



Fun Low-power Observer-interactive Waterfall

Sponsored by Orlando Utility Commission

Group 5 - Blue Team

Connor Heckman - CPE

Ben King - EE

Robert Perkins - EE

Jack Gray - EE

Motivation

- Existing solar sculptures static and unappealing
- Create excitement about solar energy
- Remove industrial stigma of solar panel appearance
- Bridge the gap between artistic appeal and solar powered technology
- Show obvious and interesting use of solar power



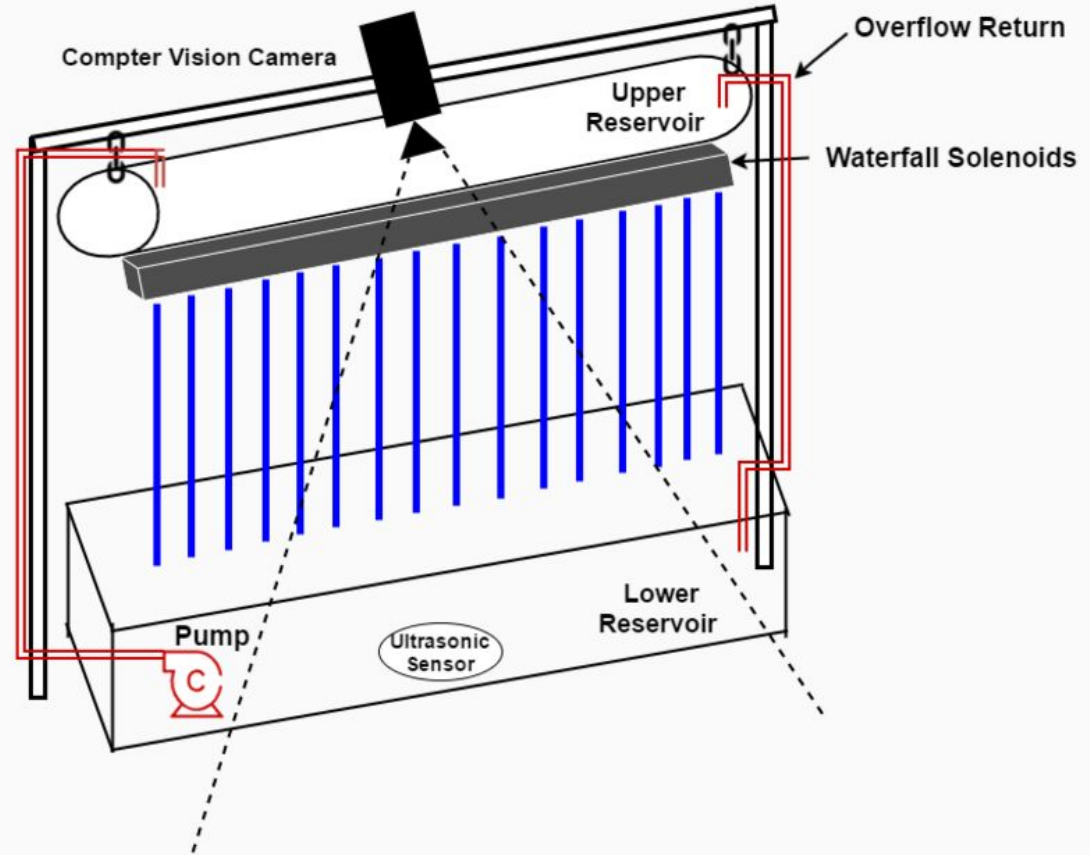
Goals and Objectives

- Design an interactive feature for a solar sculpture
 - Draw attention and entertain onlookers
- Power interactive feature while maintaining net gain
- Design with reliability and maintenance in mind
- Collaborate with mechanical engineering and art teams

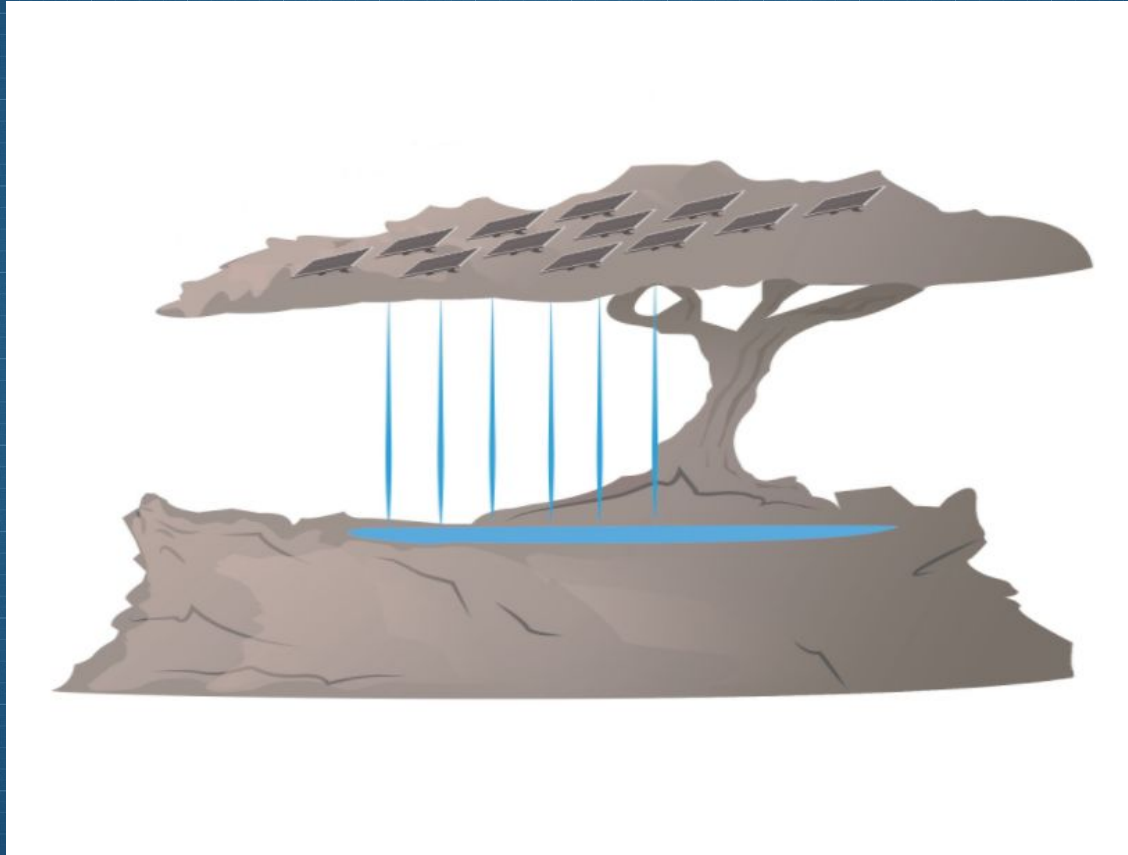
Prototype Diagram

- Computer Vision Camera
 - Capture motion of onlookers
 - PixyCam to Arduino
- Water Solenoid Array
 - Motion data sent to MSP430
- Submersible Pump
 - Supplies upper reservoir
- Overflow Return
 - Maintain constant level in upper reservoir
- Ultrasonic Sensor
 - Monitors water level

