Automating Your Lights with Open Source

Combining Open Source Hardware with Free and Open Source Software

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FOSDEM 2018

Agenda

- Home automation and smart lightning
- Open source hardware
- Open source software

The Lightning Bulb

Existing Smart Lightning Solutions

- Philips Hue
- IKEA Tradfri
- TP-Link
- LIFX
- Sylvania Lightify
- FluxSmart Bluetooth
- and many more...

Disadvantages of Existing Solutions

- High price
- Difficult setup and installation
- Additional hardware is often required (remote controls, gateway, etc.)
- Mixing smart lightning systems from different vendors causes issues because they rarely can “talk” to each other
- If the LED stops working you need to replace the whole bulb, without reusing the microcontroller in it
- Not open source
- Difficult or almost impossible for hardware modifications

Modifying Existing Hardware Is Difficult

- **Andreas Spiess** #140 IKEA Tradfri IOT Smart Lighting System Hack

  https://www.youtube.com/watch?v=olxPqiJcUAQ

The Question

How difficult is it to create lightning solution that combines **open source hardware** with free and **open source software**?

Open Source Hardware

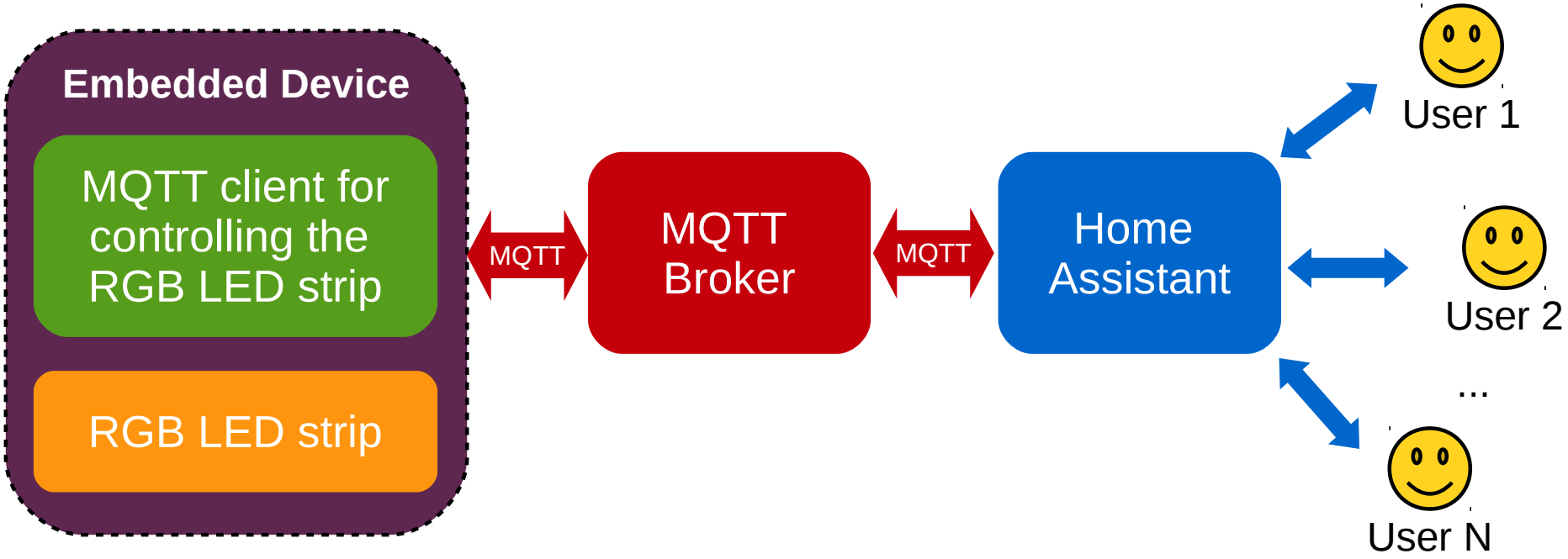
- Design of physical objects that is publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design

- The Open Source Hardware Association (OSHWA) maintains the Open Source Hardware certification

So My Answer is...

