Control of the welder is done by interpreting information from the following feedback and control elements:

**Current Sensor**

Data from the current sensor gives an idea of the precision of the deposition. The current sensor is placed in-line with the ground connection of the welder. When the wire of the welder completes the circuit, it melts the wire and creates a small droplet of molten metal which is shown as a spike in current.

Using a peak detection algorithm, the frequency of droplets being deposited can be determined. Comparing these values to a nominal value, which was found through testing, the wire speed knob is adjusted.

**Temperature Sensor**

An infrared temperature sensor is used to provide a reading of temperature prior to depositing material. When the temperature of the weld is outside of the allowed range, the system will pause. If is it too hot, the system waits for the deposition to cool and if it is too cold, a hand held torch is used to manually heat the part.

**Incremental Encoder**

Attached to the wire feed drive pulley inside the welder is an incremental encoder that is used to calculate the actual wire speed. During testing, this sensor was used to find ideal wire and CNC speed pairs. At the beginning of each print, a user inputs the CNC speed that the machine will be running at and the system sets up the appropriate initial wire speed. This is done via a process that sends the wire speed adjustment knob to a home position and measures the wire speed at that position. This provides an offset which is used in all proceeding wire speed calculations.

**Welder Switch Bypass:**

The CNC machine has two movement modes: relocation and deposition. Each movement mode has its own digital signal, which are read by the controller. The controller uses these signals to activate or deactivate a relay, which bypasses the mechanical switch on the welder gun. This relay module also includes visual indication of the current CNC movement mode.

the spacing of the droplets occurring during the weld. When using a MIG welder, a wire is fed out the end of the welding nozzle. When this wire comes into contact with a metal plate that is also connected to the ground terminal of the welder, the circuit is completed and the high current melts the wire. The current is so high, that the wire melts past the point of contact, which then creates an open circuit, until the wire again reaches the ground plane and the circuit is again completed. Looking at this process closely, it can be seen that the deposition of the wire isn’t continuous, but rather a bunch of tiny droplets. We call this droplet spacing, and used it extensively throughout the remainder of our project. Through testing we determined that the average droplet spacing for a good weld was around 50 milliseconds (although this would change if the input current were to change drastically). Our control program looks at half a second time period, determines the average droplet spacing, and makes corrections to either increase or decrease wire speed accordingly. To know how to correct the weld, we ran a series of tests and created a lookup table of what we determined to be an ideal weld.