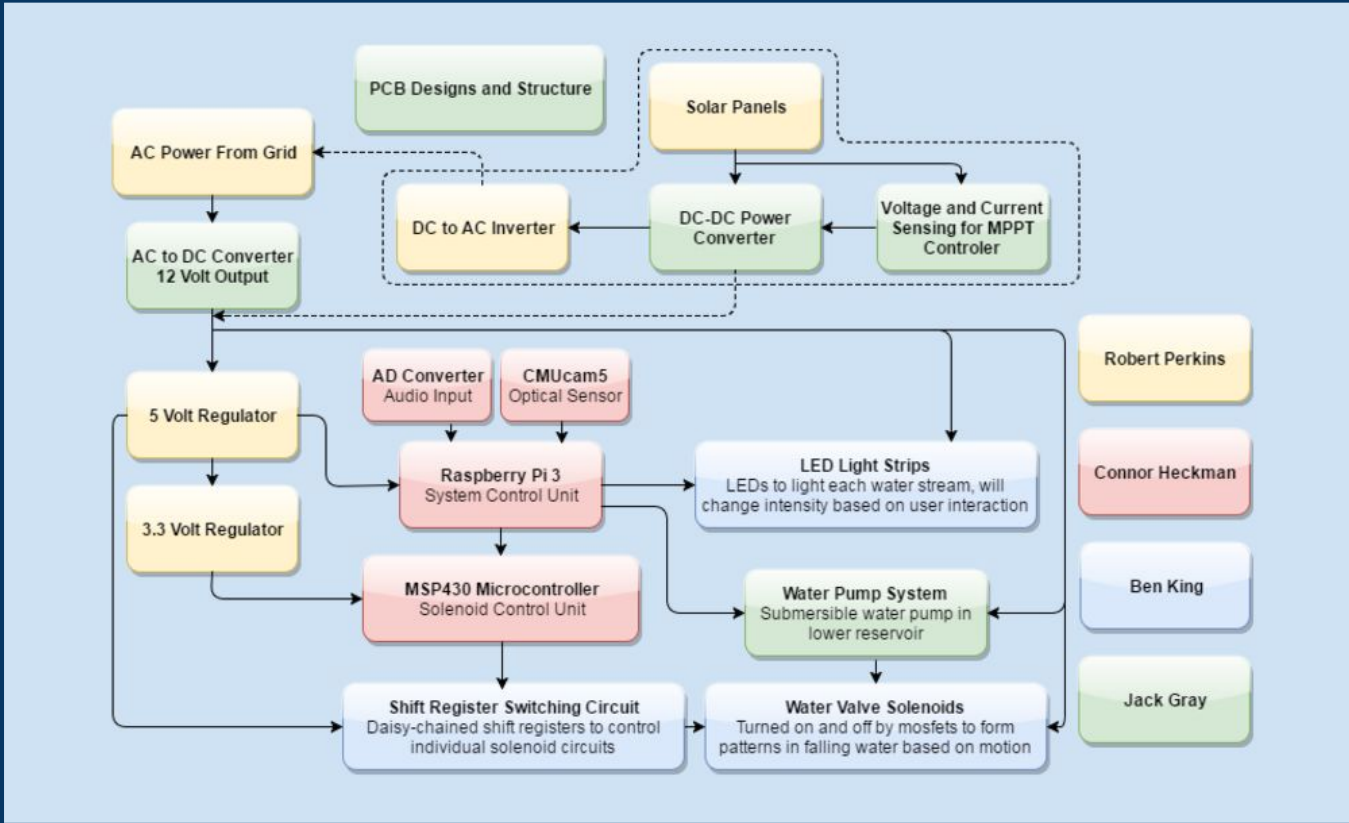
Interactive Waterfall Diagram



Artist Incorporation - "Rain Forest"