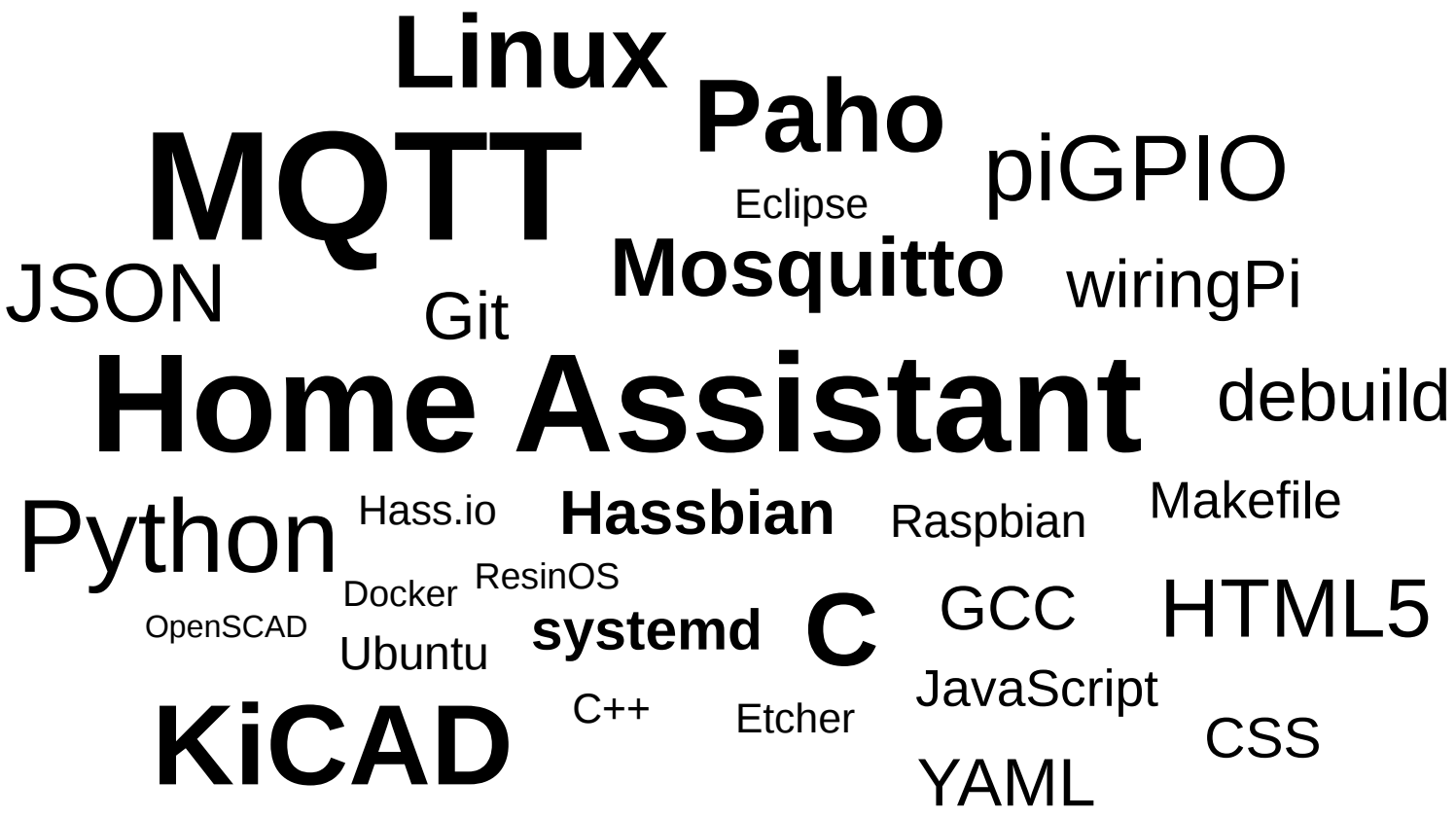
- 12V RGB LED strips
- Open source hardware controllers using Raspberry Pi or ESP8266
- MQTT and Mosquitto
- Home Assistant
- Open source daemon application using Paho and piGPIO

How Does it Work?



