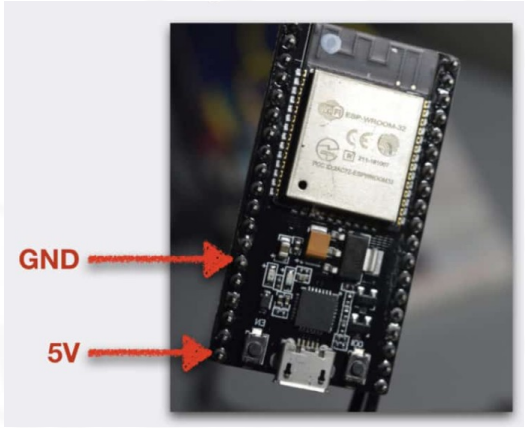
UNIVERSIDAD COMPLUTENSE MADRID

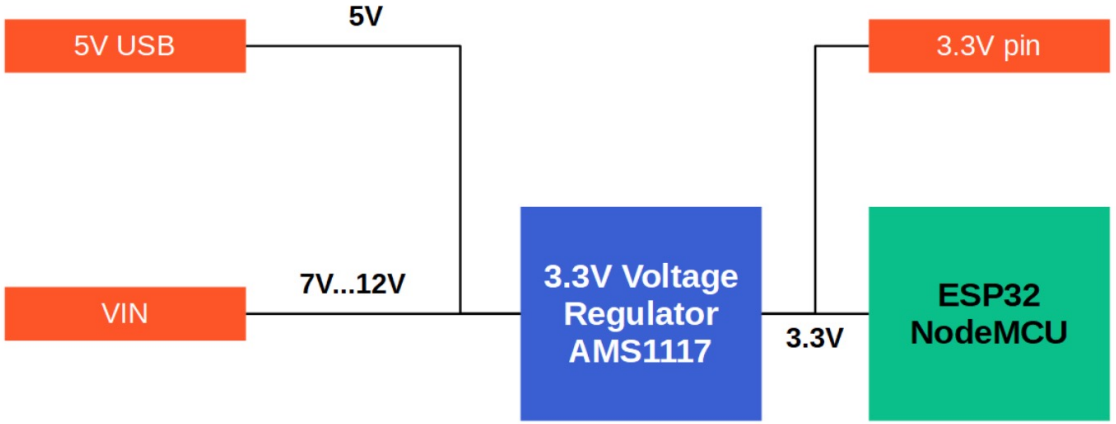
ESP32 power options

IoT node architecture

Power options for ESP32 DevKitC

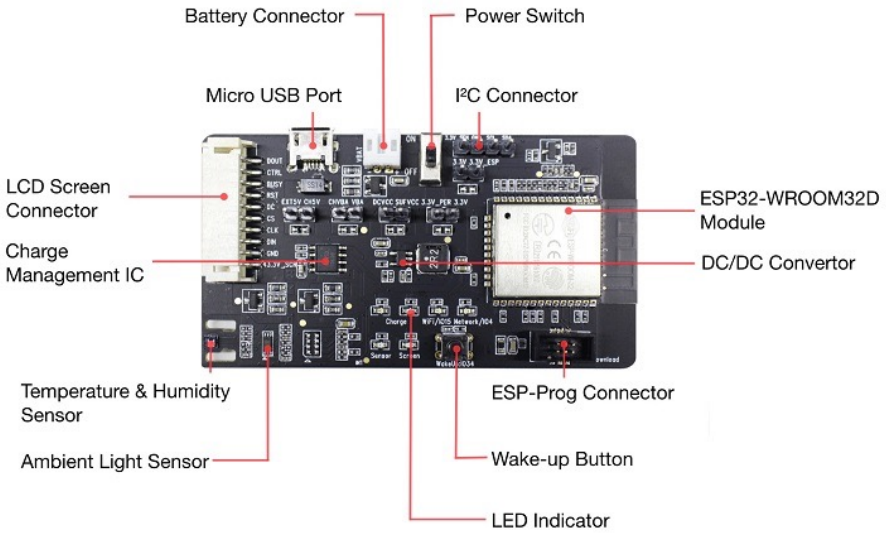
- USB
- Connect an external unregulated power supply to the 5V pin
  - Anything between 5V and 12V should work
    - The AMS1117 voltage regulator in the ESP will transform it to 3.3V
    - It is best to keep voltage below 7V to avoid loosing too much power and increase heat
- Connect an external **regulated** power supply to the 3.3V pin
  - **BEWARE**: you are bypassing the LDO
- IMPORTANT: only use one of the options at the same time

