Overall Design

A custom-designed circuit board will be used to regulate the air pressure in the bladder. To do this, the circuit board will contain an Atmega328p microprocessor, a NPA-700B differential pressure sensor, and a relay to control a Parker CTS micro diaphragm pump. Figure 1 below shows the hardware functionality of the system.

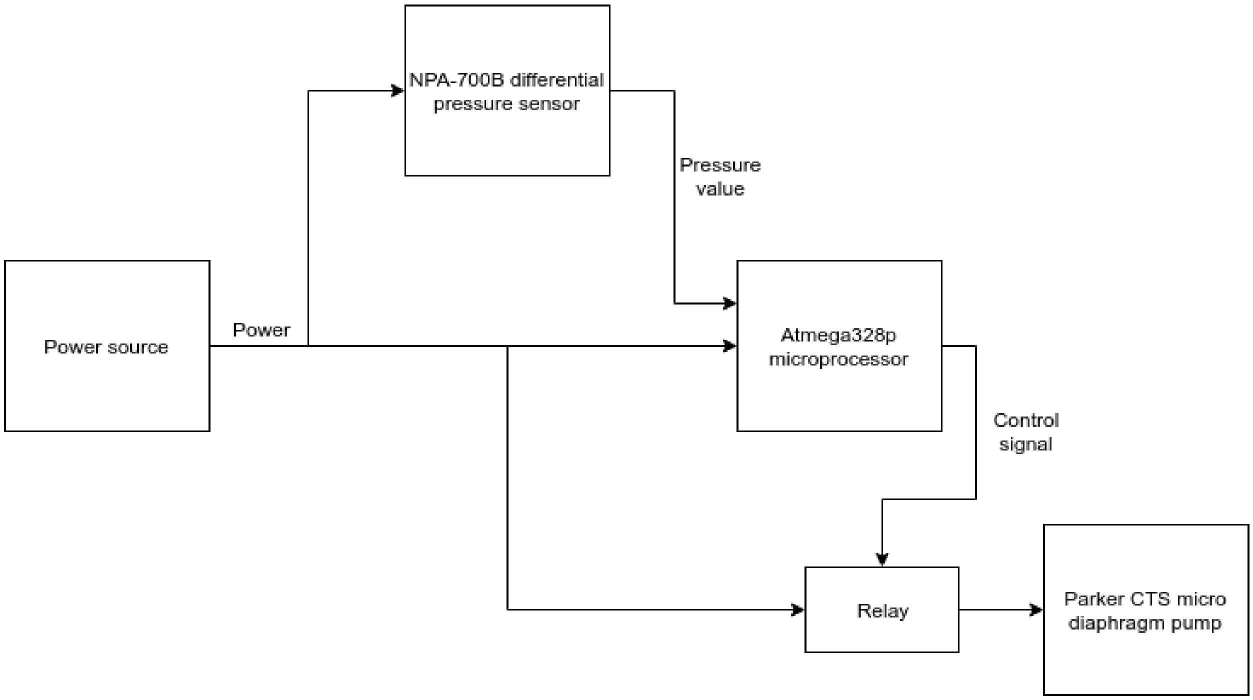

Figure 1: Payload electronics hardware block diagram

The microprocessor will engage the pump whenever the pressure in the bladder is below a threshold value that corresponds to a full bladder. When the pressure in the bladder reaches the threshold value, the pump will be disengaged. To account for an over inflated bladder, a mechanical relief valve will trigger when the pressure becomes too high. This system will keep the bladder at an ideal pressure to secure the fragile material. Figure 2 shows the software operation of the microcontroller.