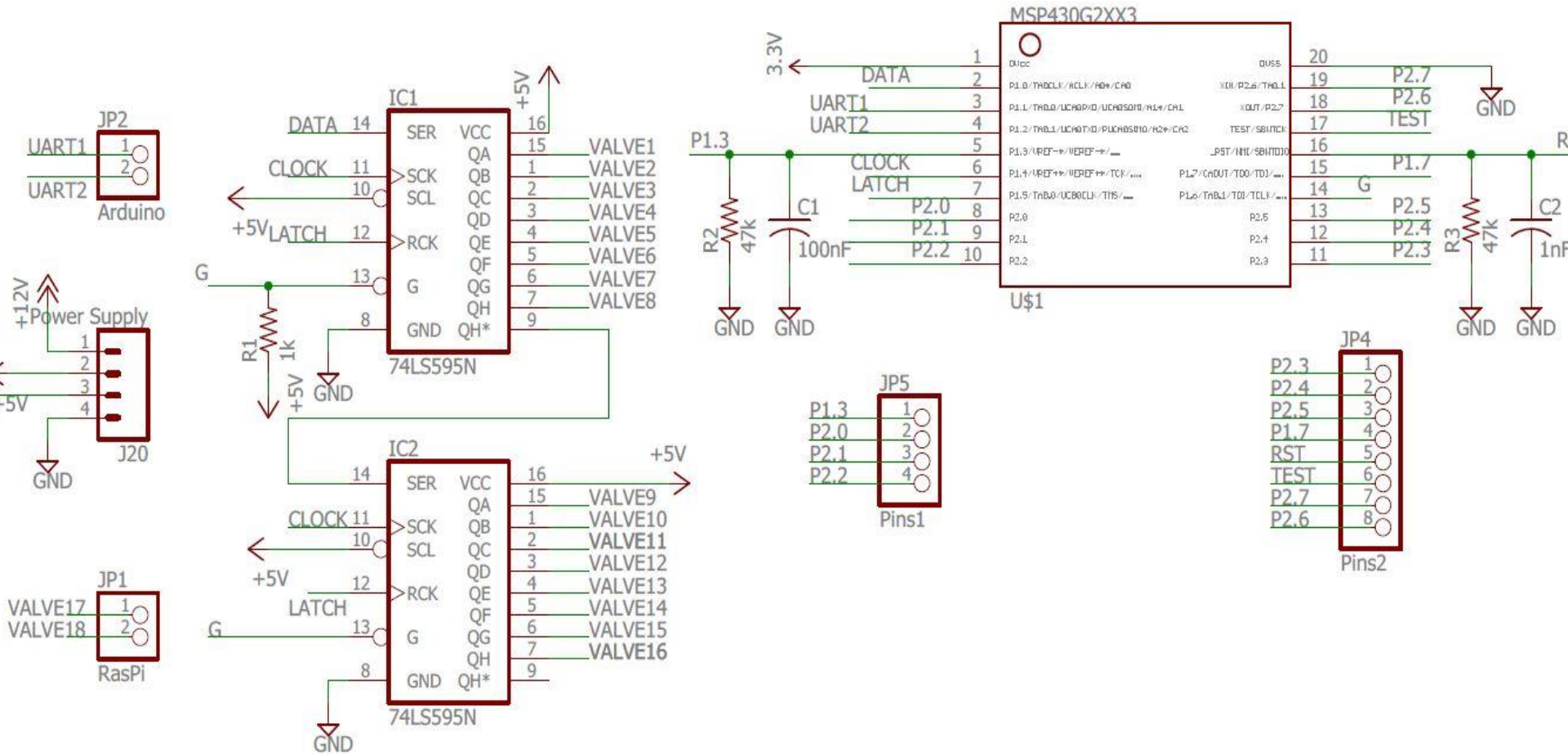


Block Diagram

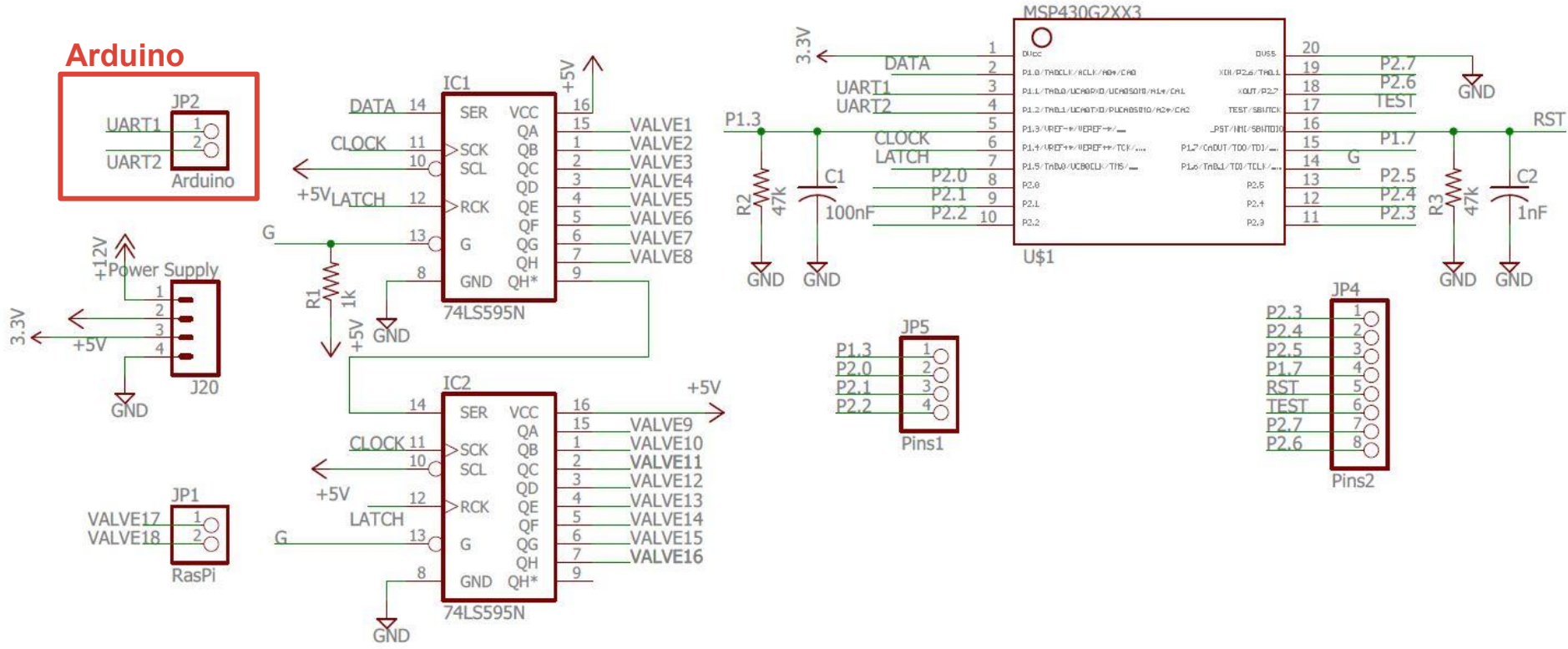


Project Specifications

| Parameter | Specification |
|------------------------------|----------------------------|
| Location | Laureate Park Lake Nona |
| Dimensions | Scale Model (2.25ft x 4ft) |
| Prototype budget | \$1,000 |
| Max power consumption | 180 W |
| Max motion recognition range | 8ft |
| Solenoid Response time | < 25 ms |

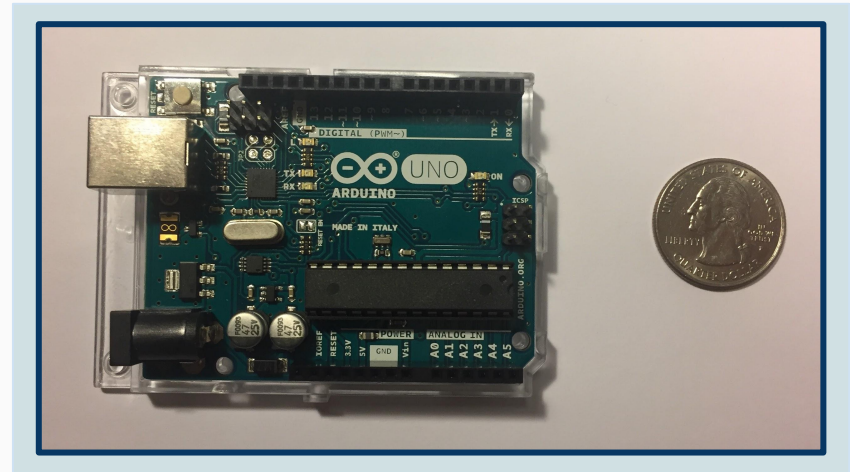


PCB Schematic MCUs



Arduino Uno R3 Specifications

- ATmega328 microcontroller
 - Improved speed and memory
- 16 MHz clock speed
- Operating Voltage - 5 Volts
- Free and open source dev environment
- Serial Communication - UART, SPI, I2C
- Cost - \$24.95



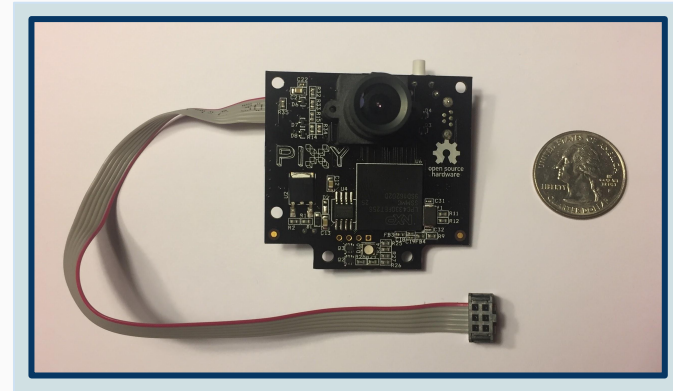
Vision System Component Selection

- Onboard processor and open source software/firmware preferable
- Power consumption and unit maintenance
- Resolution concerns

| System | Method | Lowlight/Outdoors | Communication | Pricing |
|--------------|-------------------|----------------------------------|---------------------|----------|
| Xbox Kinect | IR depth sensor | Performance suffers | USB | \$99.99 |
| CMUcam5 | RGB color tagging | Auto-exposure, Auto-gain | SPI, I2C, UART, USB | \$69.00 |
| FLiR Thermal | IR thermal imager | comparative thermal segmentation | SPI, I2C | \$259.95 |