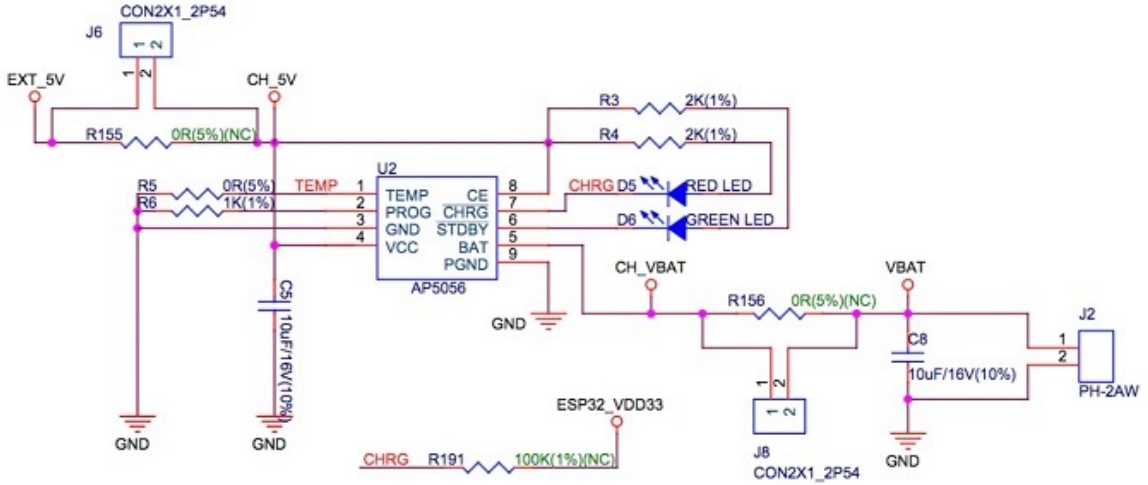


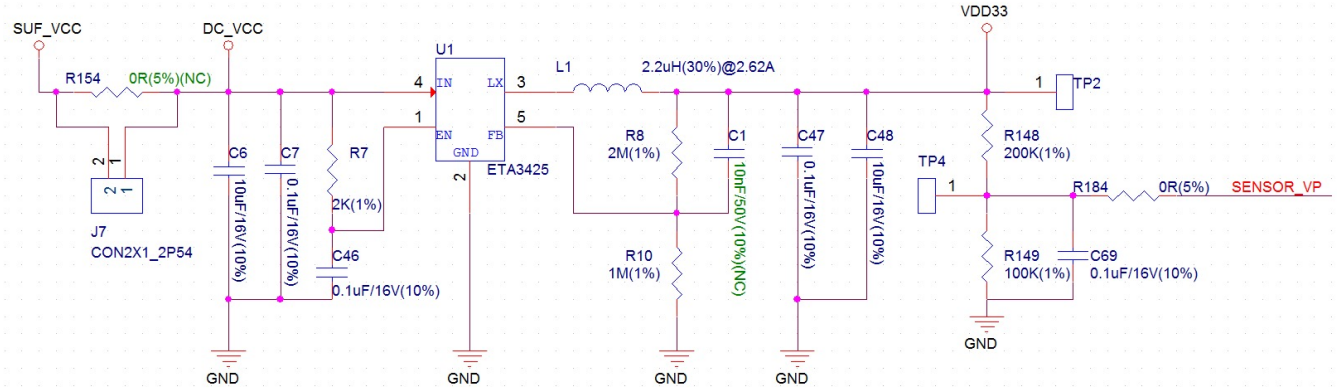


https://techexplorations.com/guides/esp32/begin/power/
https://diyi0t.com/esp32-tutorial-what-do-you-have-to-know-about-the-esp32-microcontroller/

