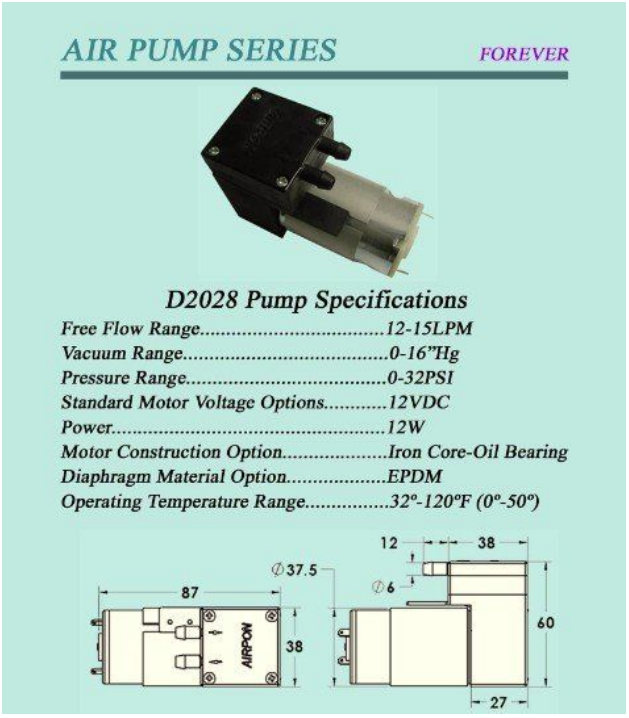
Vacuum Pump

Block Owner: Mack Hall
Date: Mar-17-2020

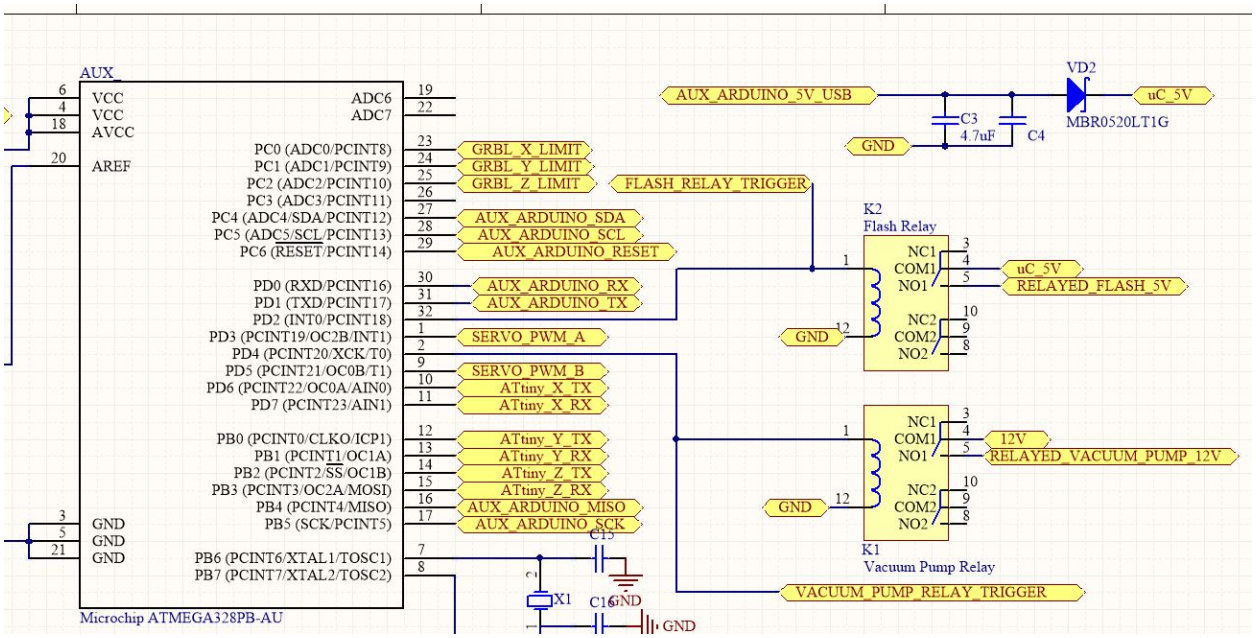
Design Overview



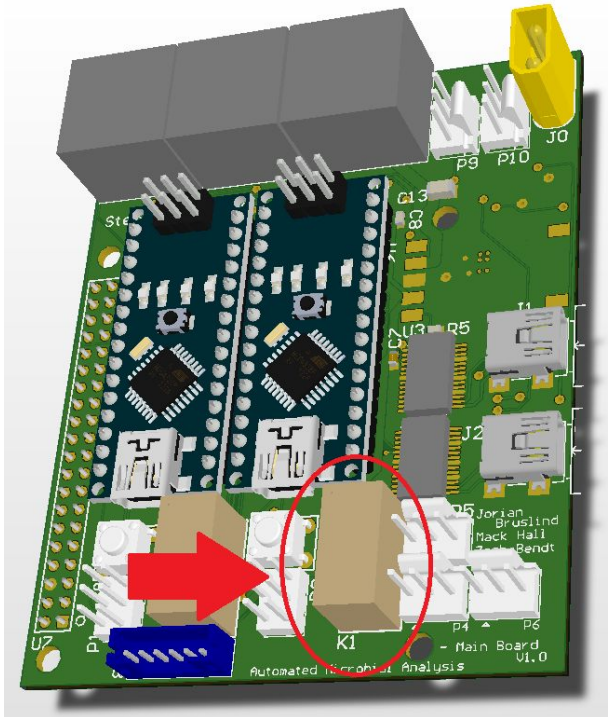
Design Validation Overview

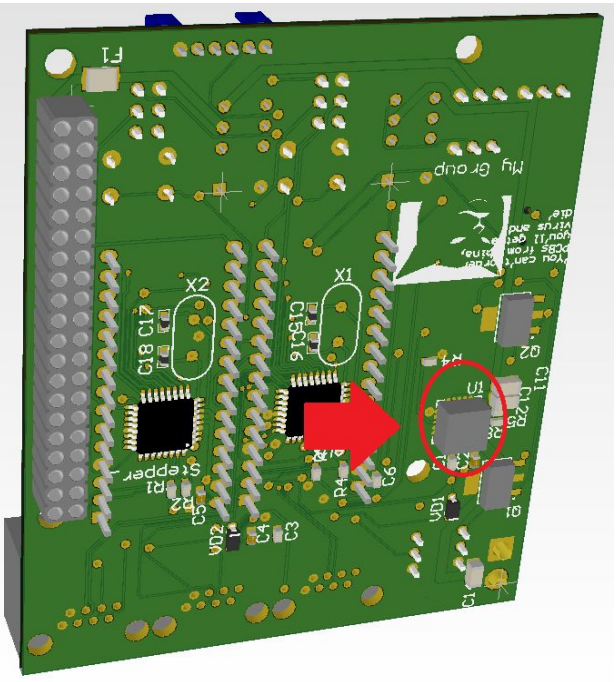
This vacuum pump is used to create suction in order to pick up the cultural samples. It is controlled via a relay located on the primary control PCB. The D2028 is very common among enthusiasts, and with good reason: this budget motor is dead simple, reliable, and effective. 16” of mercury over a ¼” diameter suction cup means this pump can theoretically lift a little over ⅓ of a pound, which is plenty for our application, as its load weighs only ~100 g. This allows for a safety factor of ~50%.