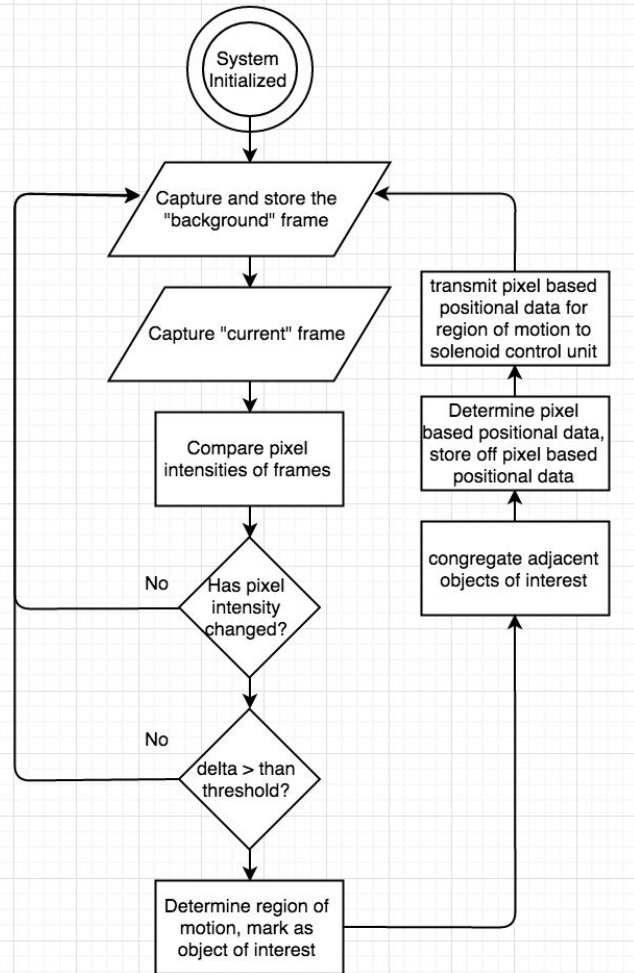
CMUcam5 (Pixy cam) Specifications

- Onboard processor - NXP LPC4330, 204 MHz, dual core
 - supports C/C++ and Python
 - Arduino and OpenCV libraries supported
- Optical sensor - Omnivision OV9715, 1/4", 1280x800
 - Adjustable framerate and resolution
 - Detects objects using “learned” color signatures
- Power consumption - 140 mA @ 5 volts
- Configuration software application is open source

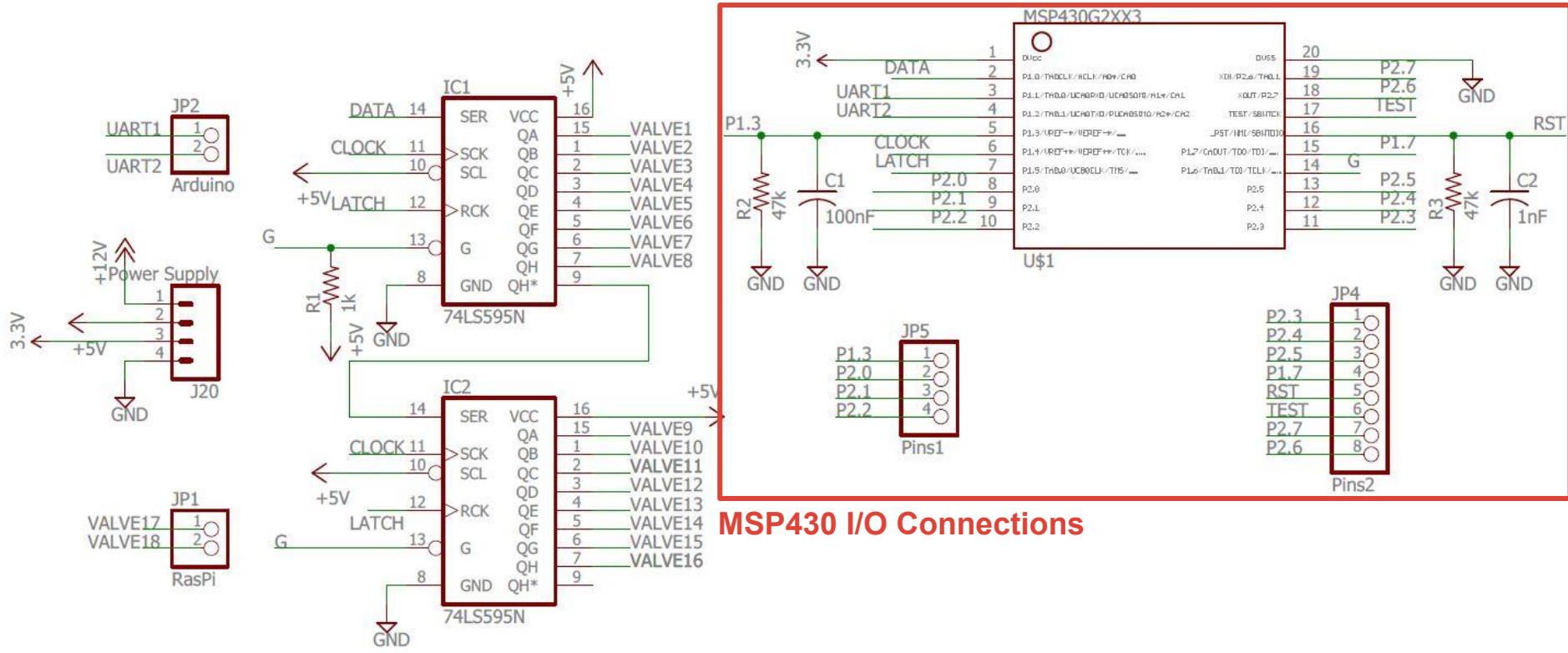


Computer Vision System Design

- Motion Segmentation using OpenCV libraries on Pixy cam
- Gaussian filter to eliminate image noise
- Arithmetic image difference calculation
- Hysteresis thresholding to eliminate background movement
- Aggregating regions of motion into “objects” of interest