ESP MeshKit Sense



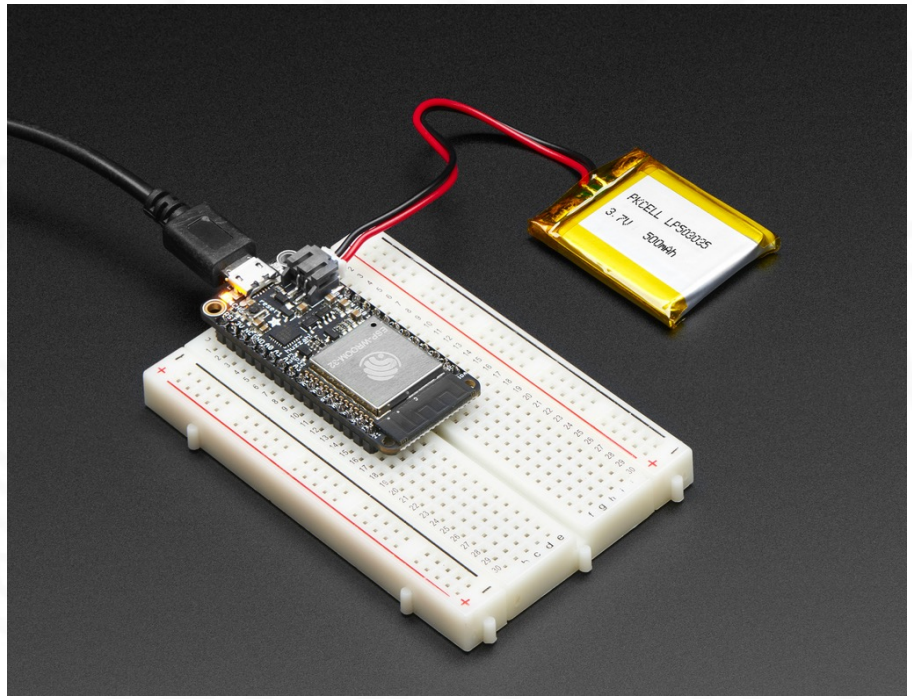




Notes:
1.Vout=1.13*(1+R1/R2)=3.39V;
R2 is recommended to be 1M ohm for low standby current.

Other boards with ESP32

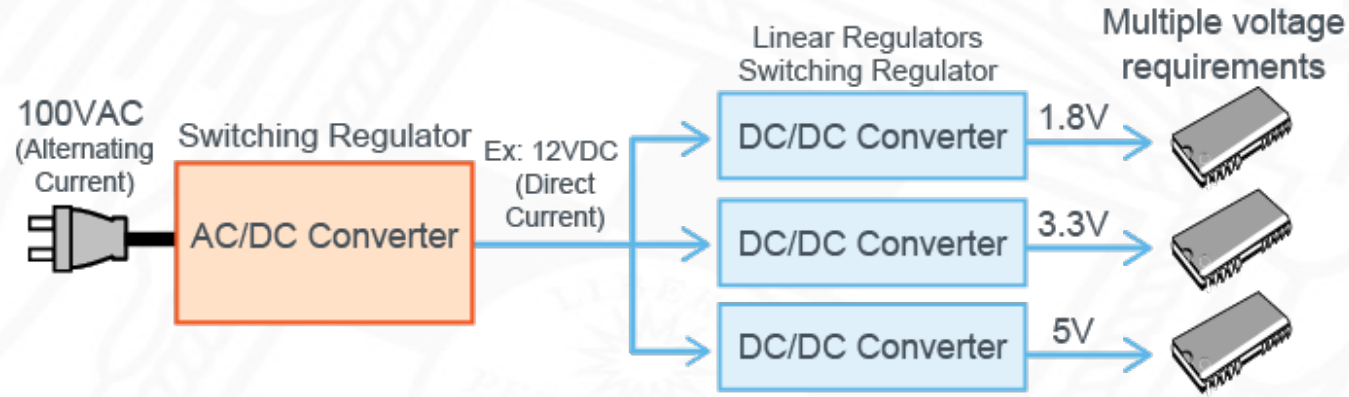
- Example *Adafruit Feather HUZZAH32*
  - It has a JST jack to connect LiPo batteries
    - 4.2/3.7V Lithium Polymer (Lipo/Lipoly) or Lithium Ion (LiIon)
  - It is powered using USB, if one is connected, and the battery starts charging if the source provides at least 200mA
  - Pin for battery monitoring
    - LiPoly is at 3.7V most of the time
    - It slowly decreases to 3.2V before the protection circuitry cuts it off
- Other alternatives with JST jack:
  - Sparkfun ESP32 Thing Plus, WEMOS LOLIN32, FireBeetle ESP32….