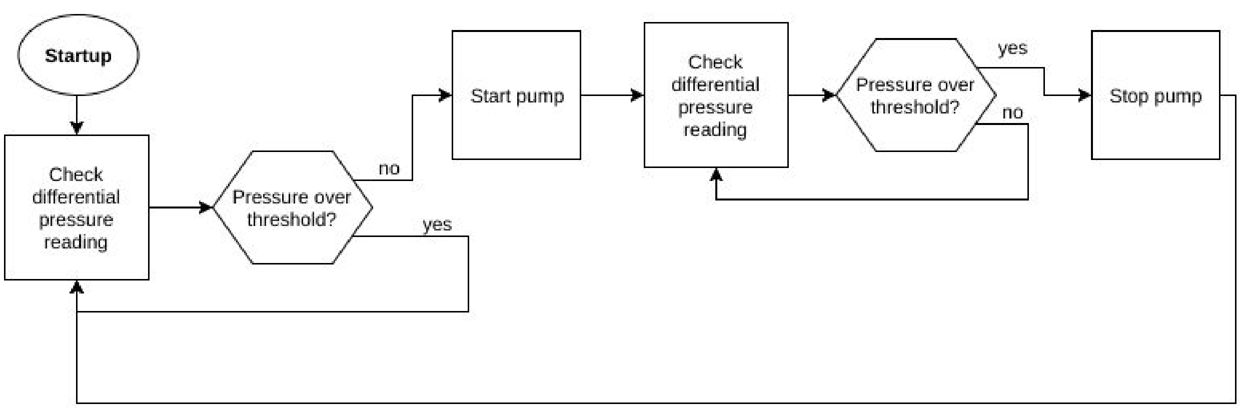

Figure 2: Payload electronics software flowchart

Microprocessor

The Atmega328p is an 8-bit microprocessor manufactured by Atmel. This microprocessor contains the necessary I2C pins for communicating with the pressure sensor, has a small form factor, draws just 0.2 mA of current, and can operate in temperatures up to 85°C. Figure 3 shows the schematic for the Atmega328p. The pins being utilized have markers attached to their ends. These markers will appear in following schematics. Notice that the I2C bus (SDA and SCL) requires pull-up resistors in order to operate, as explained in the I2C protocol.

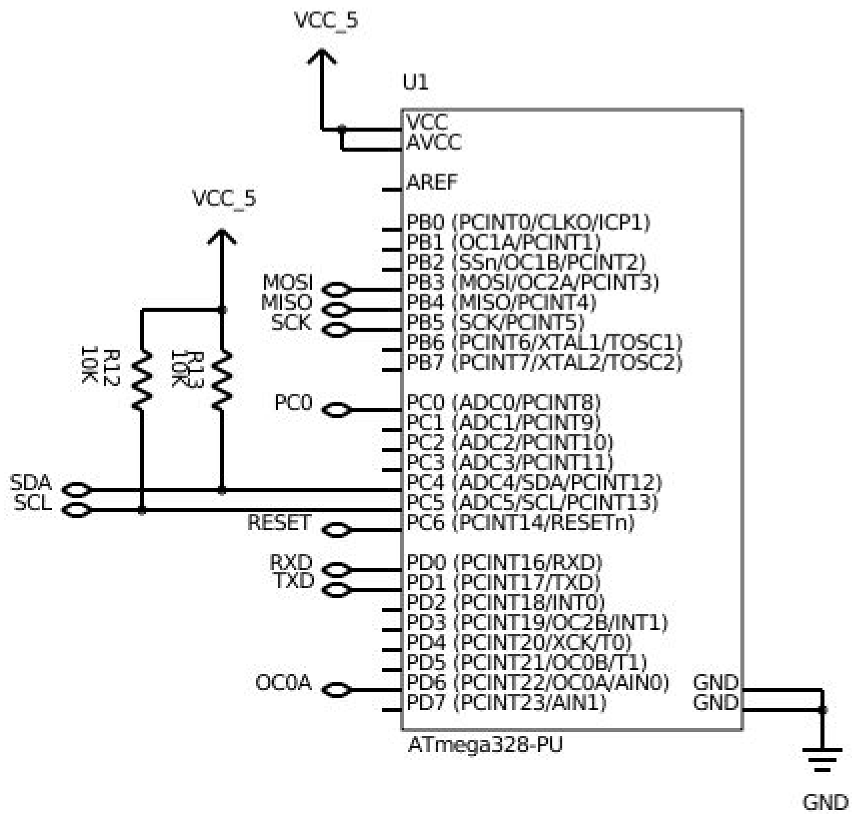

Figure 3: Atmega328p schematic

Pressure sensor

The pressure sensor chosen for this design is the NPA-700B. The NPA-700B intakes air in two separate valves, and outputs a digital signal representing the differential pressure between the two. For this application, one valve will be open to the atmosphere while the other will be open to the internal air of the bladder. This way, the air bag pressure relative to the atmosphere will be measured. A drawing and schematic of the sensor is shown below in Figure 4.