It is possible to run the whole setup on a single Raspberry Pi or to split it on several devices

Open Source Technologies

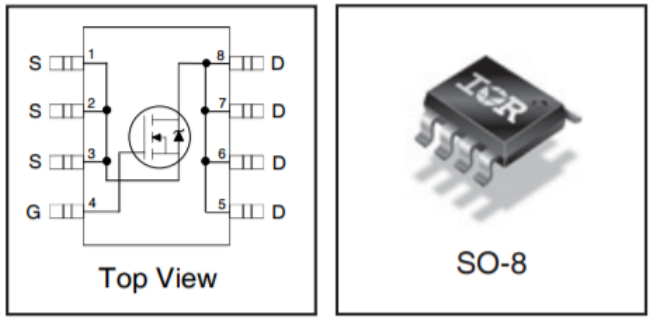


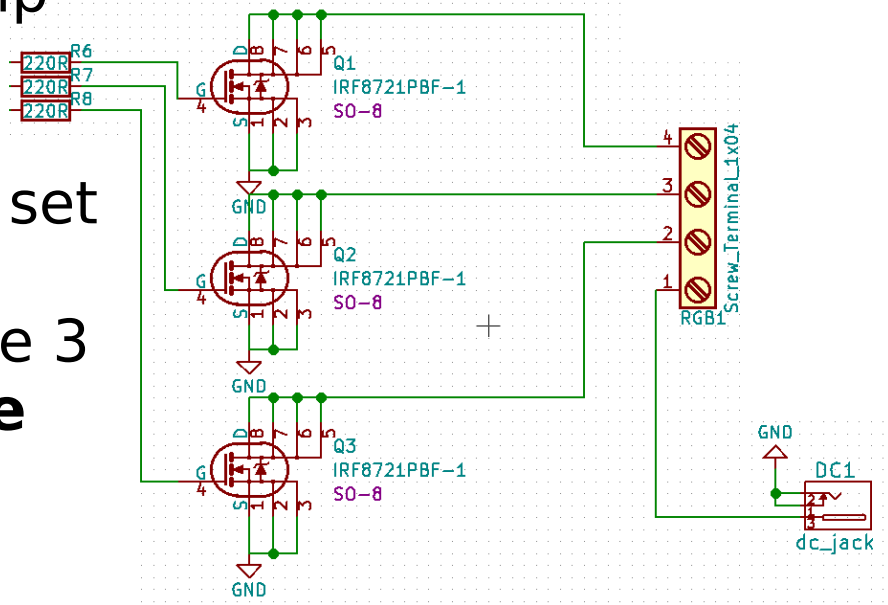
Classification Of LED Strips

- Color (single color or RGB)
- Addressable (different color for each LED)
- Diode Type (3528, 5050, etc)
- Number of diodes per meter
- Voltage (24V, 12V, 5V, etc)
- IP code (International Protection: resistance to dust, waterproof, etc)

Wiring 12V RGB 5050 LED Strip

- 30V Single N-Channel HEXFET Power MOSFET **IRF8721PbF** per each color
- Packed in SO-8 for SMT
- **12V** Power supply for the LED strip
- Pulse-width modulation (PWM) to set a color from 16 777 216 (256^3) possible combinations through the 3 main colors: **red**, **green** and **blue**





Designing PCB with KiCAD EDA

- Free & open source software (GNU GPLv3)
- Cross platform (works on GNU/Linux distributions, MS Windows and Mac OS X)
- Supports PCB with multiple layers and integrated 3D viewer
- Contributions from CERN developers
- Already well adopted by the industry
- Written in C++, source in Git repositories

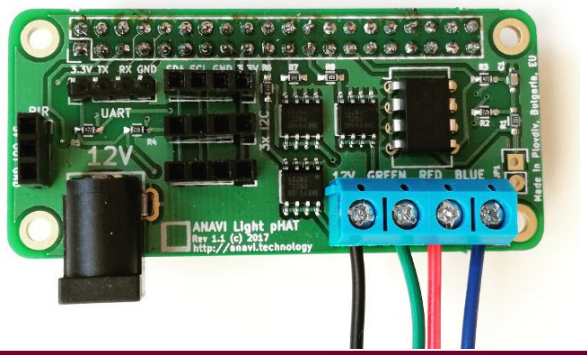
- http://kicad-pcb.org/

ANAVI Light pHAT

- Raspberry Pi add-on board with pHAT form factor (65x30mm)
- 40 pin header compatible with Raspberry Pi B+ and the newer models
- EEPROM with device tree fragment
- Open source hardware (CC BY-SA 4.0 license)