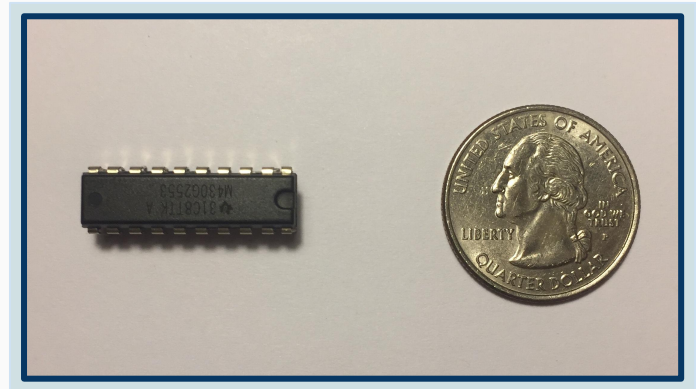
PCB Schematic MCUs



MSP430 I/O Connections

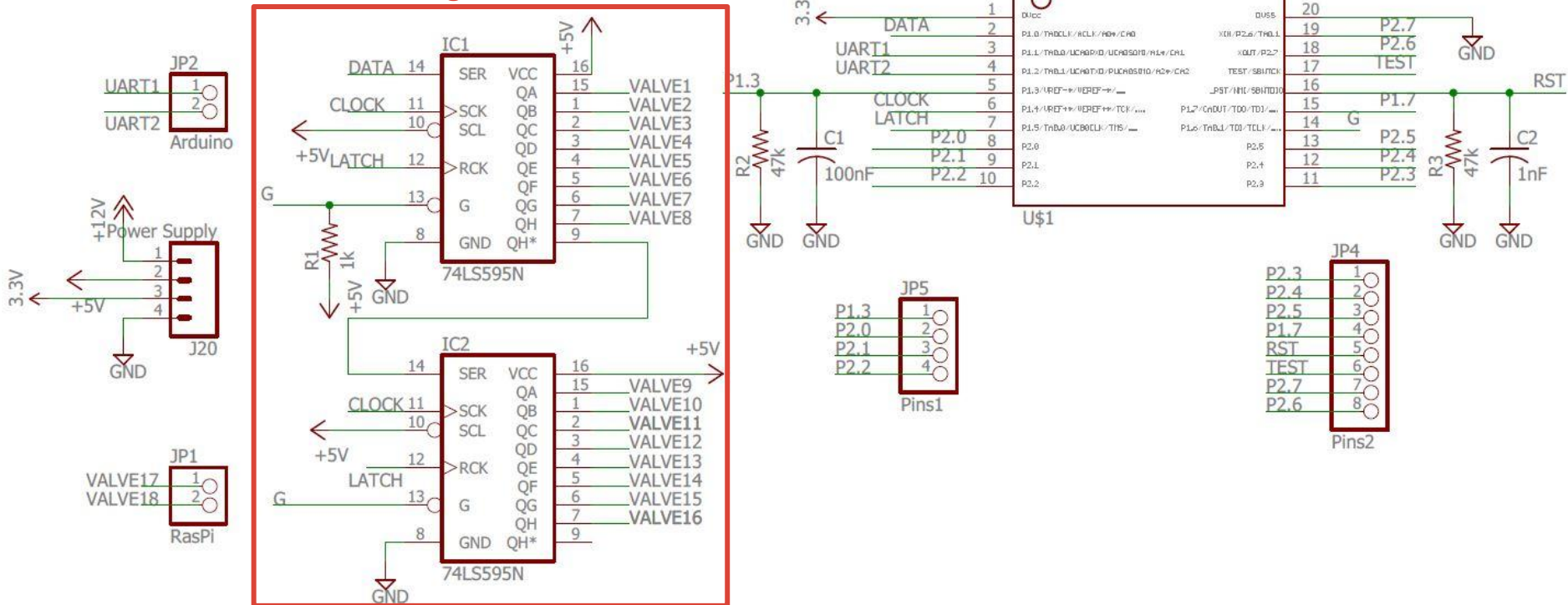
MSP430G2553 Specifications

- Increases modularity in the system
- TI ultra low power instrument - 230 μ A @ 3.3V
 - Running at 1MHZ
- Serial communication - I2C, SPI, UART
- 16 bit architecture
- Code composer IDE
- Cost - \$19.75



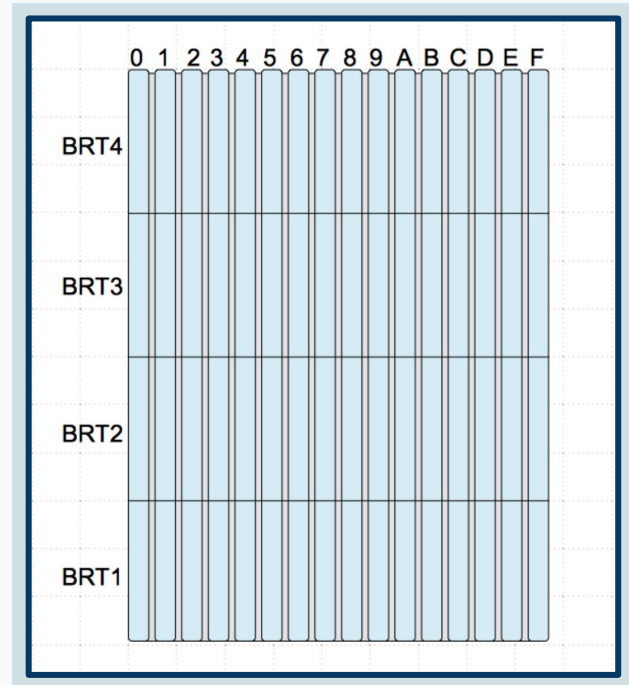
PCB Schematic Solenoid Switching Circuit

