Battery Eliminator Circuit (BEC) with Battery Monitoring

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As part of the autonomous UAV project, a Battery Eliminator Circuit (BEC) is required to provide 5 V and 3.3 V power to the servos, MCU and peripherals of the UAV, drawing power from a single LiPo battery while measuring the voltage and current for battery life calculation by the MCU. This is a basic document to cover just the circuit schematics. Bear in mind that the design may be changed substantially before the PCB layout is finalised.

1 5V and 3.3V Power

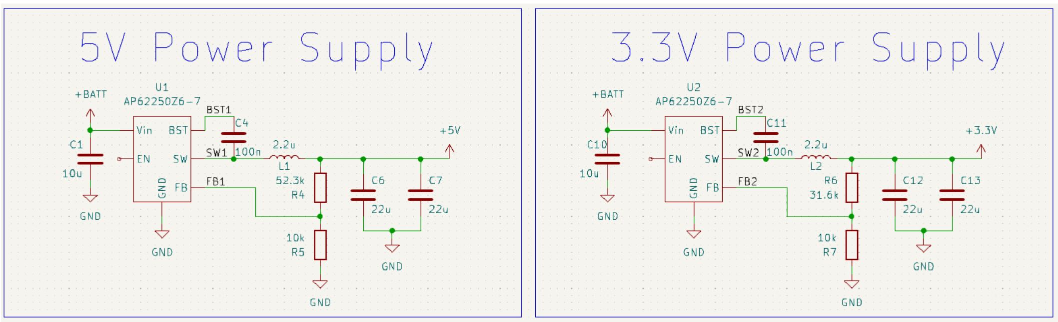

Figure 1: Power Supply Schematics

Two AP62250 power converters are used to provide both 5 V and 3.3 V power up to 2.5 A. Implementation is as directed in the datasheet /citeAP62250, with potential dividers used to set output voltage. A 10 µC capacitor reduces both the surge current drawn from the input supply as well as the switching noise from the device and two 22 µC ceramic capacitors are used for output smoothing.

2 Voltage Measuring

At full charge, a LiPo battery has a potential V_{CELL} =12.6 V for each cell, or V_{BATT} = 12.6 V for a 3S battery. This value decreases non-linearly as the battery discharges.

The battery may be damaged if it is discharged beyond the point at which $V_{CELL} = 3.0\,\mathrm{V}$, so voltage is to be measured to ensure the UAV lands if $V_{CELL} < 3.3\,\mathrm{V}$.

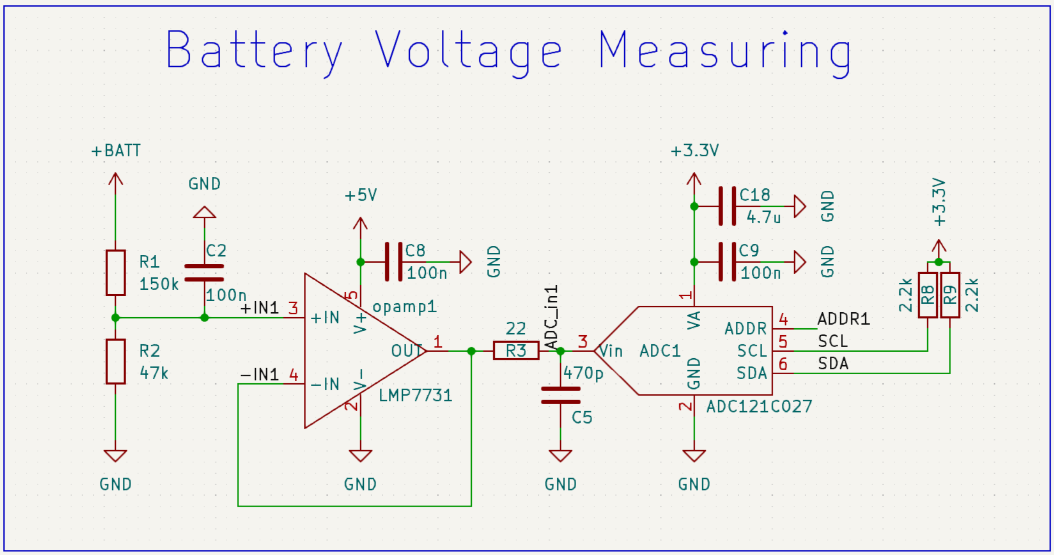

Figure 2: Voltage Measuring Circuit Schematic

This is implemented here using a potential divider, unity gain buffer and ADC. The unity buffer is required to provide a low-impedance signal to the ADC for measuring. It is implemented using the LMP7731 opamp, which takes power from the 5 V supply, giving a maximum input voltage of 3V without distortion. From this the required resistances of the divider have been calculated, yielding 150 kΩ and 47 kΩ to give 3 V for a fully charged 3S battery. The potential divider can be expected to leak a maximum current of 64 mA, but this is considered acceptable given the expected maximum current draw of 25 A for the UAV, and the UAV is not intended to retain battery charge for long periods of time while idle.

The 100 nC capacitor at the opamp +IN pin doubles as a decoupling capacitor and a low pass filter in combination with the potential divider.