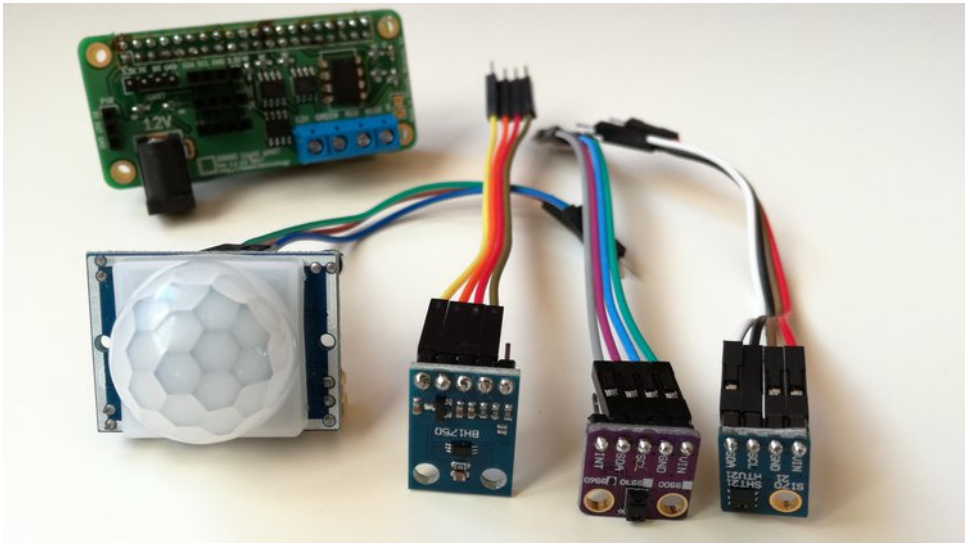
Schematics: https://github.com/AnaviTechnology/anavi-light

