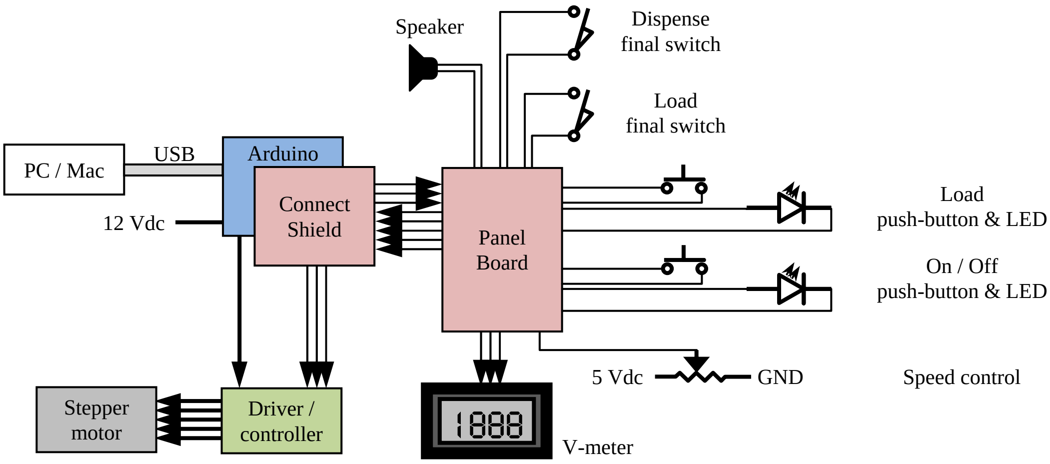
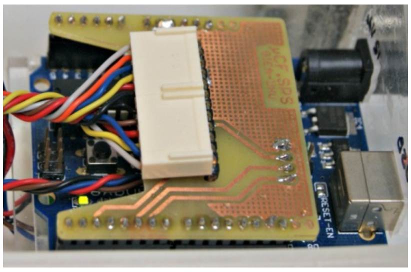
ELECTRONIC SETUP



The stepper motor can drive directly by four digital lines (conveniently boosted) attached to the four motor windings and activated in the proper sequence to generate the rotary motion. This operation can be simplified by using a driver card which, through logical circuitry, generates the appropriate pulse sequence depending on the direction and rotation mode selected. In addition, three control lines (digital outputs) are only needed, not four, and the power stage for windings is included. The RSSM2 driver card was selected (RS Components part nr. 240-7920). The driver has multiple input lines to control the motor in several ways. We have chosen to maintain the possibility to select the width of advance step and direction. Therefore we have to control the state of three lines: half/full step, clockwise/counterclockwise direction and external clock (to control speed).

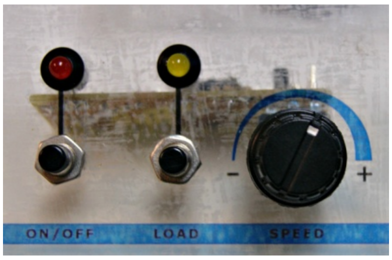
It is also possible to use a motor shield that you can purchase for a specific microprocessor. They are electronic boards designed to manage the operation of one or many motors from digital ports or by communication ports controlled by the processor. The software can be easily implemented towards free access dedicated libraries. The RS motor driver we have selected is processor-independent and it can be implemented in any platform. It can provide higher currents (up to 2 Amp) and more powerful motors can be used if necessary.

The digital control of motor as well as the management of the manual control panel to operate the syringe pump in local mode is carried out by a micro-controller. We have used an open-code full accessible and very know architecture, the Arduido Duemilanove version. See below to learn about how to program the Arduino.



We make a shield board to connect the processor board with both the panel board and the driver motor board.