The 12-bit ADC121C021 draws power from the 3.3 V supply, which doubles as a reference. A 3 V reference was previously implemented but considered unnecessary given the limited requirement for accuracy and minimal improvement in resolution. Another low pass filter is implemented between the opamp and ADC, both to filter noise and to prevent voltage fluctuations with sampling, as per the ADC datasheet.

3 Current Measuring

Each battery has a mAh rating given by the manufacturer, corresponding to the maximum current the battery can supply for a full hour. To track battery depletion, it is therefore possible to measure current supplied by the battery over time, and

V_ref	Bits	Resolution	ADC Range	Number of values
3.0	8	0.01172	0.5	43
3.0	12	0.00073	0.5	683
3.0	16	0.00005	0.5	10923
3.3	8	0.01289	0.5	39
3.3	12	0.00081	0.5	621
3.3	16	0.00005	0.5	9930

Table 1: Resolution and Number of Values for Voltage Measuring ADC

deduce from this how much charge is left. This method is significantly more reliable and less noisy than the voltage measuring method, but requires that motor power be routed directly through the board. This in turn causes problems with heat dissipation that must be considered when designing the PCB layout.

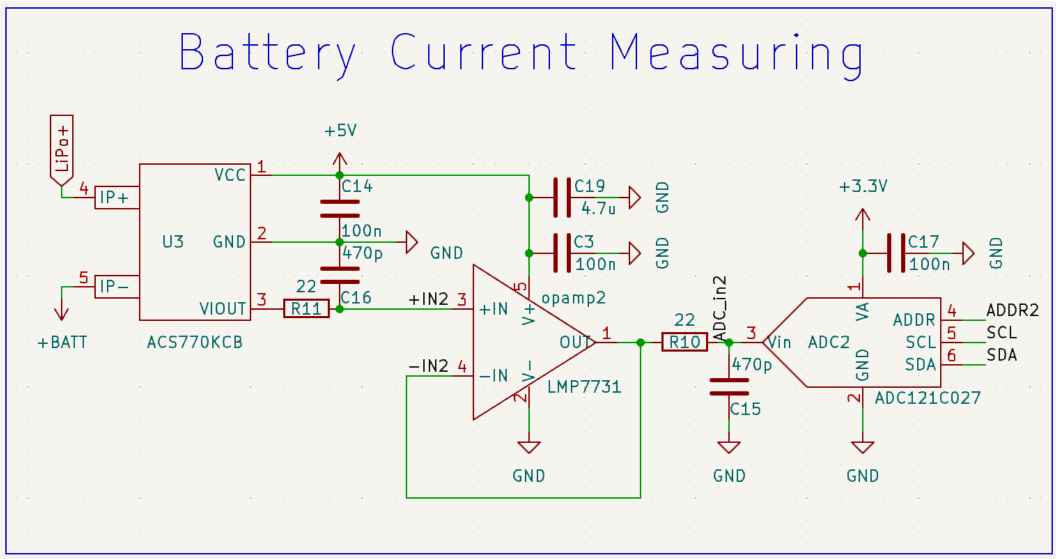

Figure 3: Current Measuring Schematic

In this design, the ACS770 hall-effect sensor is used to measure current from the battery. With a sensitivity of $80\,\mathrm{mV\,A^{-1}}$ for the chosen variant (ACS770LCB-050U-PFF-T), output varies from 0 V to 2 V for the expected current draw of 0 A to 25 A. This is then measured by the same measuring circuit as that described in Section 2

4 Connectors

The BEC must be connected to the battery, ESCs and MCU board. There are therefore three connectors. The first connects to the LiPo battery, the second connects the LiPo battery to the ESCs (after the current measuring circuit) and the third, seven pin connector connects the power supplies and ADCs to the MCU. The battery and ESC connectors will be XT60 connectors, as they are expected to carry up to

V_ref	Bits	Resolution	ADC Range	Number of values
3.0	8	0.01172	2.0	171
3.0	12	0.00073	2.0	2731
3.0	16	0.00005	2.0	43691
3.3	8	0.01289	2.0	155
3.3	12	0.00081	2.0	2482
3.3	16	0.00005	2.0	39719

Table 2: Resolution and Number of Values for Current Measuring ADC

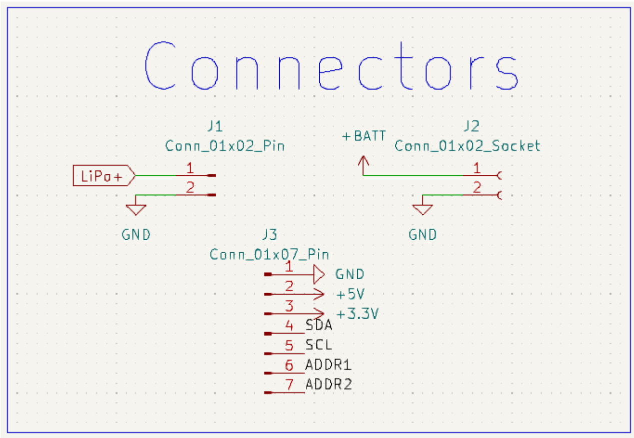

Figure 4: Board Connectors

25A current. The MCU connector will be a JST-XH connector, as it is not required to carry more than 2.5A through any pin. JST-XH connectors have a pitch of 2.5mm, but are more vibration resistant than 2.54mm headers due to their casing and locking mechanism.