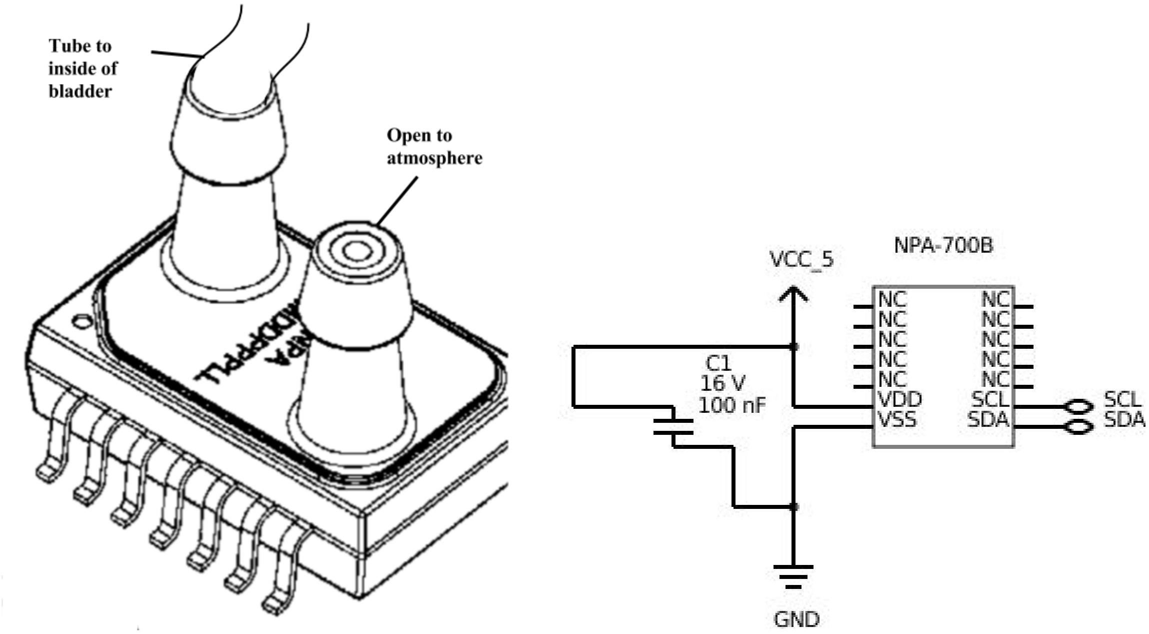

Figure 4: NPA-700B drawing and schematic

Pump

The Parker CTS micro diaphragm will be used to inflate the bladder. The pump has a small footprint and is capable of outputting air at 2.5 LPM. This is ideal since there is limited space in the electronics bay. The pump operates on 9VDC and draws a maximum current of 880 mA.