8-bit Shift Registers

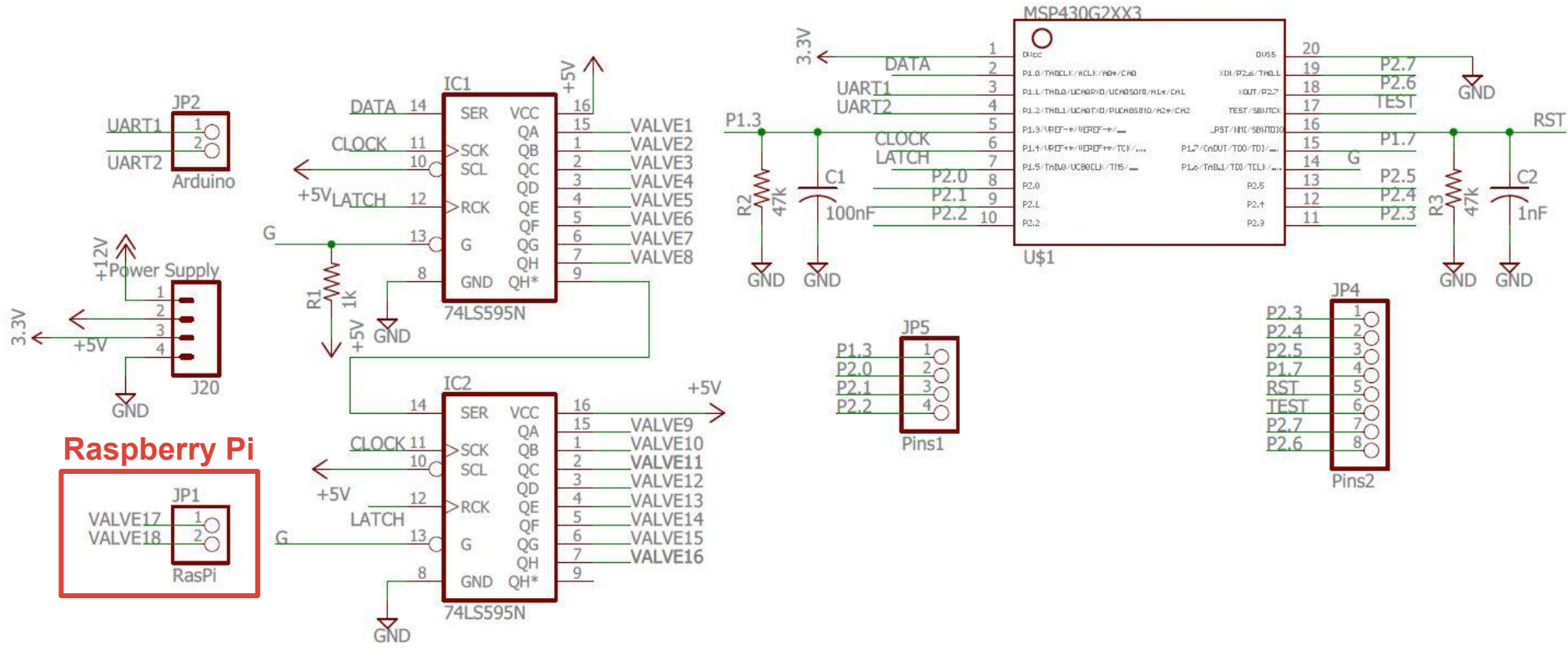


Solenoid Control Unit

- Interprets image difference map
- Graphical waterfall array visualized on right
- Performs resolution scaling
- Preprogrammed aesthetic functions
- Capable of spelling out words letter by letter

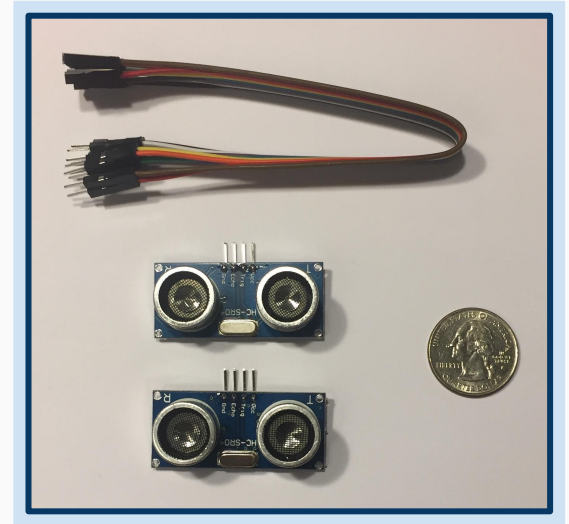


PCB Schematic MCUs



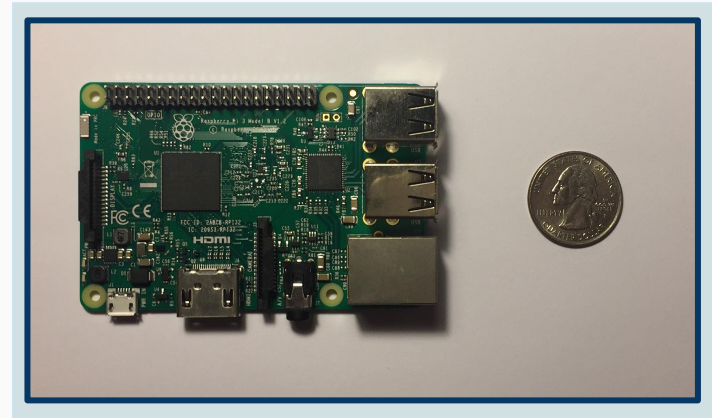
System Monitor Unit

- Submersible pump regulation
 - Monitor lower reservoir with ultrasonic sensor
 - Activate and deactivate pumps as needed
- Mode resolution
 - Motion capture mode
 - Aesthetic display mode
 - Letter Dictation mode