https://learn.adafruit.com/adafruit-huzzah32-esp32-feather/power-management

Voltage regulators

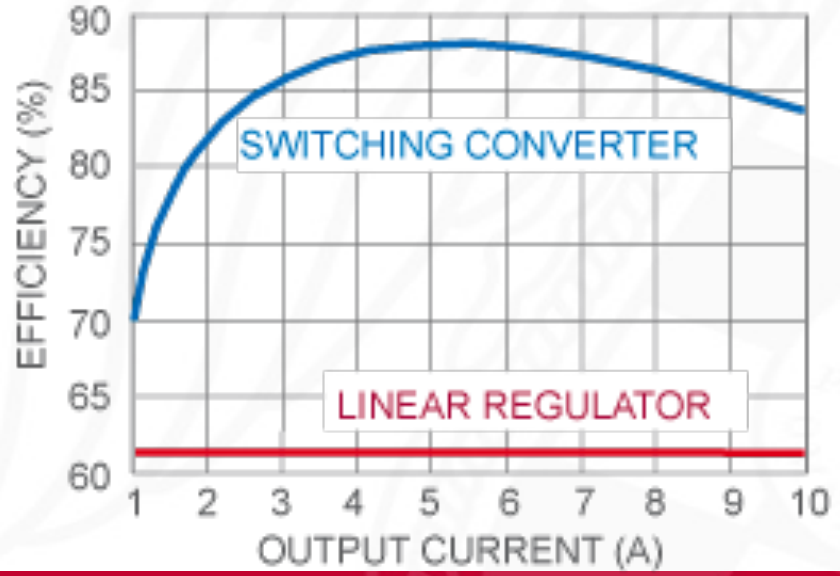
- Linear – LDO (*low dropout*)
  - A variable resistance that depends on the load is used to regulate the output voltage (OpAmp)
  - Vin >= Vout + *dropout* (*Buck but not Boost*)
- Switching
  - Fast switching (on-off) of an element is used to regulate voltage
  - It is made up of a transformer, a filter and DC conversion
  - *Buck, Boost, Buck-Boost*

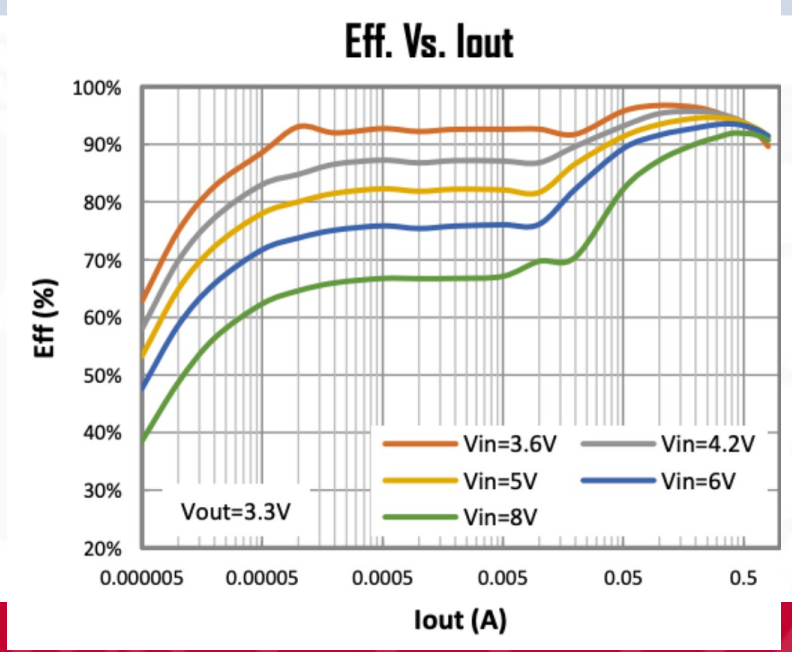


https://www.renesas.com/us/en/products/power-management/linear-vs-switching-regulators.html
https://www.rohm.com/electronics-basics/dc-dc-converters/what-is-dc-dc-converter