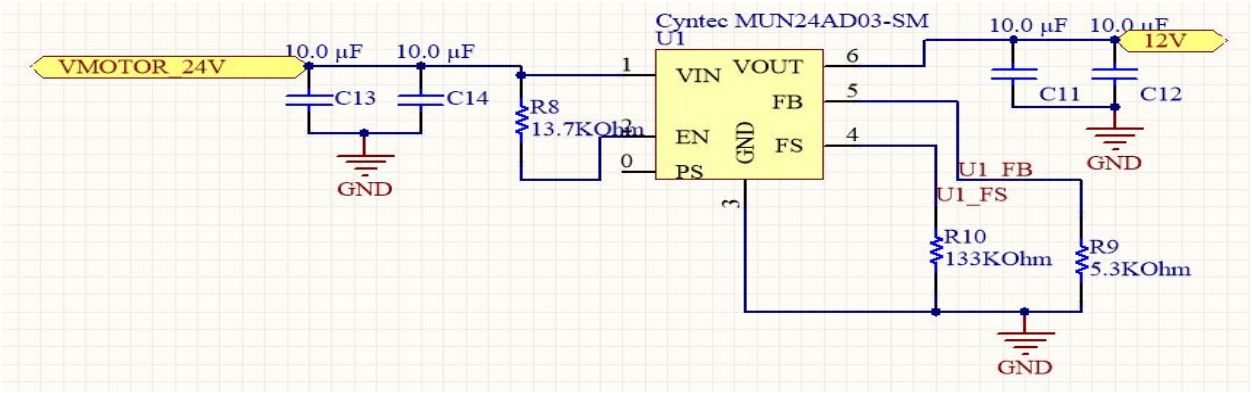
The vacuum pump simply turns on when a voltage is applied to the terminals. Therefore, the system will utilize a relay to turn the pump on and off. The schematic is as shown:



On the Auxiliary ATMEGA328 found on the Central PCB, the enable pin of the K1 relay is tied to PD4 (physical pin 2), which is capable of sending a 5VDC signal to open or close the relay. When the K1 relay is open, the RELAYED_VACUUM_PUMP_12V net, which is connected to the positive terminal of the vacuum pump, is left floating, meaning the vacuum pump is getting no voltage and is therefore off. When the K1 relay is closed, the RELAYED_VACUUM_PUMP_12V net receives 12VDC and turns the pump on.

