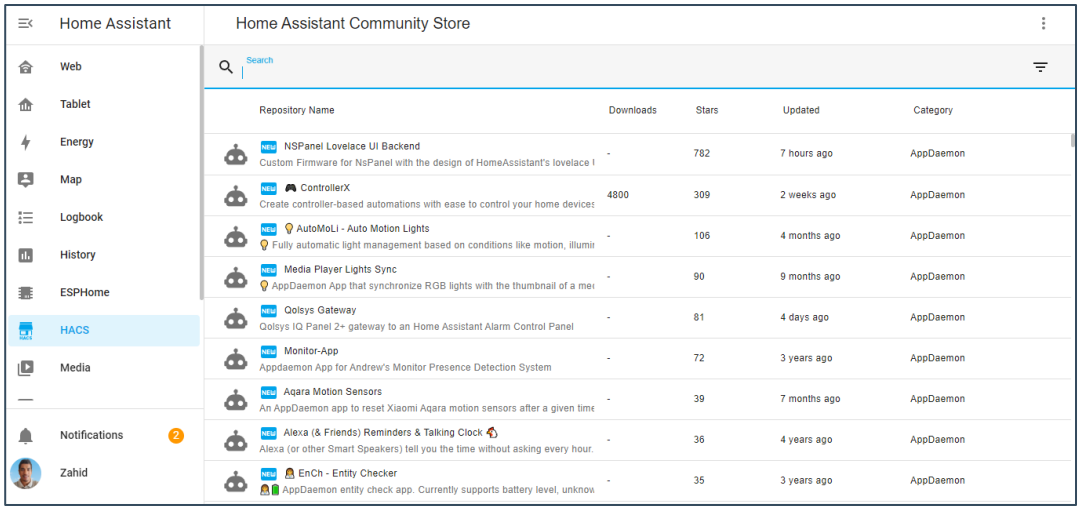
- Check all items and click **Submit**. You will see a URL and a code.
- Click on the displayed URL and sign into your GitHub account to authorize. If you don't have a GitHub account, sign up and then authorize.
- In the next screen, enter the code that was displayed to you in the Home Assistant server.
- Click Authorize HACS.
- Back on your Home Assistant server, click Submit.
- If everything goes well, you will see the Success screen. Choose the room and click Finish.
- In the **Settings > Devices & Services** dashboard, you will see **HACS.**



- Click Options or Configure and then enter a name and a number in the Number of releases to show field.



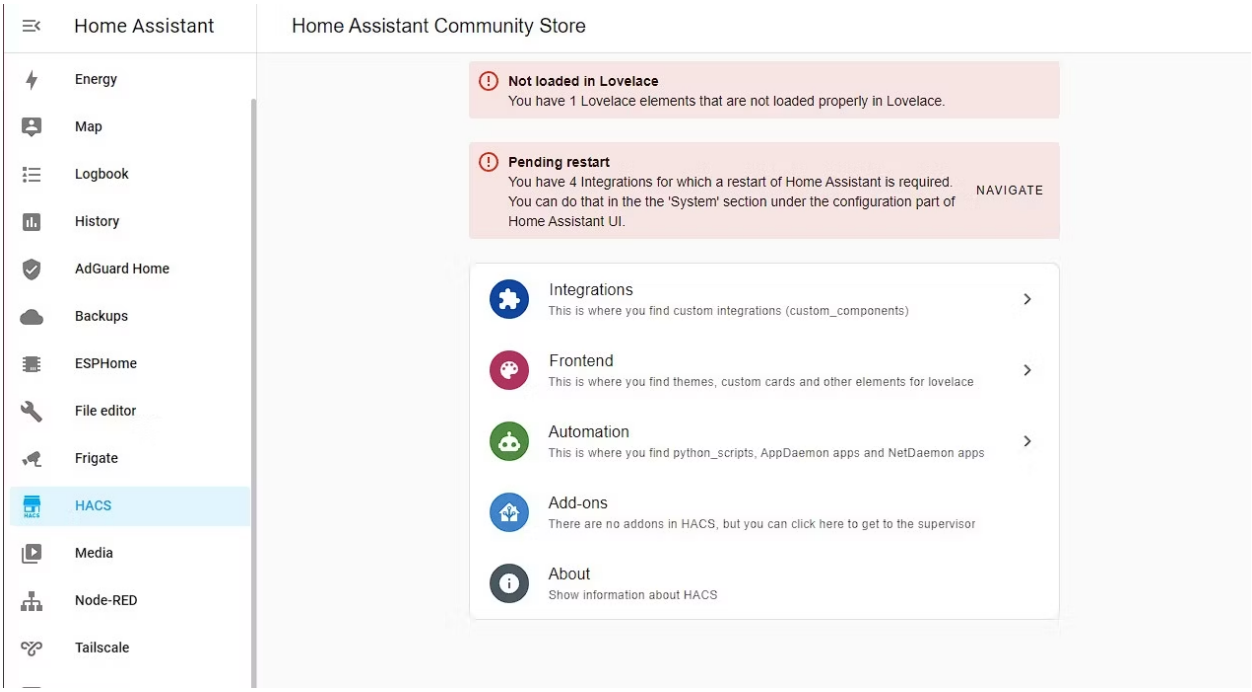
- Enable the **AppDaemon** and **NetDaemon** discovery options and click Submit. And finally, you will get the **HACS**.



Installing Custom Integrations and Themes Using HACS

After installing and configuring HACS successfully on your supervised or non-supervised Home Assistant server, you can use the community store to search for and install custom integrations and themes. The steps are as follows:

- Click on the HACS option in the sidebar and then click on Integrations.



- Click the Explore & Download Repositories button.
- Search for the required integration you want to install.
- Once you've found the required integration you need, click on it and then click the Download button.
- After the integration is downloaded, go to **Developer Tools** and click **Restart**. You need to restart the Home Assistant server for the changes to take effect.
- Similarly, you can click on **HACS > Frontend** to find and install custom themes and cards to customize the look and feel of your Home Assistant dashboard, switches, and entities.

Happy journey with Home Assistant!