**Software Description:**

T he main program for our control system was written entirely in the "C" programming language. This was chosen so as to ensure compatibility with the Sensoray 826 DAQ board used for control. The program begins by asking the user to disconnect the grounding cable of the welder and waits for an input from the user confirming this task is complete. Upon receiving that input the machine then calibrates the wire feed speed by running a PWM procedure to turn the stepper motor until the system sees that the homing switch is triggered. The program then turns on the welder's gun to feed wire while measuring the wire speed and sets the average of those wire speeds as the new home offset.

The next step of the program asks the user to input the speed at which the CNC machine will be running, given in inches per second. This is where the system would find a corresponding nominal wire speed in an array of nominal wire speeds found via testing and sets the welder to that wire speed, due to constraints the system is hardcoded to go to a default wire speed of 3 inches per second because fine tuning is handled later. The program then waits for a signal from the CNC machine confirming that it has switched from relocation mode to deposition mode. Once the system sees that we have reached deposition mode, it stops the CNC movement and makes sure the welder is not triggered, in order to check the temperature of the base plate. If the base plate's temperature is too high, the system stops and waits for the base plate to cool down below a threshold. This threshold should be around 200°C, due to our temperature sensor's range being far too high (800°C to 2200°C), this is commented out and done manually right now, a new sensor with a range of around 200°C to 1500°C should be implemented before un-commenting.

Upon completion of the torch routine, the system enters the main loop. This begins by reading a timestamp from the 826's onboard timestamp generator, given in microseconds. This value will be used to keep track of how long the machine has been in deposition mode. The system then starts the welder and runs a check for spikes in the current as seen by the Current Sensor. If no spikes are detected, the system will end the program and return an error report.If spikes are detected, the program moves on and continues the CNC's movement and checks to make sure the system is still in deposition mode. If the CNC machine is still in deposition mode at that time, it moves on to take measurements of the number of "peaks" seen by the current sensor. While taking these measurements, the system also checks and updates the movement mode provided by the CNC in order to avoid issues with the system trying to deposit while in relocation mode.

Once the CNC machine leaves deposition mode, the system will turn off the welder and wait until the CNC machine has reached deposition mode again. While the system is waiting for deposition mode, it continuously checks the temperature of the plate. If the temperature is at or below an acceptable value, it re-enters the deposition procedure which does the following measurement. The program measures the time between current spikes which are caused by the welder. It then calculates an error value from a nominal pre-programmed time that was determined through testing (found [here](../../Testing/Droplet%20Spacing%20Testing/Droplet%20Spacing%20Tests.xlsx)). If the error between the two values is greater or less than 80%, the system terminates with an error, asking the user to double check that the entire system is working. The last check is to see if the droplet spacing is greater or less than a 20% tolerance, and if so the system makes an appropriate proportional adjustment to the wire speed before continuing on.

The method used for adjusting the wire speed is based on the average error seen by the above measurements. In order to make an adjustment the program takes ten error samples, stores them in an array and calculates their average. The system then uses that average error value as a wire speed to be set because the value will always be less than 0.8 and greater than 0.2 it is an appropriate adjustment to make. Future iterations of the system could include a better adjustment algorithm for this number such as PI or PID control.

Finally at the end of the deposition loop the system calculates how long it has been continuously welding based upon the timestamp taken when it enters this loop. If the welder has been on longer than recommended by the manufacturer (2 minutes) the system halts the CNC and the Welder. It then waits for the manufacturer recommended cool down time (8 minutes). Later iterations of this machine may reach a 100% duty cycle in which this can be removed entirely.