Power Budget Analysis

Ladder 42

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Power Summary

Our robot takes advantage of a large amount of sensors to interpret the world around it. These peripherals are individually discussed in Table 1, however combined they consume an average of 637mA. Through this, the following calculations, and size considerations, we settled on a 7.4 volt, 2100 mAH lithium Polymer battery.

One of our primary concerns was sourcing the necessary power for the entire circuit from a small, light, power source. Originally standard 9V radio batteries were considered, however the alkaline structure of these batteries leads to an internal equivalent series resistance, ESR. This ESR means that as we begin to source more current from the battery, we begin to experience an internal voltage drop within the battery that leads to less voltage potential available to the circuit. This internal loss of potential is often times referred to as brown out and can cause unexpected and unpredictable circuit response if unexpected. Because of the relatively high current consumption of our circuit, 9V batteries are unable to provide the necessary power needed while also maintaining a stable voltage potential. To circumvent this we converted the circuit to be powered from a rechargeable lithium polymer battery, often called a Li-Po. Li-Po batteries have the inherent benefit of a near-zero ESR which correlates to a very stable voltage potential even during high current draw.

Our design fails to take advantage of disabling unused peripherals. Our various external logic elements contain sleep modes, and those that do not could be designed to be digital disabled using a high side P-Fet. Based off of the power consumption calculations shown in Figure 1, with a worst case scenario we are expecting a battery life of approximately 1 hour. Average power consumption gives us a more realistic approximation to battery life, which estimates battery life to be somewhere between 1 and 4.3 hours, nominally 3. These long battery life estimates are much longer than the time needed to compete, and as such complicating the circuit with sleep mode and disabling peripherals was not designed into the circuit. This means that even during different phases of the algorithms lifetime we will see a very minimal difference in power consumption and battery life.

In the design of our power regulation circuit, we have to make sure both the 5 volt and 3.3 volt regulators can withstand both the average draw and spikes in current draw. With this in mind, we must consider not only the max current rating (i.e. the spikes) but also thermal considerations. We chose linear regulators for noise resilience (Fast Fourier Transform A/D conversion requires low noise on the power rails), simplicity, and number of components. The drawback to this design is the very large voltage drop between the supply from the battery and our rail voltages. The 3.3 volt regulator will be dropping up to 7.8 - 3.3 = 4.5 volts internally, for a possible total of 4.5 Watts of heat is it were ran at its max rating of an amp. However, as one reads further, we find that it is internally set to shut down once a certain temperature is reached. This can be found using the following formula:

The same analysis can be done for the 5 volt regulator (They are the same series)

When looking at the power data supplied on the following page, we can see if we meet these criteria:

These average values are well within what we calculated for the thermal capabilities of the regulators. Let’s now consider the possible spikes in demand:

So, we meet thermal and transient requirements of both regulators. There is also sufficient load on both regulators at all times to meet stability requirements.

Component and Sensor Power Characteristics:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Motors | FONA | LCD | Pixy | Level Shifters | Compass Sensor | FTDI  USB | PIC | Wii Oscillator | Ground LED | Color Sensor | Motor Drivers | Mic Op-Amp |
| 500  *100* | 200  *20 mA* | 2 | 140 | 10 | 100  *2* | 15 | 300  *150* | 40  *20* | 30 | 330  *65* | 20 | 350 |
| 7.4v | 5v | 5v | 5v | 3.3/5v | 3.3v | 3.3v | 3.3v | 3.3v | 3.3v | 3.3v | 3.3v | 3.3v |

As you can see, when taking into account the very worst case (this is the stall current of our motors along with everything else maxed out as well) we still can run for an hour straight. Now let’s look at a more reasonable approximation.

This is what we expect our average runtime to be, if we were driving the entire 3 hours. Let’s see how long we could idle (i.e., no movement).

From this analysis, we can safely and confidently conclude that our 7.4 volt, 2100 mAH lithium polymer battery can run our robot for between one to three hours continuously, our voltage regulators can handle the average and peak current draw, and our battery will not brown out due to its ESR