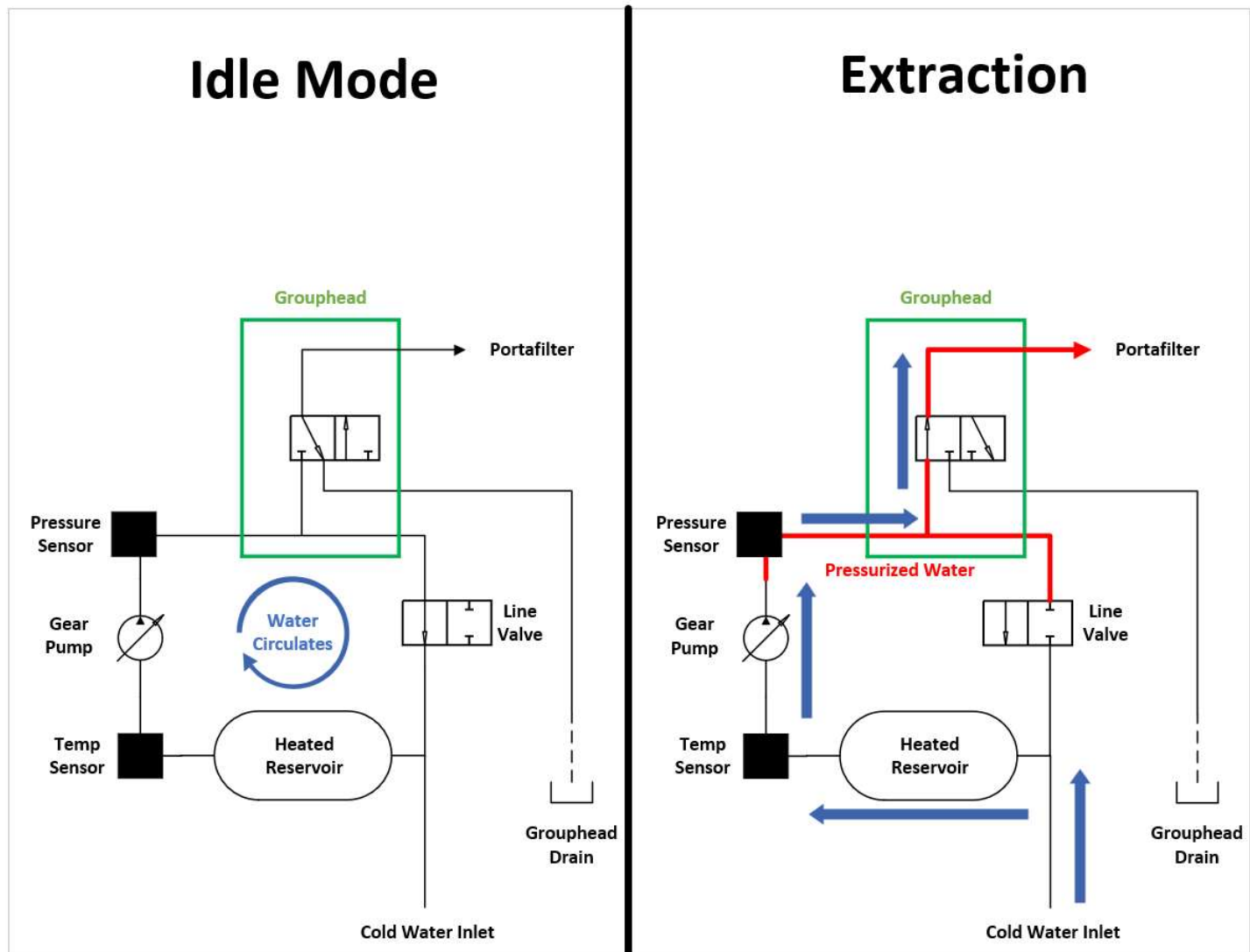


# Mechanical Schematic + Overview

Saturday, April 2, 2022 5:04 PM

- Key functions of an espresso machine
  - Push water into espresso puck
  - Precise/controlled temperature
  - Precise/controlled pressure
- General design
  - Idle Mode
    - Circulates water through reservoir
    - Everything preheats due to flowing water through components
    - 3/2 valve in the grouphead vents the portafilter to the drain
  - Extraction
    - Line valves closes to isolate the loop and form a pressurized size
    - 3/2 valve in the grouphead lets water flow into the portafilter and closes the drain
    - Water in the loop is replaced by cold water flowing into the water inlet