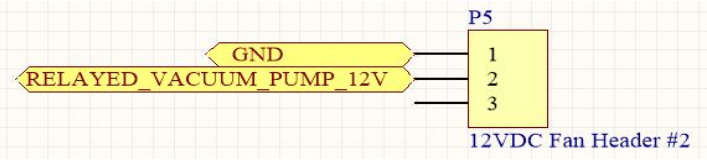


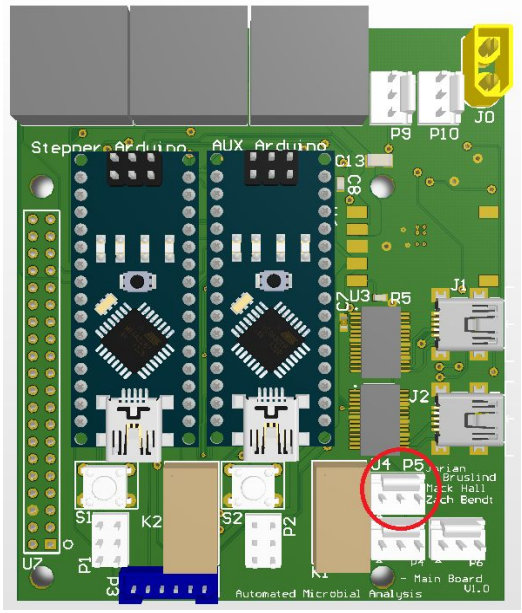




The 12VDC line is supplied by U1, a Cyntec MUN24AD03-SM, which is a simple buck converter that steps down a 24VDC signal to a 12VDC signal. The 24VDC signal is the “common” DC-bus throughout the system, which means it is supplied from an external load-regulating power supply that rectifies wall voltage. The Cyntec MUN24AD03-SM is capable of handling up to 3A, and is therefore more than plenty for our vacuum pump, which only draws 1A at maximum.

The D2028 vacuum pump is connected to the Primary Control PCB via the P5 header.





If further inspection of the PCB schematics are desired, all of the relevant project schematics will be supplied in their respective block section within this packet.

Design Validation Interface Table

prmry_cntrl_pcb_vcm_pmp_dcpwr

Inominal: 0.5-0.8A	For the D2028B: ● 12V and 12W maximum operation, makes for 1A peak current http://bit.ly/2tOJsEd ● Although the motor is rated for 12W, and therefore 1A operation, that is not the case in real life. The motors are not 100% efficient of course, so some of the energy must be used to account for losses in the system. Through experimental observation we found this range to be more accurate under nominal voltages. ● Since motor torque is proportional to current, this motor draws more current under load, as more torque is needed to overcome the air pressure in order to attempt to pull a vacuum
Ipeak: 1A	For the D2028B: ● 12V and 12W maximum operation, makes for 1A peak current http://bit.ly/2tOJsEd ● Although the motor is rated for 12W, and therefore 1A operation, that is not the case in real life. The motors are not 100% efficient of course, so some of the energy must be used to account for losses in the system. Through experimental observation we found this value to be the absolute maximum this motor will ever see
Vmin: 11.5VDC	For the D2028B: ● Motor is rated for 12VDC operation http://bit.ly/2tOJsEd ● Page 5 of the Cyntec MUN24AD03-SM datasheet states voltage should only drop up to 3%, which means only 97% of the target voltage will be supplied. 0.97%*12VDC = 11.64VDC, which is plenty for allowing the motor to turn on, albeit with diminished suction. Furthermore, the 3% reduction only occurs under maximum load, which is 3A. Our 12VDC line only needs to provide enough current for the vacuum pump, which has a maximum of 1A.

	Therefore, voltage should never realistically dip that low. https://bit.ly/3b6xplo ● Confirmed through experimental observation
Vmax: 15VDC	For the D2028B: ● Motor is rated for 12VDC operation http://bit.ly/2tOJsEd ● Motor can run at higher voltages (and therefore, higher currents) for short periods of time, at the cost of longevity to the motor ● Confirmed through experimental observation