# Autobag 3.0 Final Prototype

# Design Notes

**Control Architecture**

* **Microprocessor:** An Arduino Uno was selected as the microprocessor controller primarily because of it’s abundant supply, ease of use and robustness.
* **Code:** Custom code was written initially by UofT, rewritten by Promation and finally reviewed, revised and tested by Alithya (Matthew Humeny - Matthew.Humeny@alithya.com). Note that there are some anomalies with the code that should be addressed in future revisions:

1. The limit switches were inadvertently soldered in at NC instead of NO. This was corrected using software. This should be reinstated as initially designed.
2. The rotation of the pots was reverse to correct the reverse electrical connection on the PCB. This should be correct on the PCB and the software
3. A 2nd order correction was added to the IE ratio to offset errors introduced due to the stepper losing steps at very high speeds. This needs to be fixed with hardware and software so that steps are not lost. Then the code can be reverted back as before
4. The plateau pause was reduced from 150mS to 50mS because it seemed the delay was longer than the software was set at, and it was not possible to measure the delay with the FluxMed. The plateau delay needs to be reinstated to 150 mS.
5. Although an alarm was connected, it was not programmed in. Alarming would be good to add.
6. The current code does not allow changing of bags that have a dramatic diameter difference from the Carestream BVM used at TGH. This feature can be easily added. 2 DIP switches (allowing for 4 different, DIP selectable bag diameters)

* **Wiring and PCB:** Initial wiring was designed and done by Promation using soldered and screw connections. The general electronic design was then incorporated into a custom PCB designed by Laveer Engineering (Jeff Hulcoop - [jhulcoop@laveer.ca](mailto:jhulcoop@laveer.ca)). The current board has several fixes required (the 16 pin connector needs to be rotated 180deg., and the standby/run switch needs to be pulled to ground instead of +5V. The three pots are wired backwards [fixed with software))
* **Power Supply:** The entire unit is power by a Delta medical-grade power supply rated for 24VDC and 90W. This power supply has a robust locking plug which prevents removal without pulling back the plug jacket first (ie. tugging on the power cord will not disconnected it).
* **LCD:** The display used is a 2x16 LCD, although the device was initial designed for a 4x20 LCD. Subsequent versions should revert back to a 4x20 display which is easier to see and can display more information simultaneously.
* **Shielding:** Because of EMI generated onto the limit switch wires in Prototype #1, shielded 24AWG wiring was used for the two limit switches, and a shielded braided sleeve was placed over the stepper wires. The shielding for the stepper was grounded at both ends (to the stepper itself and to the control enclosure). A metal enclosure was selected intentionally to reduce noise. A large ferrite was added to the stepper motor wiring, and ferrites and capacitors were added on the PCB to reduce the effect of electrical noise. The stepper wiring and the limit switch wiring were kept apart to limit induced noise onto the limit switch wire.
* **Stepper Controller:** Electromate (Alex Werner - [alex@electromate.com](mailto:alex@electromate.com)) worked with Applied Motion engineers to select and configure the appropriate industrial grade controller and stepper motor. The controller used is an STR4  (<https://www.applied-motion.com/products/stepper-drives/str4>). The controller is operating in 200 steps per rotation smooth.
* **Stepper Motor:** The industrial grade stepper motor is an Applied Motion [HT23-601](https://can01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.applied-motion.com%2Fproducts%2Fstepper-motors%2Fht23-601&data=01|01|cbarber@promation.com|a72073bf79ea4925ea1908d7dc006e20|ee3c86f2c5f747038da1063ef7877c55|0&sdata=QIFBgJHb5%2B2LooglJrSroPkEdYK9UfYgwHT%2BoFjdW2s%3D&reserved=0) (<https://www.applied-motion.com/products/stepper-motors/ht23-601>). It was connected in the bipolar parallel configuration, and the controller motor type was selected as type 8.
* **Planetary Inline Gearbox:** A 5:1 inline planetary gearbox was installed between the stepper motor and the device drive train to increase the delivered torque to the arms (see[GAM PE-N23-005G Inline planetary gearbox](http://catalog.gamweb.com/catalog3/d/gam/?c=products&cid=pe_n&id=PE-N23-005G) ).
* **Moisture Resistance:** Some efforts were made to minimize the potential ingress of liquids into the enclosure and components. The potentioment shafts were sealed using rubber seals, and the LCD display was sealed with RTV sealant. The enclosure itself is relatively moisture resistant. With prolonged exposure to moisture, it is expected that electrical connections will corrode and this device will cease to operate properly. There is not concern about electrical shock because the device runs entirely on 24VDC, with a [ower consummation of well below 90W. The power supply itself is sealed and medical grade.
* **Safety:** This prototype device is guarded on both sides of the drive train with lexan shields, although pinch points do remain on this device. A resuscitator bag should never be installed or removed unless the arms are retracted and in the standby position, or if the power is physically disconnected from the device.
* **Rebooting:** In the unlikely case that the controller locks up, unplug the power supply from the device, and reconnect it. This will reset he microcontroller.

**Mechanical Design**

* **Design origins:** The initial design was based on the MIT E-vent geared design. Prototype #1, like the MIT design, did not take into account the significant mechanical loading generated by the resuscitator when under full ventilating load (30BPM, 1:3.0 IE, 100% Vol, PEEP at 30cm H2O, 2 HEPA filters, plus the resistance/compliance of a test lung).