https://www.crowdsupply.com/anavi-technology/light-phat



ANAVI Light pHAT & Sensors

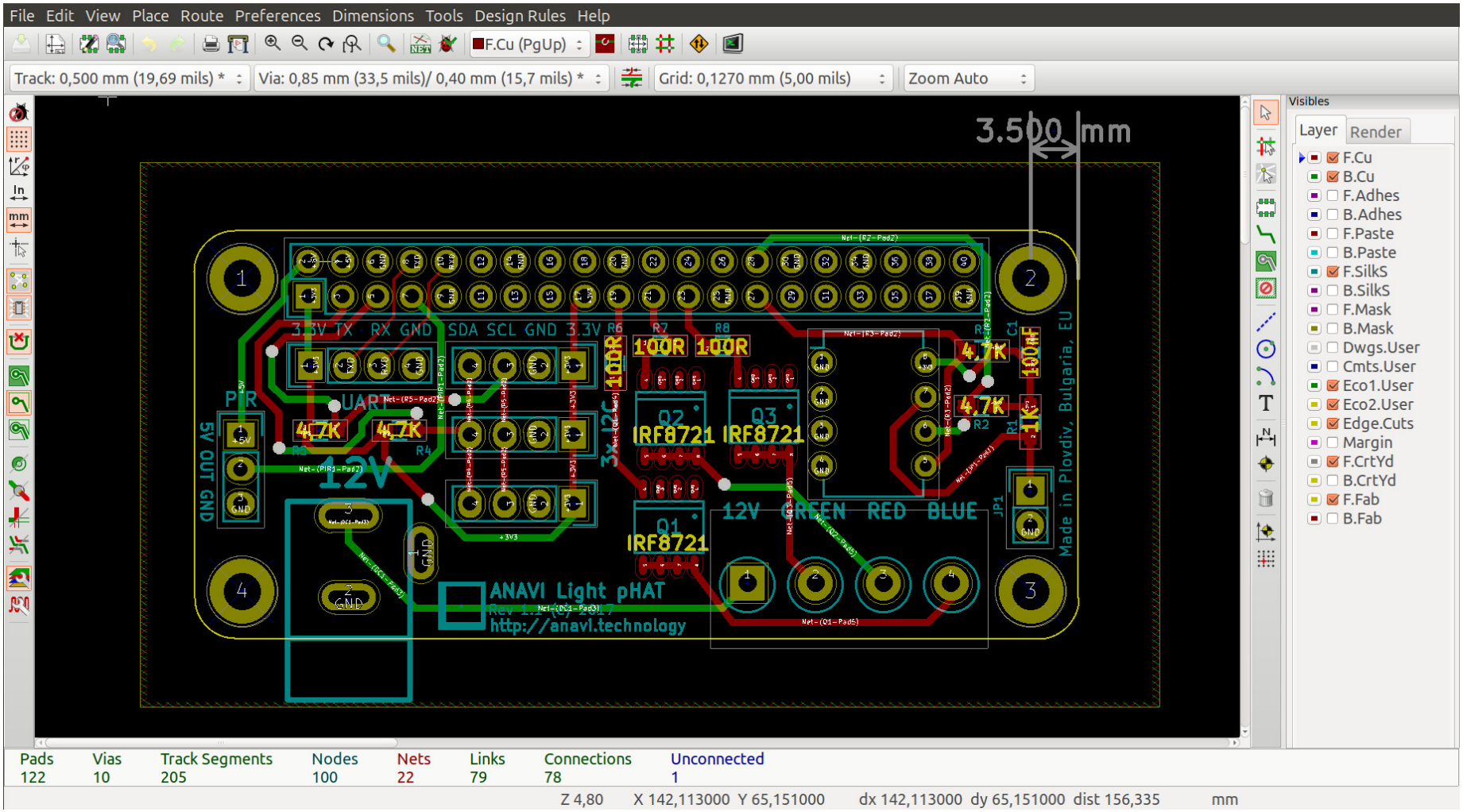
- BH1750 I2C sensor module for ambient light intensity (Lux)
- HTU21D I2C sensor module for temperature and humidity
- APDS-9960 I2C sensor for RGB color and gesture detection
- PIR motion sensor



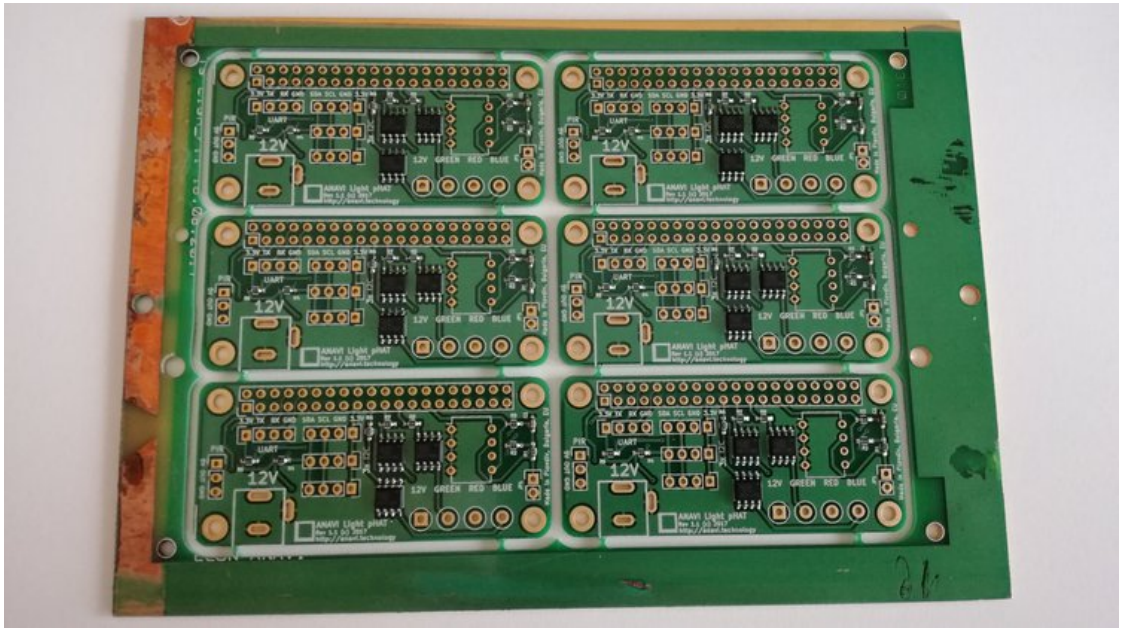
- Examples:

