# Robot electrical design

- Batteries
- Motors
- Electronics

# What Makes Up a Robot's Electrical System?

Battery and Battery Management System BMS (It’s going to be Lithium)

Power conversion (Switching or linear)

Battery charging (On or Off robot)

Main Processor (PC-like or microcontroller)

Motor Controllers / Motors (Small to large, brushless or brushed)

Sensors (What a variety we have to choose from)

Communication systems (WiFi, Bluetooth, Other RF)

# Choosing a battery voltage

Common Robot Voltages

3.3 V → Processors & small IC-type sensors

5 V → Small motor controllers and larger sensors like LIDAR

12 V → Medium motor controllers and solenoid-based grippers

24 V → Large motor controllers

48 V → High-power servo-based motor controllers

# Choosing a battery voltage

Pick a battery voltage that is compatible with your high-power loads.

- If you have 12 Volt motors, pick a 12 Volt main battery so you don’t have to convert the voltage for your high-power load.
- It’s more efficient to convert to a lower voltage than to a higher voltage.
- Higher battery voltage requires less current for a given load.
- Lower current can use smaller wire, smaller connectors  and has less loss due to resistance.

# Choosing a battery

Lithium. That’s your choice.

Li-ion vs. Li-polymer

- Li-Ion: Rigid cells with a liquid electrolyte
  - Heavier but more durable.
  - Better for long-term continuous use.
  - Might catch on fire.
- Li-Po: Flat somewhat flexible packs with a gel electrolyte
  - Lighter but more fragile.
  - Probably need to design in a battery protection mechanical system.
  - Higher discharge during storage.

# Battery management system

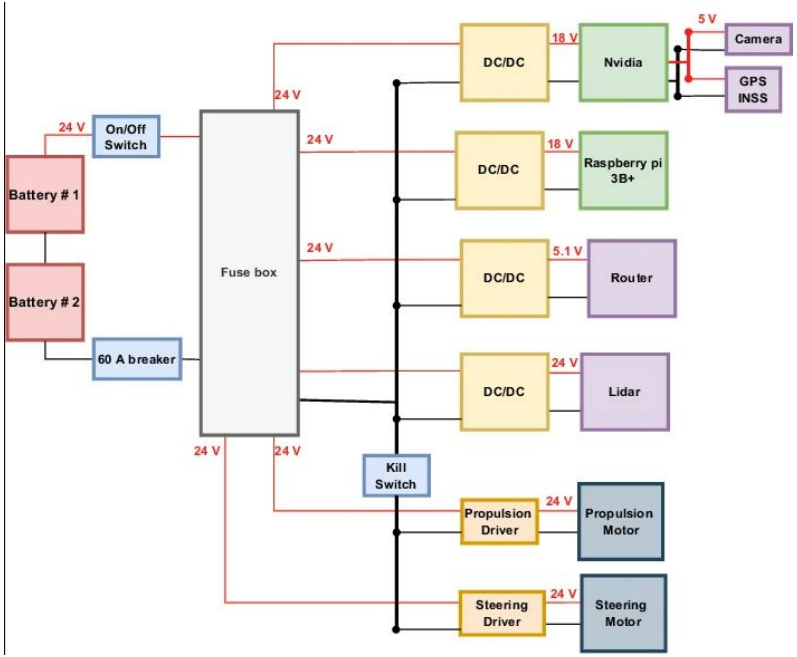
Functions built into the battery:

- Prevent over discharge. Disconnects battery if any one cell gets too low.
- Prevent over charging. Disconnects battery when it’s charged 100%.
- Overcurrent disconnection.

Functions that can be built in or offboard:

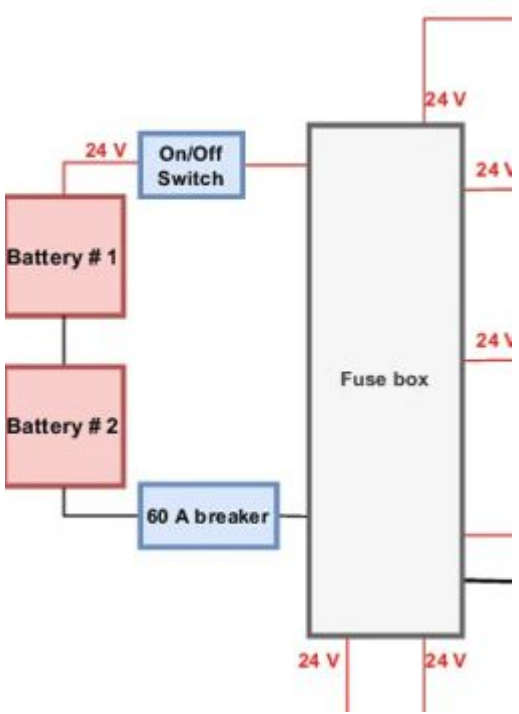
- Balance cells in series during charging.
    - Built in has some weight and space costs.
    - Offboard requires many connections from the battery to the charger.