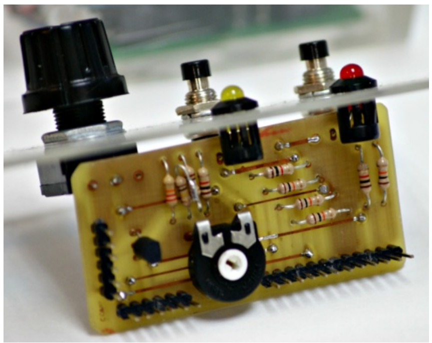
The control panel for manual operation of syringe pump is as simple as possible. It only has two push buttons with two LED indicators and a potentiometer to speed setting. The potentiometer (linear type) is connected to ground and 5 Vdc and the wiper drive a variable voltage that is read by and analog input in Arduino. It's used to calculate the frequency of motor steps. One of the pushbuttons is used to start or stop



the motor motion in the infusion direction; it has an associated LED that is ON when the motor is running (no matter the direction) and OFF when stopped. Finally, the other pushbutton is used to start or stop the Load of syringes; the associated LED is ON when motion is in the withdraw mode and OFF in the infuse mode.

It’s a good idea to include a digital voltmeter connected to the analog voltage driven by the potentiometer. This way it’s easy to reproduce the speed at several experiments by setting the same number in the display. This type of voltmeters operates from 0 to 200 mV, so the voltage output from potentiometer must be divided by 25 (with a tunable voltage divider). The SP400 model by Lascar has 3 ½ digits and the adequate dimensions. It can show numbers from 0 to 1999 and it can be powered by 5 Vdc. However, these modules are normally expensive and, as the pump can be controlled without them, they must be considered optional.

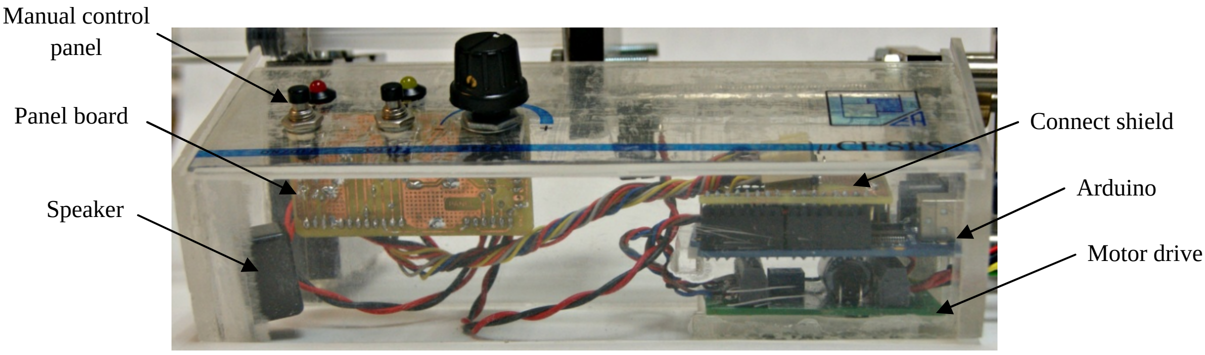
Both pushbuttons are normally open and are connected to respective Arduino digital lines. While they are open a 10 k pull-down resistor drives a Low level; when they are pushed, they connect 5 V to digital input, driving a High level. The LED indicators have a 1 k resistor connected in series to limiting the current. Both are driven directly from two digital outputs from the Arduino, cathodes are grounded and a High level lights up LEDs.



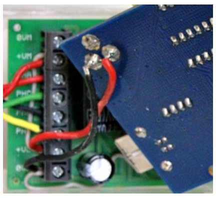
The circuitry associated to LEDs, pushbuttons and potentiometer and the devices themselves are integrated in the named Panel Board. This board also includes circuitry for a speaker to make sound alerts when the syringes are completely empty or filled with fluid. It includes an amplifier stage Vdc power supplied and controlled by an Arduino digital output. To check the limit states of syringes, two limit switches are used, whose circuitry (a pull-down resistor each) is also on the panel board. Both the limit switches and the speaker are cable mounting and are connected to the board by header pins. Header pins are also used to connect to the Arduino the digital and analog lines and the power supply and also the optional panel-mount voltmeter.

Schematics and masks for double layer board are available for free. You can make your panel board, mount all components, connect with Arduino and then think about the programming.