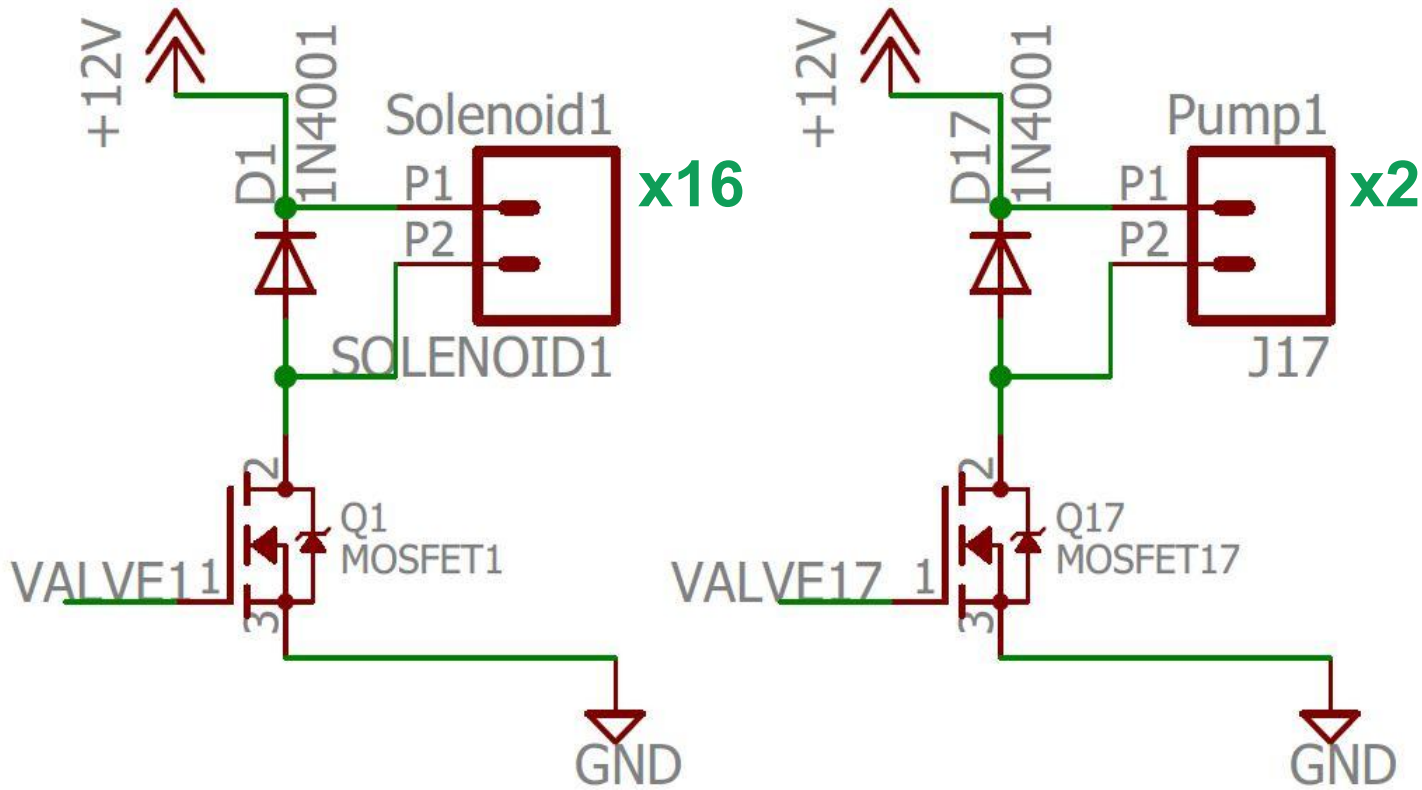


Raspberry Pi 3 Specifications

- ARM Cortex-A53 microcontroller
 - 1GB memory
 - Wifi and Bluetooth capabilities
- 1.2GHz Clock Speed
- Easy to setup a Raspbian control terminal
- Serial Communication - UART, SPI, I2C
- Cost - \$39.96



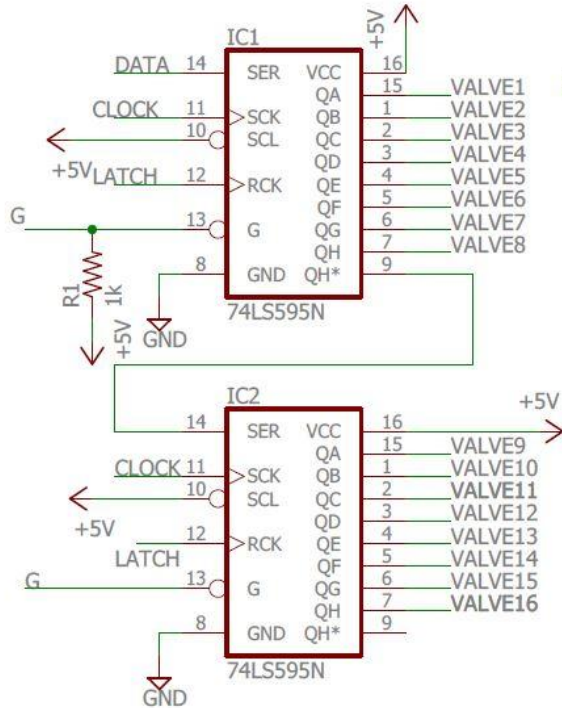
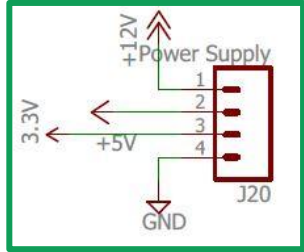
PCB Schematic Switching Circuit



PCB Schematic



Power Supply



Power Needs

| Voltage | Component(s) |
|---------|---|
| 12V | (16) Solenoid Array and (2) Water Pumps |
| 5V | Raspberry Pi, Arduino, and 8-bit Shift Register |
| 3.3V | MSP430G2553 |

Power Limitations

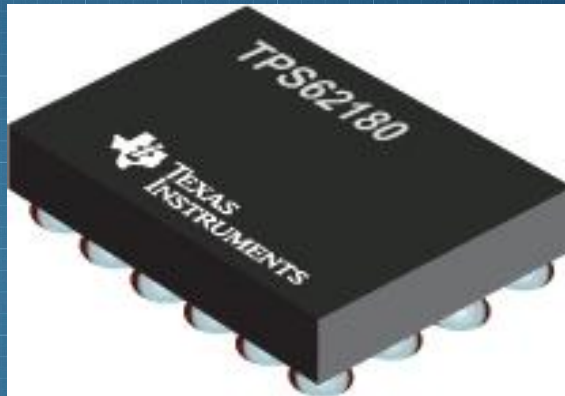
- Low power considerations
- Necessary for solar powered operation
- Low power components
 - Normally closed valves
 - Low power water pump



Integrated Step-Down Chips

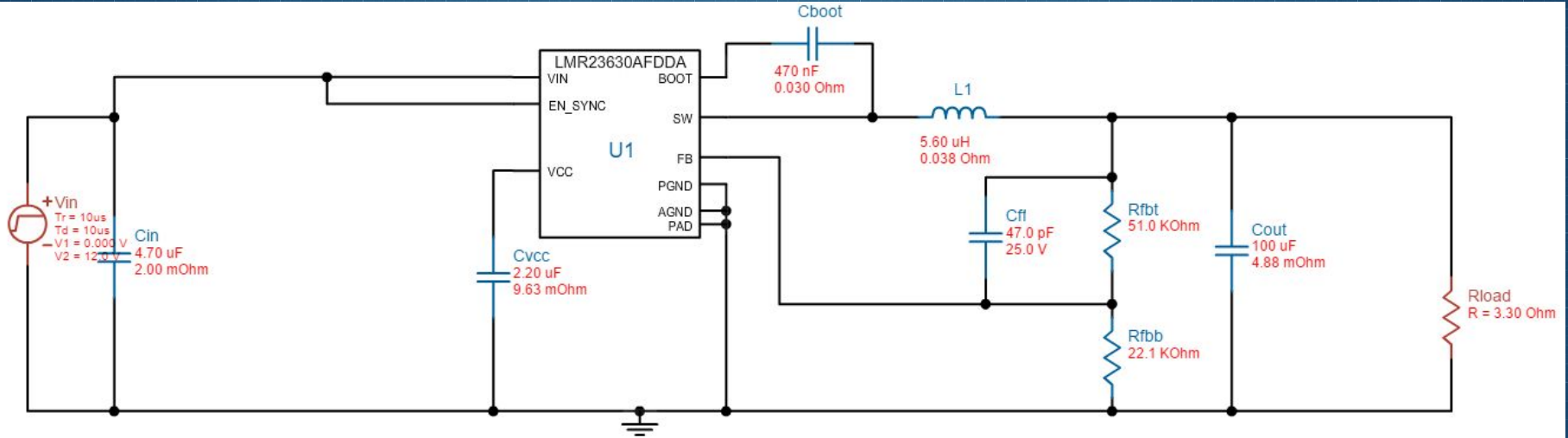


- 4.5V to 36V input
- 1V to 30V output @ 3A
- Protective features for reliability
- 400 kHz switching frequency