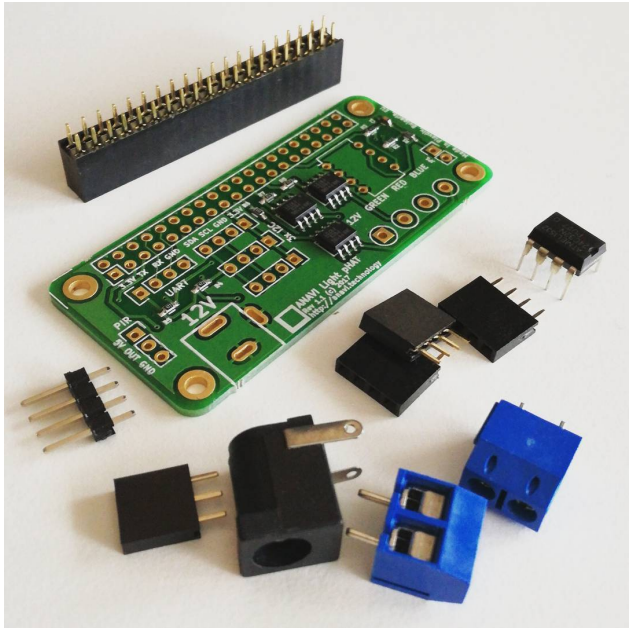
https://github.com/AnaviTechnology/anavi-examples/tree/master/sensors

The PCB for ANAVI Light pHAT in KiCAD



Manufacturing ANAVI Light pHAT

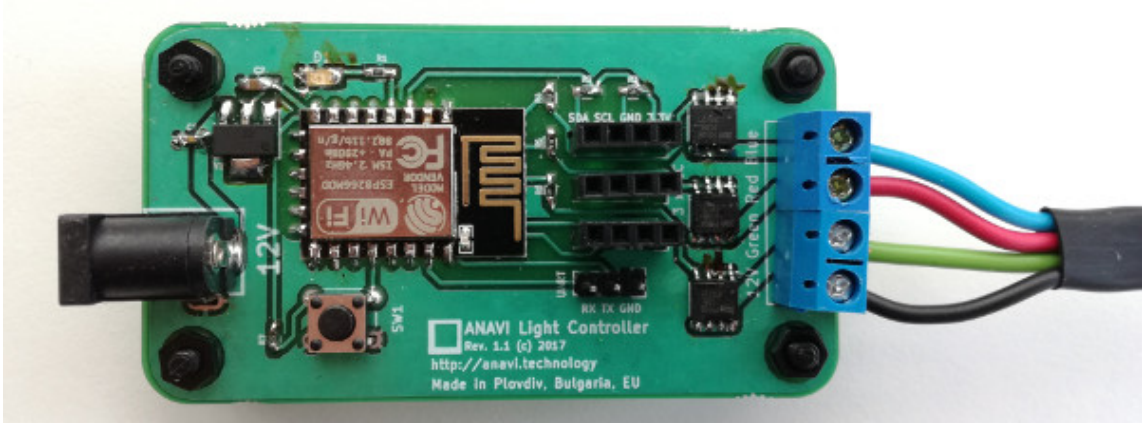




- Panel with printed circuit boards (PCB)
- SMT and THT assembly
- Made in Plovdiv, Bulgaria