# Control Hierarchy

Saturday, April 30, 2022 3:43 PM

## Windows GUI - High Level Control

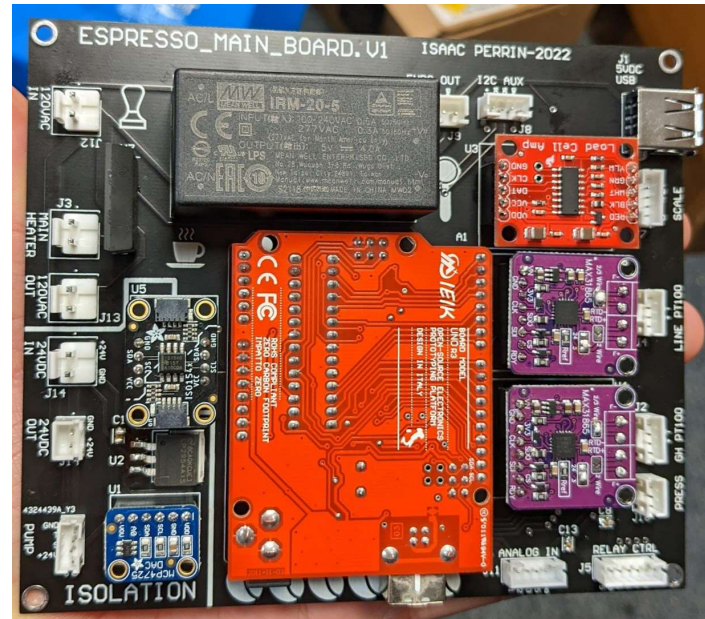


2-Way Serial Communication

Requested State

Actual State

## Arduino - Low Level Control



Hardware

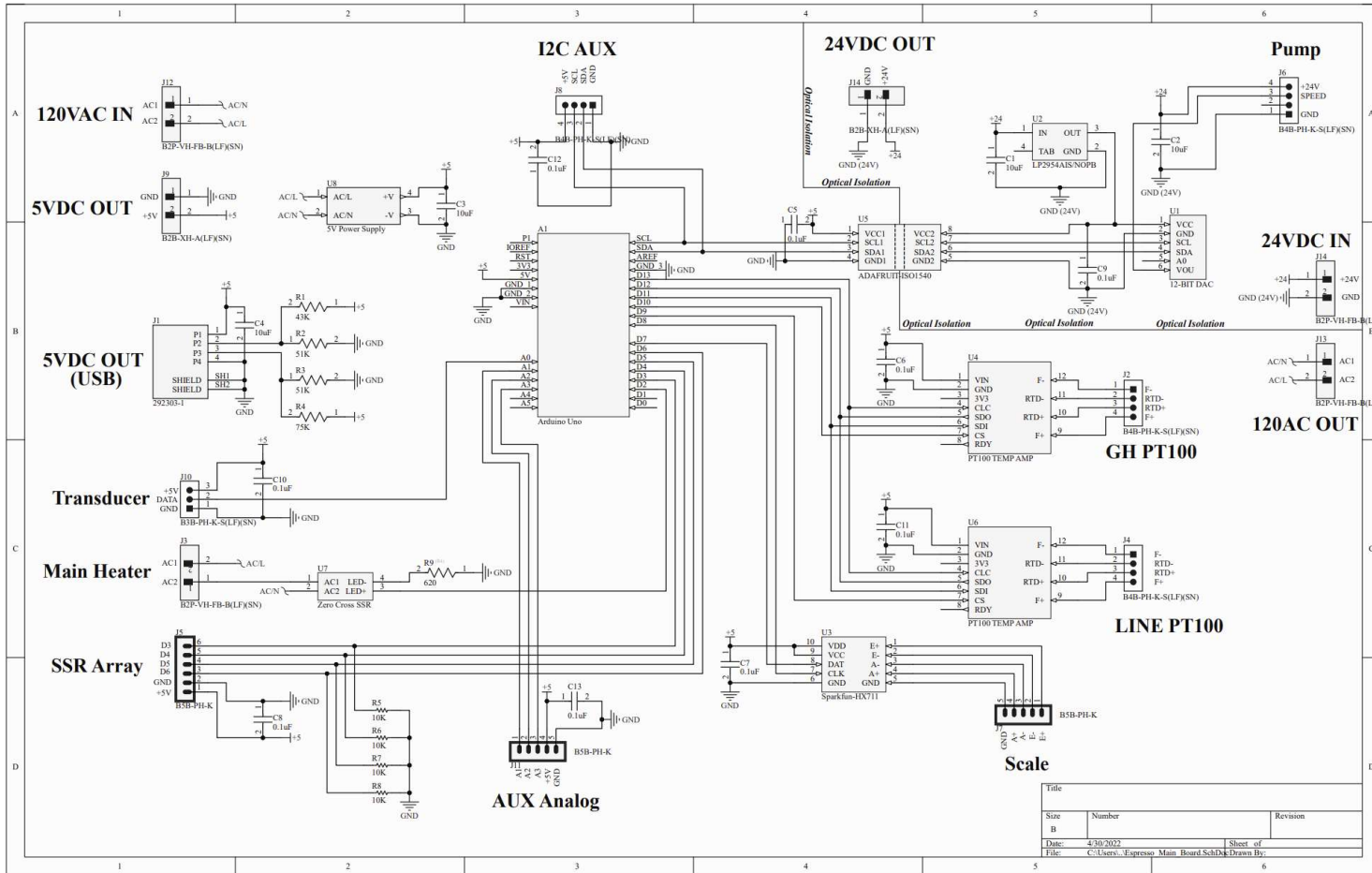
## Serial Communication Protocol

- GUI => Arduino
  - "SVVMMMMTTTK"
  - S start character
  - VV valve states 1/0 represent on/off
  - MMMM motor state - first character is M/P to represent pressure vs speed setting
  - TTT desired temperature in tenths (0 represents temperature control off)
  - K termination character
- Arduino => GUI
  - "SPPPPPPPTTTTTTTTGGGGGGGWWWWWWWWFFFFF\n" - 42 characters
  - S start character "S"
  - P (pressure+1000)\*100 (with leading zeros)
  - T (temperature+1000)\*100 (with leading zeros)
  - G (temperature+1000)\*100 (with leading zeros)
  - W (weight+1000)\*100 (with leading zeros)
  - F (frequency+1000)\*100 (with leading zeros)

# Electrical Schematic

Saturday, April 30, 2022 1:26 PM

- Most components are connect to or are mounted on the main PCB
- Not shown on PCB/schematic
  - 120VAC out and 24VDC IN connect to 24V DC Power Supply
  - 24VDC Out goes to an optically isolated FET controlled by a pin on the SSR array out - used to throttle the grouphead heater - will be put on the board in future iteration



