1 Power Section

The board can be directly supplied from any 3.3Vdc/500mA source. There's also some optional sections to efficiently interface with a protected single cell Li+ battery and most bicycle dynamos. Here's a flowchart:

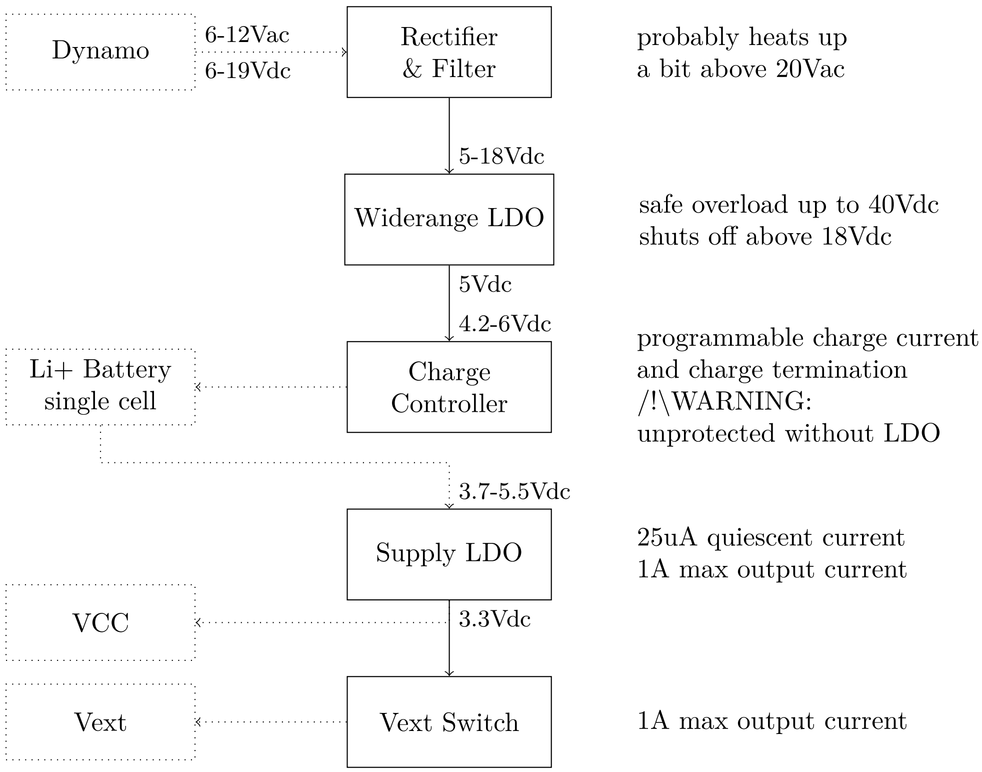

Figure 1: Dependency Flowchart

1.1 Rectifier & Filter

Due to space limitations, there is no filter coil, but the inductance of the dynamo itself should suffice to provide reasonably low ripple at average driving speed. By adjusting the charge current of the charge controller ripple can be further reduced if necessary. A 22V Zener clamps with a reasonable safety ratio to the 35V electrolyte. The rectifier pads can be soldered together pairwise to allow for 5-18Vdc at the Dynamo header if ac is not needed, with the header row labelled '1' serving as positive supply and '2' as ground.

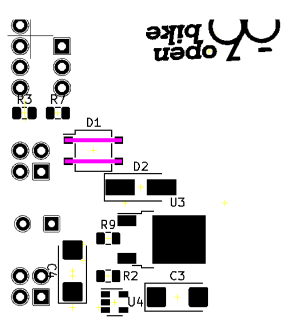

Figure 2: Bridged Rectifier

BOM: D1, D2, C2, Charge Controller and Widerange LDO section

1.2 Widerange LDO

When overvolted, the charge controller would probably in return overvolt the battery, which is generally considered a messy thing. The widerange LDO can deal with inputs up to 40Vdc, although it shuts down at 18Vdc. Max current 500mA, supply current 500uA, 0.45V dropout. It's prudent to use the input stabilization and protection even when the board is configured for dc only.

BOM: U3, D2, C2, Charge Controller section

1.3 Charge Controller

The charge controller takes anything between Vbatt+0.3V to 6V and charges a single cell Li+ battery in constant current mode for Vbatt<4.2V, then switches to constant voltage mode and finally terminates the charge when the charge current drops to prolong the lifetime of the battery.
The charge current during the constant current phase, the preconditioning current and the charge termination current can be programmed in tandem with R2:

$$I_{charge} \propto R_2^{-1}$$
$$I_{charge}^{max}/R_2^{min} = 500mA/2k$$

$$I_{charge}^{stock}/R_2^{stock} = 100mA/10k$$
$$I_{termination}/I_{charge} = 0.05$$
$$I_{preconditioning}/I_{charge} = 0.1$$

/!\WARNING: If a voltage above 6V is applied the internal controller is somewhat undefined and might let more through then you might want on a Li+, so be really sure your source is safe. If you want additional protection, look into the next section.

BOM: C4,R2,C3,U4

1.4 Supply LDO

The digital section has a single 3.3Vdc power supply. If 3.3V are externally supplied via the VCC header, R3, R7 and U5 should be omitted. The input of the LDO should never be below the output by more than 0.3V or damage to the regulator can occur.