ANAVI Light Controller

- Standalone embedded device for controlling 12V RGB LED strip with **ESP8266** WiFi microcontroller (work in progress)
- Software developed thanks to the support for ESP8266 chip in the Arduino environment using libraries WiFiManager, PubSubClient and ArduinoJson



https://github.com/AnaviTechnology/anavi-light-controller

Comparison

	ANAVI Light pHAT	ANAVI Light Controller
12V RGB LED	**Yes**	**Yes**
WiFi	**Yes** (through Raspberry Pi)	**Yes**
Open Source Hardware	**Yes**	**Yes**
Slots for I2C sensors	**3**	**3**
PIR motion sensor	**Yes**	**No**
Stand-alone	**No** (requires Raspberry Pi with 40 pin header)	**Yes** (with built-in ESP8266 module)
Power Supply	**12V 5.5*2.1 DC jack + 5V microUSB** for Raspberry Pi	**12V 5.5*2.1 DC jack**

Home Assistant

- Open-source home automation platform running on Python 3
- Perfect to run on a Raspberry Pi
- More than 950 components for integration with popular Internet of Things such as IKEA Trådfri, Philips Hue, Google Assistant, Alexa / Amazon Echo, Nest, KODI, etc.
- Started in 2013 by Paulus Schoutsen
- Huge community, more than 830 contributors
- Source code available at GitHub under Apache 2.0 license
- https://home-assistant.io/

Home Assistant on Raspberry Pi

A couple of popular options for getting started:

- **Hass.io**

  An operating system based on ResinOS and Docker for running Home Assistant. Started by Pascal Vizeli in 2017. Compatible with Raspberry Pi, Intel NUC or generic Linux servers.

- **Hasspbian**

  GNU/Linux distribution for Raspberry Pi with Home Assistant based on Raspbian that uses the same repositories.

MQTT

- Lightweight publish/subscribe machine-to-machine protocol on top of TCP/IP
- Near real-time communication
- Message broker
- Small source code footprint for embedded devices
- Open source MQTT brokers: Mosquitto, HiveMQ, Mosca, emqttd, etc.

- http://mqtt.org/

Mosquitto

- Open source MQTT broker implemented in the C programming language
- Supports MQTT protocol version 3.1 and 3.1.1
- Available for all popular GNU/Linux distributions, Windows, FreeBSD and Mac
- Easy installation on Hassbian:

```
sudo hassbian-config install mosquitto
```

- Requires an update of configuration.yaml for Home Assistant
- Project of iot.eclipse.com
- https://mosquitto.org/

anavid

- Open source Linux daemon application written in C for controlling ANAVI Light pHAT on Raspberry Pi through MQTT
- Uses **Paho MQTT C** library for implementation of MQTT client
- Uses **PiGPIO** library for PWM control of the RGB LED strip
- Uses **WiringPi** library for retrieving data from the supported I2C sensor modules
- Provides systemd service anavi
- Supports creating of **deb** package using debuild
- Available at GitHub under GNU General Public License v3.0:

  https://github.com/AnaviTechnology/anavid

MQTT JSON Light Component

- Home Assistant component for controlling a MQTT-enabled light that can receive JSON messages

  https://home-assistant.io/components/light.mqtt_json/

- Example configuration for ANAVI Light pHAT, where *YOURMACHINEID* should match **/etc/machine-id**:

```
light:
  - platform: mqtt_json
    name: "ANAVI Light pHAT"
    command_topic: "YOURMACHINEID/action/rgbled"
    brightness: true
    rgb: true
```

Integration with Alexa

- Home assistant is compatible with Alexa and Amazon Echo
- Component **emulated_hue** *"allows Home Assistant to represent non-Philips Hue devices to Amazon Echo as Philips Hue devices, which Amazon Echo can control with built-in support."*