# Mechanical Components

Saturday, April 2, 2022

3:23 PM

Item	Spec	Purpose	Link
Gear Pump	Diener Extreme Series Gear Pump  24VDC power 0-5V analog in control  35 Watt BLDC Motor  PEEK Gears	Pressurize the water	<a href="https://dienerprecisionpumps.com/precision-gear-pumps/">https://dienerprecisionpumps.com/precision-gear-pumps/</a> (purchased used on ebay)
Grouphead	Faema E98/2A	Connect to portafilter and direct water	<a href="https://www.coffeeparts.com.au/faema-spare-parts-1-group-head-e98-1a-2a">https://www.coffeeparts.com.au/faema-spare-parts-1-group-head-e98-1a-2a</a> (purchased used on offerup)
Line Solenoid Valve	Asco 1/4" Solenoid Valve (Normally Open)	Close the water loop so the portafilter can pressurize	<a href="https://www.grainger.com/product/ASCO-110-120V-AC-Brass-Solenoid-4EKZ6">https://www.grainger.com/product/ASCO-110-120V-AC-Brass-Solenoid-4EKZ6</a> (purchased used on ebay)
Heaters	In electrical components		
Plumbing Connections	Various		

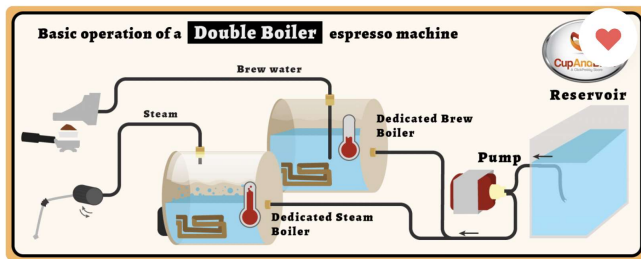
# Electrical Components

Saturday, April 2, 2022 3:23 PM

Item	Spec	Purpose	Link
Main Heater	120VAC - 500 Watts	Heat the water	<a href="https://www.amazon.com/DERNORD-Immersion-Cartridge-Heating-Replacement/dp/B074K98XR7/ref=sr_1_1?crid=2ESVBUEMQ5BW0&amp;keywords=cartridge+heater+1%2F2+npt+500w&amp;qid=1651349830&amp;sprefix=cartidge+heater+1%2F2+npt+500w%2Caps%2C154&amp;sr=8-1">https://www.amazon.com/DERNORD-Immersion-Cartridge-Heating-Replacement/dp/B074K98XR7/ref=sr_1_1?crid=2ESVBUEMQ5BW0&amp;keywords=cartridge+heater+1%2F2+npt+500w&amp;qid=1651349830&amp;sprefix=cartidge+heater+1%2F2+npt+500w%2Caps%2C154&amp;sr=8-1</a>
Grouphead Heater	24V 50 Watt 3D printer cartridge heater	Heat the grouphead	<a href="https://www.amazon.com/gp/product/B086JM394F/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;psc=1">https://www.amazon.com/gp/product/B086JM394F/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;psc=1</a>
Pressure Sensor	5VDC Analog Signal  0-200PSI	Measure pressure in the grouphead	<a href="https://www.amazon.com/gp/product/B0748CVN3F/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;th=1">https://www.amazon.com/gp/product/B0748CVN3F/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;th=1</a>
Water Temperature Sensor	PT100 Thermister - 3 Wire	Measure GH temp	<a href="https://www.amazon.com/gp/product/B07DP3X8BC/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;th=1">https://www.amazon.com/gp/product/B07DP3X8BC/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;th=1</a>
Grouphead Temperature Sensor	PT 100 Thermister - 3 Wire	Measure water temp	<a href="https://www.amazon.com/gp/product/B0711WRM4X/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;th=1">https://www.amazon.com/gp/product/B0711WRM4X/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;th=1</a>
I2C Optical Isolator	5VDC	Electrically isolate the pump to minimize noise	<a href="https://www.adafruit.com/product/4903">https://www.adafruit.com/product/4903</a>
I2C DAC	5VDC Analog Out	Give analog input to the pump to set speed	<a href="https://www.adafruit.com/product/4470">https://www.adafruit.com/product/4470</a>
PT100 Amplifier	5VDC Thermister Amplifier SPI Bus	Measure the PT100 resistance to get temperature readings	<a href="https://www.adafruit.com/product/3328">https://www.adafruit.com/product/3328</a>
Load Cell	4 Wire - 300g Single Point Weight Beam	Measure espresso mass	<a href="https://www.amazon.com/gp/product/B07NRVML17/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;psc=1">https://www.amazon.com/gp/product/B07NRVML17/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;psc=1</a>
Load Cell Amplifier	HX711 - 5 VDC 2-wire GPIO com	Measure load cell wheatstone bridge state to get mass	<a href="https://www.sparkfun.com/products/13879">https://www.sparkfun.com/products/13879</a>
Zero Cross SSR	SPST NO 5A	Controls the main heater	<a href="https://www.digikey.com/en/products/detail/ixys-integrated-circuits-division/CPC1998J/2561233">https://www.digikey.com/en/products/detail/ixys-integrated-circuits-division/CPC1998J/2561233</a>
24V Power Supply	100-150Watts power out	Power for the pump and GH heater	<a href="https://www.amazon.com/gp/product/B08D3QVTNY/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;psc=1">https://www.amazon.com/gp/product/B08D3QVTNY/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&amp;psc=1</a>
Optically Isolated FET Circuit	Generic	Control the grouphead heater	Standard FET and optocoupler circuit