# Voltage conversion and control



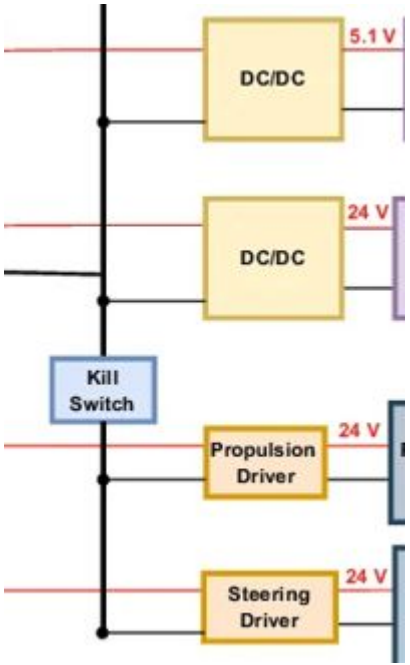
# Batteries and fuses

- One or more batteries in series with a switch.
- Some kind of overcurrent protection.
- Switch might be a “soft” switch controlled by a processor.
  - This allows the processor to shutdown an OS before disconnecting the battery.



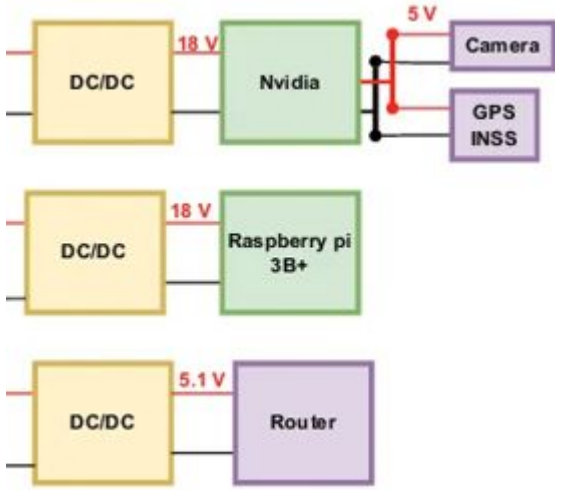
# Voltage converters

- Individual DC:DC converters per voltage
- Mechanical switch to shut off dangerous motion devices.
- Common ground on the input, separate grounds output.
- Common grounds on output are necessary between devices that communicate with each other.
- It’s great when they have an enable line and can be disabled by the main processor to save power.



# Voltage converters

- DC:DC converters can be put in series to produce multiple voltages.
- For most robots with lower voltage batteries, DC:DC converters are connected to the battery voltage and are not connected in series.




- Do as few voltage conversions as possible.

# Motor types

- Brushed DC
  - Simple, common, inexpensive motor controller
  - Makes electrical noise that can bother sensors
- Brushless DC (BLDC)
  - More compact compared to a Brushed DC motor of the same power
  - More complex driver
  - Quiet both electrically and sound
  - More expensive
- Stepper
  - Easiest driver. Simple positional control (Requires processor/software/firmware)
  - Very inexpensive
  - HUGE variety

# Motor types

- Linear via threaded rod
  - VERY high force
  - Easy to control if the motor is Brushed DC
  - Easy to damage things or the actuator itself.
- “Hobby” servo
  - Extremely easy positional control from software
  - HUGE variety
  - Great mechanical mounting options for servo unit and output.
- “True” servo
  - Can be very high performance. High speed, accurate positioning, high loads
  - Much more complex controller. Generally a separate unit taking instructions from a processor.

# What’s typical in Robots?

Educational  3.7–12 V • drycell • MCU • DC motors

Mobile  12–24 V • Li-ion • Motor controllers

Drone  LiPo • BLDC • ESCs

Robotic Arm  24–48 V • Servo/BLDC

Autonomous vehicles  24–48 V • BLDC/servo

Large Robot  48 V • High-current systems

# Other electronics

- Processor
  - Microcontrollers. Cheap, low power, dedicated to a function, turn on and off at will.
  - Arduino. Cheap, low power, multifunction, TONS of examples, turn on and off.
  - ESP32. Inexpensive, moderate power, very capable, lots of examples Wifi/BLE.
  - Raspberry PI. More expensive, multifunction, OS, should be properly shutdown.
  - Beagleboard. Higher performance but like the Raspberry PI.
  - Nvidia Jetson. Very high capability, high power, complex, should be properly shutdown
  - PC-style compact motherboards. Can be operated remotely using VNC.
  - Laptops. All-in-one solution.

# Sensors

Yeah, there are a lot.

- Consider the voltage and power required.
- Consider the communications interface requirements.
  - Serial bus
  - Ethernet
  - I2C
  - SPI
  - Digital signals
  - Analog
- Consider the processing requirements.

# References


Beagle: https://www.beagleboard.org/boards

VERY small arduino-like: https://tinycircuits.com/

LiPo vs. LiIon:
https://www.ufinebattery.com/blog/lithium-ion-vs-lithium-polymer-battery/

Brushed vs. Brushless:
https://www.smashingrobotics.com/brushed-vs-brushless-motors-in-robotics/

Power: https://www.dfrobot.com/category-70.html

# References:

Robot power systems:
https://www.robocloudhub.tech/learn/blog/power-systems-robotics