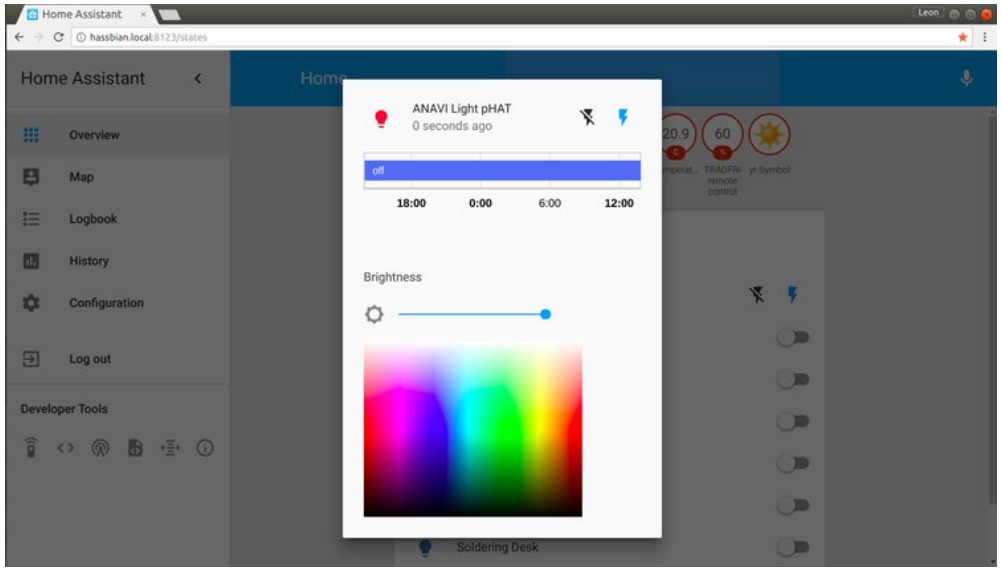
```
emulated_hue:
  type: alexa
  expose_by_default: true
```

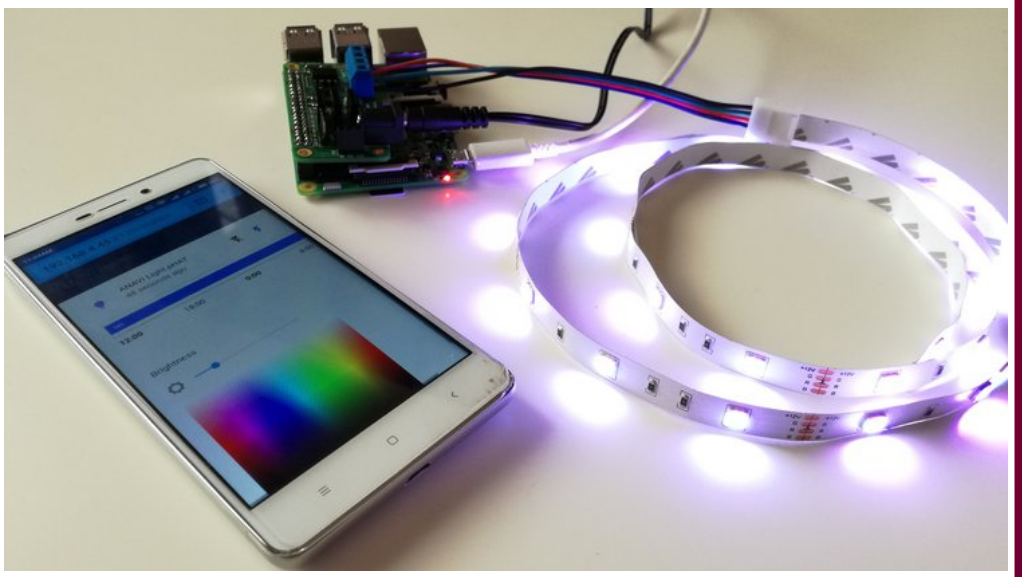
- Example voice command:

```
Alexa, turn on ANAVI Light pHAT
```

The End Result

- Automation of lights using Home Assistant on Raspberry Pi and open source hardware through the MQTT protocol
- User friendly web UI that can be accesses from any modern web browser on smartphone, tablet or a personal computer





Conclusions

- Open source hardware brings value to the community as it allows anyone to study, modify, make and improve the design
- Combining open source hardware with free and open source software for smart lightning is possible but requires some extra technical efforts for integration
- Further efforts are needed to make the proposed open source solution for smart lightning more secure, user-friendly and easy to setup

Thank You!

Useful links:

- https://home-assistant.io/
- http://mqtt.org/
- https://mosquitto.org/
- https://www.eclipse.org/paho/
- https://www.linux.com/news/home-assistant-python-approach-home-automation-video
- https://github.com/AnaviTechnology/
- https://www.crowdsupply.com/anavi-technology/light-phat
- Join “Turning On the Lights with Home Assistant and MQTT” at FOSDEM 2018 Internet of Things devroom for a deep dive in the source code!