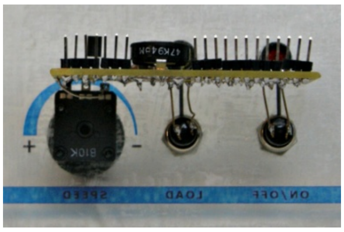
All electronic components are installed inside a cabinet specifically designed to be attached to the mechanical assembly and getting a compact and nice equipment. We have made the cabinet with transparent PMMA to better see the inner for teacher purposes, but other plastic or metallic material can be used. In any case, there are several things to consider in the design to be operational that are listed below.



Arduino power and USB connectors should be accesible from the outside. The power plug must be derived to the motor driver directly (there’s the higher power consumption), so we welded two wires to the weld between the connector and the Arduino board and we connected them to the driver.

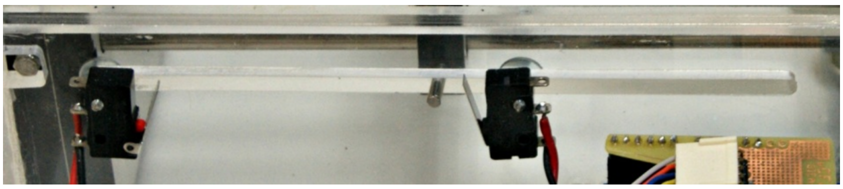


The connections of the motor windings must be made through the wall of the cabinet. To prevent accidental spills to reach the electric circuits, they are made in the far side of the syringes.

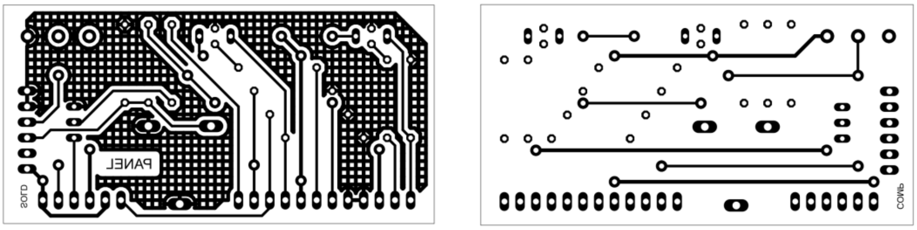


Obviously, the control panel should be placed on top as well as the voltmeter if included. The panel board is attached to the panel by the panel components themselves which are welded to the PCB and fixed to the panel. The speaker is placed anywhere in the cabinet.

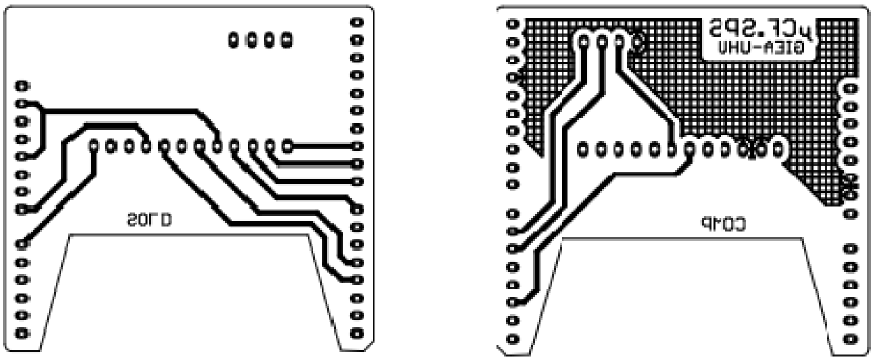
The limit switches are mounted on the inside of the back wall, near the mechanical actuator. In that wall a slot has cut for peeking out a small piece that moves with the actuator and push switches. The same slot is used to install both switches on the right positions depending on the syringes volume. To avoid the slot and having a perfect isolation of the electronics, more expensive magnetic field switches could have been used.



In short, we must build two printed circuit boards: the Connect shield for Arduino and the Control panel board. We use the Eagle PCB Design Software from CadSoft to design them. The Eagle Light Edition is a freeware edition for non-profit purposes only. It is fully operative within a few limitations and it can be downloaded for free from the CadSoft web site (http://www.cadsoftusa.com/download-eagle/?language=en). Both PCB designs have two signal layers and both schematics and PCB design are freely available. Both layers masks for components and routes are also available in printable version.



Panel board route masks for top and bottom layers (not to scale)



Connector shield route masks for top and bottom layers (not to scale)