## Dedicated Brew Boiler (Dual Boiler) (E98)

- Running espresso brewing on a single boiler at the brew temperature
- No need for syphons or complex methods to cool the grouphead below water temperature
- Fine control on grouphead temperature
- Usually a supply and return line goes to the grouphead to allow passive convective heat transfer to preheat the grouphead



## Advanced Dual Boiler

- Synesso machines and Decent
- Run a dedicated brew boiler at a relatively lower end of espresso temps
- Use mixing valves to combine water from both boilers and/or a heat exchanger in the steam boiler to get a source of cold and hot water
- Good thermal control
- Can rapidly change temperatures

## Thermosyphon/HX Design (E61)

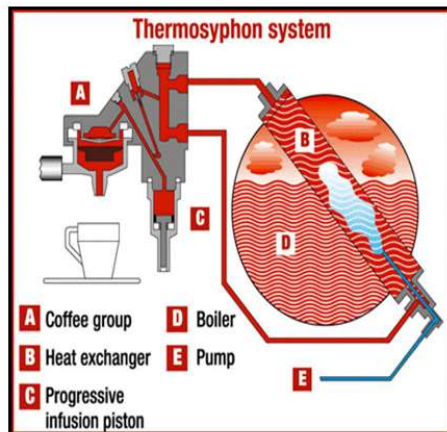
- For running a steam/espresso machine on a single steam boiler
- Complex thermosyphon/HX design is used to get grouphead at a specific temperature for extraction (less than boiler temperature)
- Lack of fine control on grouphead temperature

*HX/ Heat-Exchanger*

Pump (E) inactivated= the water in it tends to raise its temperature at the same level with the surrounding water

Pump(E) activated=we have a complex water boiling process as well as a blend of cold and hot boiling water

Everything is based on liquid thermodynamics, having as a result an appropriate extracting temperature



## Thermoblock (Breville Barista Pro)

- In low cost machines
- Preheating doesn't include water, just the block
- Lowest amount of control
- Heats water as used and injects directly into grouphead (one way) or into steam wand



# Resources

Saturday, April 2, 2022

3:05 PM

- Resources
  - <https://build-its-inprogress.blogspot.com/search/label/Esspresso%20Machine>
  - [https://www.reddit.com/r/Coffee/comments/63k31b/diy\\_esspresso\\_machine\\_what\\_are\\_the\\_key\\_elements\\_to/](https://www.reddit.com/r/Coffee/comments/63k31b/diy_esspresso_machine_what_are_the_key_elements_to/)
  - [Product Review: Decent DE1+ Espresso Machine](#)