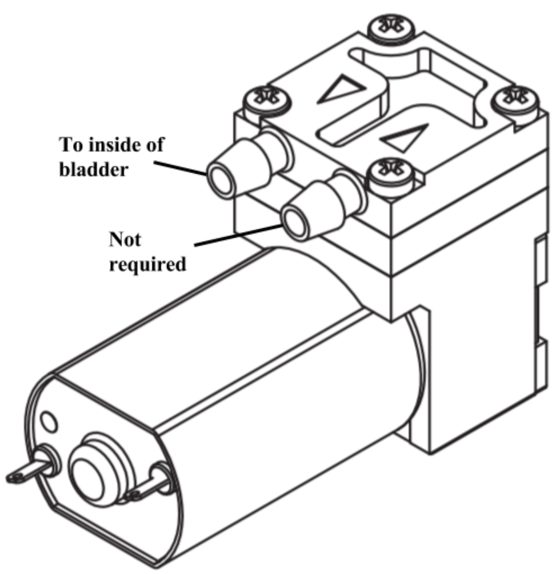

Figure 5: Parker CTS pump drawing

Since the Atmega328p is only capable of outputting 3.3VDC, a relay is needed in order to drive the pump. The relay design that will be used is an nMOS transistor with the pump in series with the drain. The relay schematic is shown in Figure 6. Note that PC0 is an output pin from the Atmega328p. In this configuration, the transistor acts as a 9V switch that can be operated by pulling PC0 high and low. When PC0 is pull low, the transistor becomes an open circuit with with the negative terminal of the pump floating. No current will flow through the pump and the pump will not operate. When PC0 is pulled high, the transistor becomes a short circuit with the negative terminal of the pump connected to ground. The 9V will be applied across the pump and the pump will turn on.

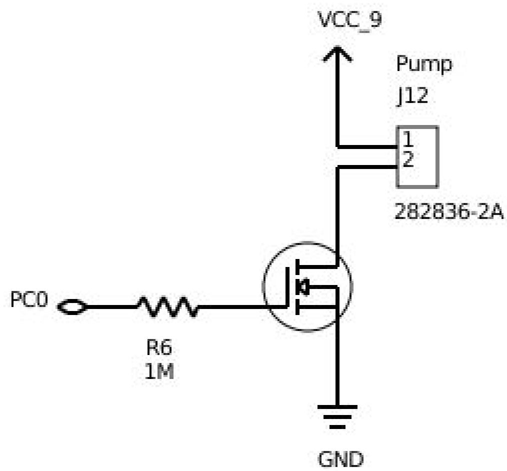

Figure 6: Relay schematic

Power

A 5V power rail is needed to operate the microprocessor and pressure sensor, whereas a 9V power rail is needed to operate the pump. Because of this, two voltage regulators are needed on the circuit board. The LM7805CT and LM7809CT will be used because of their availability.

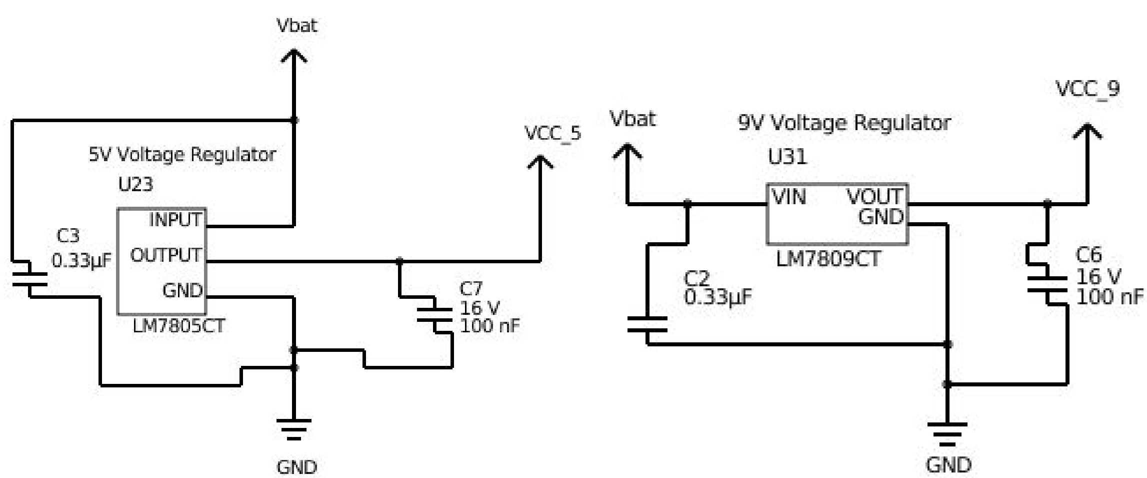

Figure 7: LM7805CT and LM7809CT schematics

Switches and batteries

To ensure that the electronics will last for the duration of competition, the payload will support an external power source connection that can be used leading up to the launch. A 2-pole rotary switch will be used to toggle power on the electronics. Another 2-pole rotary switch will be used to configure whether the electronics draw power from the external or internal power source. Before the launch, the external power source can be used to test the electronics and fully inflate the bladder. Then, before the payload is inserted into the rocket a rotary switch will be turned to select the internal power source. The internal power source will be two 9V lithium-ion capable of outputting 1000mAh each. This will be enough to power the pump at full load for over two hours. See Figure 8 below for the operation of the rotary switches.