Voltage regulators

	Linear Regulator	Switching Regulator
Funcionality	Buck	Buck, Boost, Buck-Boost
Efficiency	Medium (30%-70%). Better for low Vin-Vout	High (60%-95%)
Complexity	Low	Medium to high
Size	Small. Larger at high power	Smaller than LDO at high power
Cost	Low	Medium to high
Noise	Low	Medium to high
Vin Range	Narrow	Wide





What batteries can be used?

- ESP32 has a nominal voltaje of 3.3V, it can operate between 2.3V and 3.6V
  - Upto 300mA peak
  - More than 150mA when WiFi is used
- AA alkaline batteries
  - Nominal voltage 1.5 V (minimum 1V ; maximum 1.65V)
    - 2 batteries connected in series provide 3V
    - But voltage decreases to 1V as charge decreases
  - Number of recharges: ~500
  - *Energy density:* 80Wh /kg
  - Maximum current provided: 50mA
  - ESP32 needs more than 100mA at some points
  - **It is NOT possible to** power ESP32 using 2 alkaline batteries

https://diyi0t.com/best-battery-for-esp32-nodemcu/
https://www.radioshuttle.de/en/media-en/tech-infos-en/battery-powered-esp32/

What batteries can be used?

- AAA NiMH batteries
  - Nominal voltage 1.2V – 1.25V (maximum 1.4V - minimum 0.8V)
    - 4 batteries connected in series provide 4.8V-5V
    - They can be used in combination with an LDO to reduce voltage
  - Number of recharges: ~1000
  - *Energy density:* 60 - 120 Wh/kg
  - Conclusion: **not a good choice**
- Lithium batteries
  - Nominal voltaje 1.5V (2 in series are needed) or 3V (CR123)
  - Voltage is kept quite constant (2.7V when only 10% of capacity is left)
  - High short-term answer (needed for WiFi)
  - Non chargable
  - Very low self-discharge and very good temperature range
  - Varta CR123 (3V, 1700mAh) can last for 5 years if the WiFi/Bluetooth are used moderately
  - Conclusion: **a very good choice**

What batteries can be used?

- LiPo (Lithium Polymer) and Li-ion batteries
  - Nominal voltage 3.7V (maximum 4.2V ; minimum 2.7V – 3.0V)
  - Number of recharges: ~5000
  - Energy density: 100 Wh/kg – 265 Wh/kg
  - It needs an regulator to reduce voltage
    - LDO can consume 2000 more than ESP32 in *deep sleep*
  - It can be charged while ESP32 is running
    - Charging circuit is simple
    - An external power source is needed: USB, solar panel...
  - It can work for a day (or a few days) without being charged
  - Very strict temperature ranges for function and charge
    - Danger of fire/explosion
  - Conclusion: **very good choice** jointly with and external power source

What batteries can be used?

- LiFePO4 Battery (lithium iron phosphate)
  - Nominal voltage: 3.0V – 3.2V (maximum 3.65V – minimum 2.5V)
  - Number of recharges: ~5000
  - Energy density: 90WH/kg – 160 WH/kg
  - Very flat discharging curve: the voltaje drops slowly
  - It is very complicated to charge while in use
  - It provides 70% less enery tan a similar Lithium battery
  - Conclusion: **very suitable** for short-term operation (weeks-months), directly connected to the 3.3V pin
- USB *power bank*
  - It internally uses a 3.7V lithium battery
  - Then, it transforms the voltaje to 5V (with loss)
  - Finally, the regulator in the ESP32 reduces it again to 3.3V (with loss)
  - Some *power banks* switch off automatically when they don´t detect the load
    - It can occur in low power mode
  - Conclusion: **not a good choice** for a device