/!\WARNING: Do not connect an external supply while a battery is connected. Unregulated reverse current into a Li+battery is bad. Also note that there is no undervoltage protection for the battery, so do not use unprotected batteries.

Module	Quiescent Current
Supply LDO	25uA
Voltage Dividers + Comparator	1uA
Vext Switch	1uA
ESP32 (Deep Sleep)	5uA
MPU9250 (Sleep)	8uA
RFM95W (Deep Sleep)	1uA
total	41uA

Figure 3: Sleep Depth

BOM: C4, U5

1.5 Vext Switch

This can be used to switch off power hungry external modules during sleep. If the inrush current is too high for the supply to handle, adding a small (~1-10nF) capacitor as C1 may help against ESP32 brownouts.

BOM: R1, R5, C1, Q1

2 Interfaces

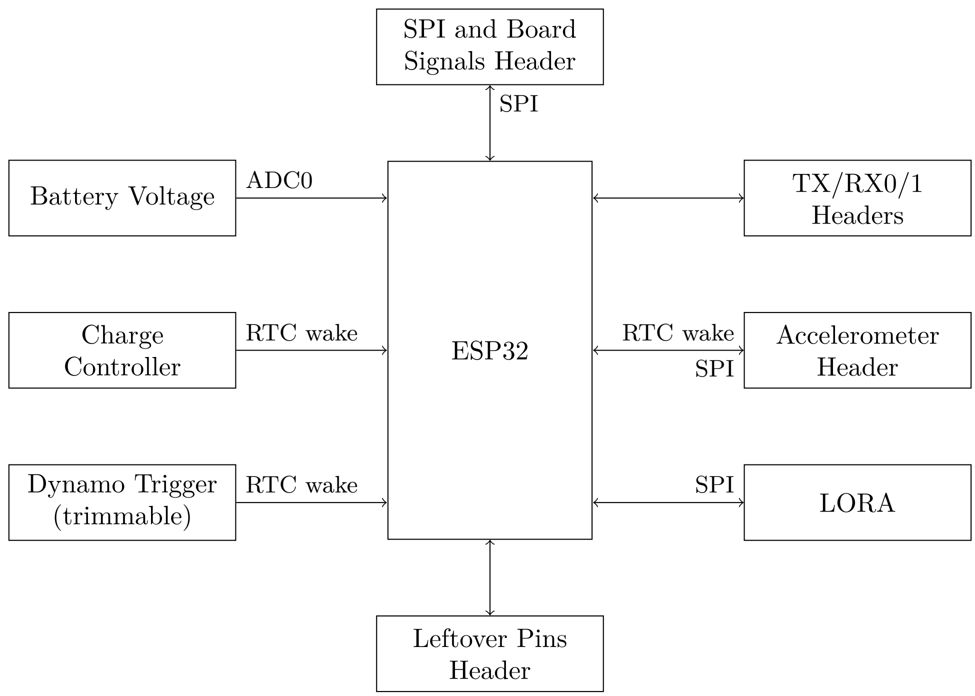

Figure 4: Interfaces

2.1 Battery Voltage

The battery voltage can be read via a voltage divider on the ADC0 bank. The 1/10 voltage divider sacrifices resolution for reduced current draw. Note that the ESP32 ADCs are not very linear, and also that the ADC1 bank does not work if wifi is enabled.

BOM: R3, R7, Supply LDO section

2.2 Charge and Dynamo Wakeup

The charge controller can send its charge state to the ESP32 with a single resistor. Additionally, a trimmable comparator can detect lower voltages at the input of the wide range LDO and send a wakeup signal on slight movement. The trim range by default is 0-7.35V, when a lower range is desired for better adjustment R6 can be increased to 470k for a range of 0-1V.

BOM Charge: R9, Charge Controller section
BOM Dynamo: R8, R6 ,R10, R11, RV1, D3, U6, Charge Controller and Widerange LDO section

2.3 Accelerometer Header

There's a common cheap prototyping board for the MPU 9250 that can be directly installed here.

2.4 Leftover Pins Header

This header exposes all the unused pins. Please note that some of them have special properties such as blocking the boot process or accessing the onboard flash. Consult the datasheet or look online for explanations if undesired side effects occur.

2.5 SPI and Board Signals Header

The system is designed for a common SPI bus. This is generally not problematic, but different devices may use different configurations in terms of clock idle state etc.; switching these protocols depending on the selected slave may be necessary in software.
The board signals are also exposed. Note that interfering with them might interfere with them, however if a section is not installed those can be used as additional GPIOs.

Annex

Pin Configuration

GPIO	Function
1	TX0
2	$\overline{\text{Charge}}$ (configure as pullup)
3	RX0
4	MPU9250 Wake
5	MPU9250 SPI Select
15	Dynamo Wake
16	RX1
17	TX1
18	SPI Clock
19	SPI MISO
21	RFM95W SPI Select
23	SPI MOSI
26	RFM95W Digital IO0
27	RFM95W Digital IO1
32	Battery ADC
33	RFM95W Reset

List of optional components

R1, R2, R3, R5, R6, R7, R8, R9, R10, R11, RV1
C1, C2, C3, C4
D1, D2, D3, Q1, U3, U4, U5, U6