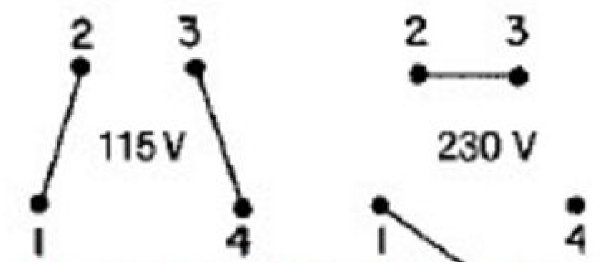

Figure 8: Missleworks 2-pole rotary switch operation

The 230V position will be the original position of the both rotary switches. In this position, rotary switch 1 will have the positive and negative terminals of the circuit board shunted, blocking power to the board. Turning rotary switch 1 to the 115V position will connected the positive and negative terminals of the circuit board to rotary switch 2. Rotary switch 2 will then configure which power source the circuit board draws from. Rotary switch 2 in the 115V position will connect the external power source, while rotary switch 2 in the 230V position will connect the internal power source.

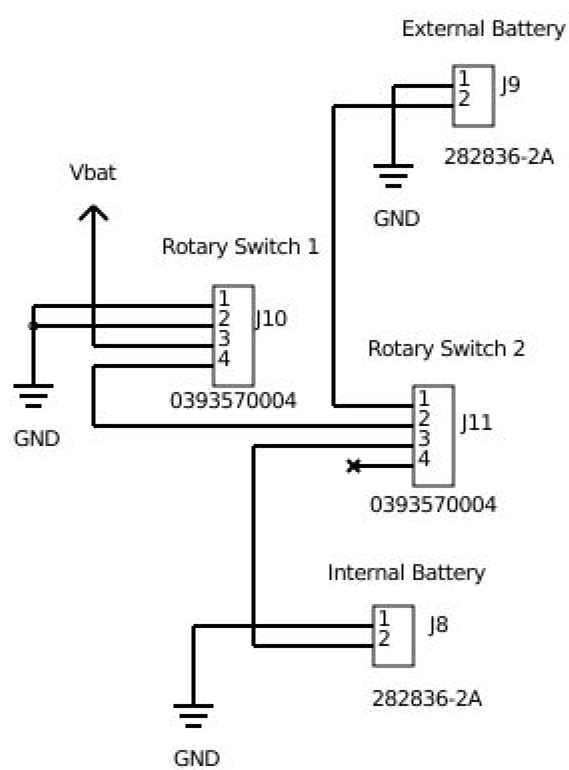

Figure 9: Switch and power source schematic

Headers and indicator

The circuit board will contain headers for programming and debugging purposes. In addition, an LED will be used to indicate when the circuit board is powered.

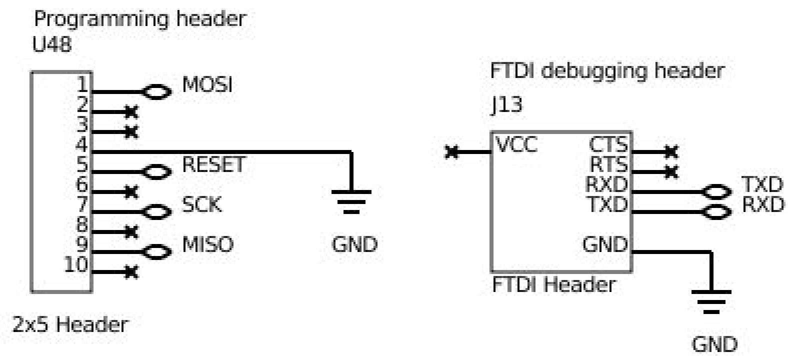

Figure 10: Header schematics

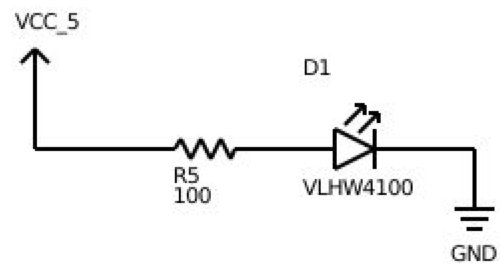

Figure 11: Indicator schematic

PCB layout

The final layout of the circuit board is shown below.

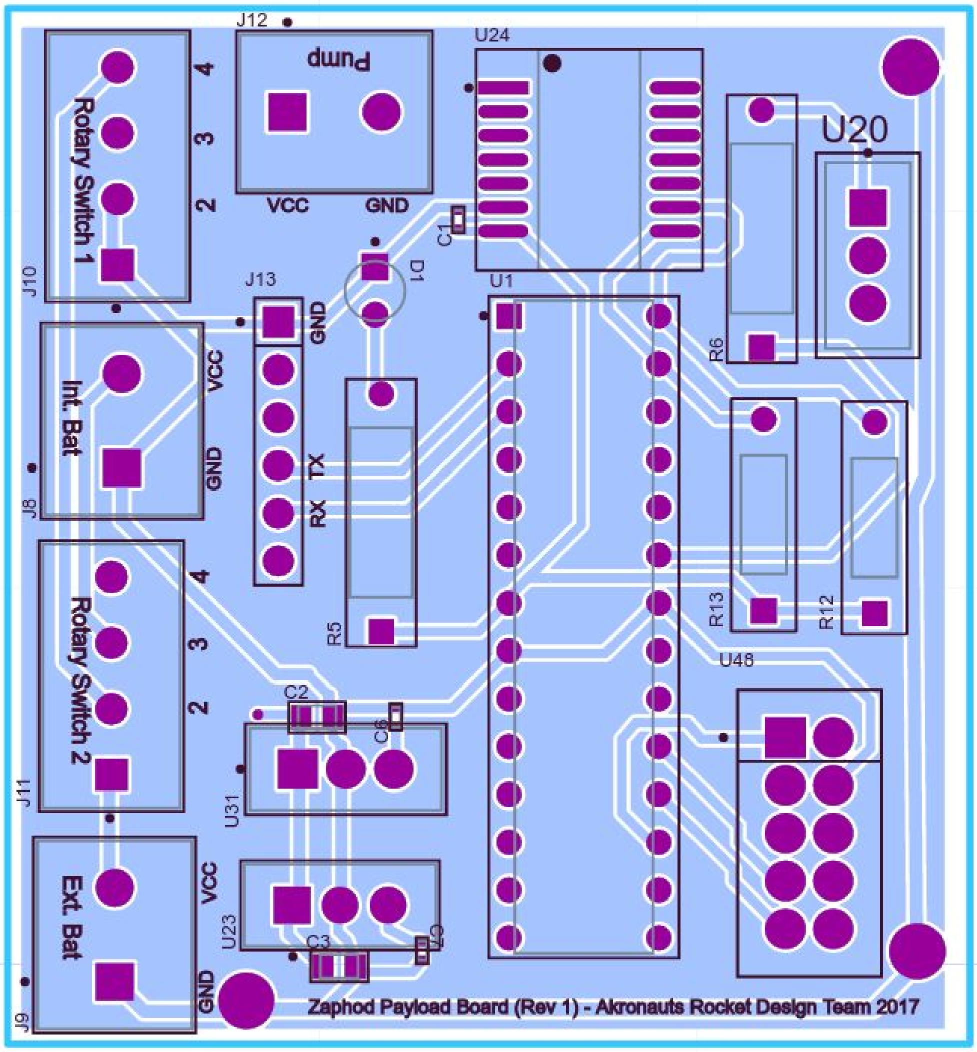

Figure 12: Payload electronics circuit board layout