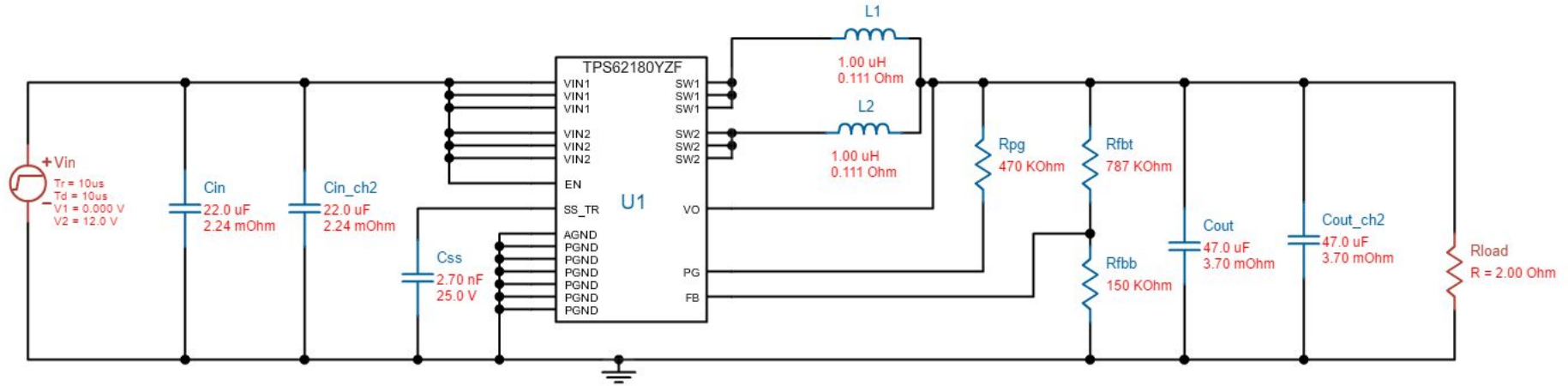


- 4V to 15V input
- 0.9V to 6V output
- Max switching frequency 2000kHz
- Dual Phase

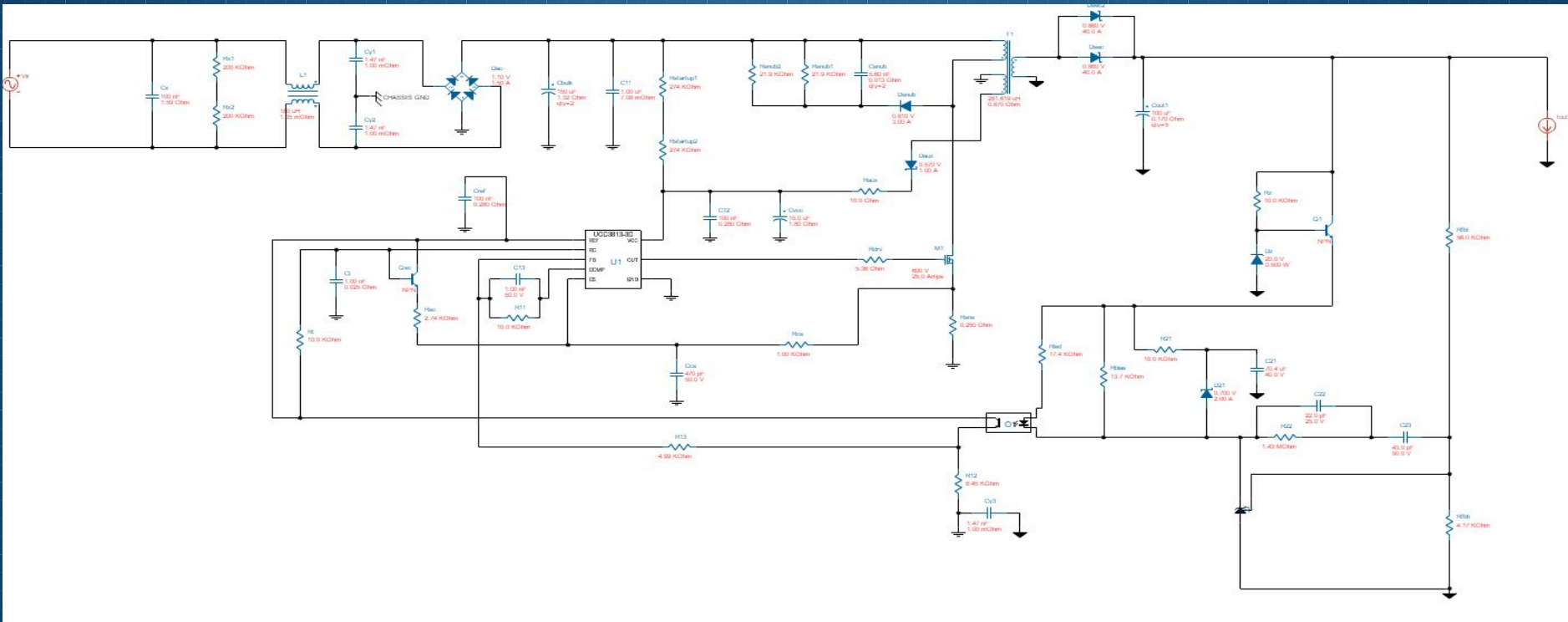
Power Schematic 3.3 Volt



Power Schematic 5 Volt

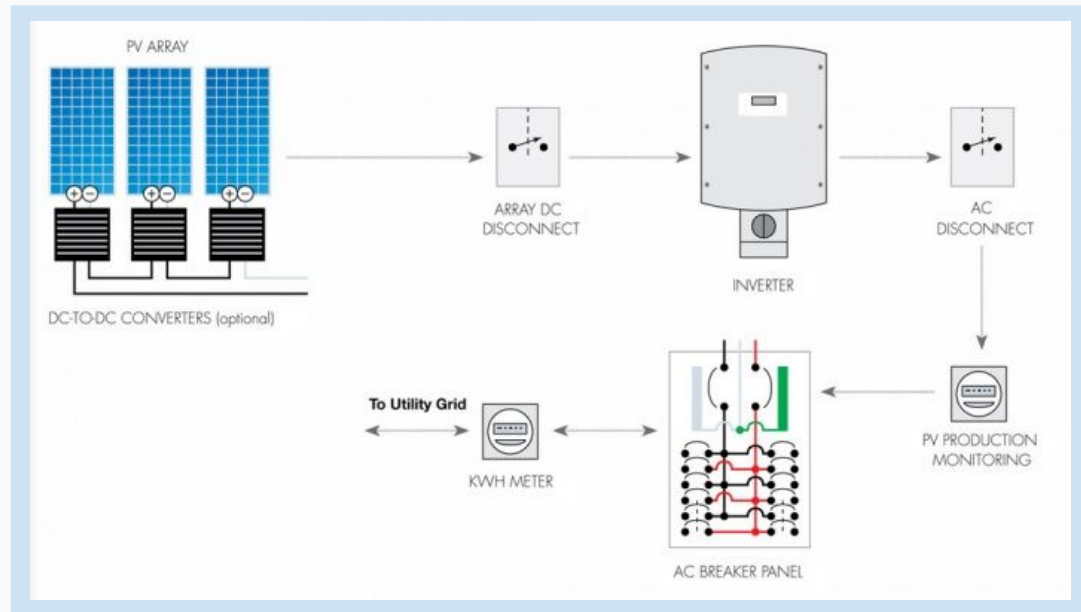


Power Rectifier

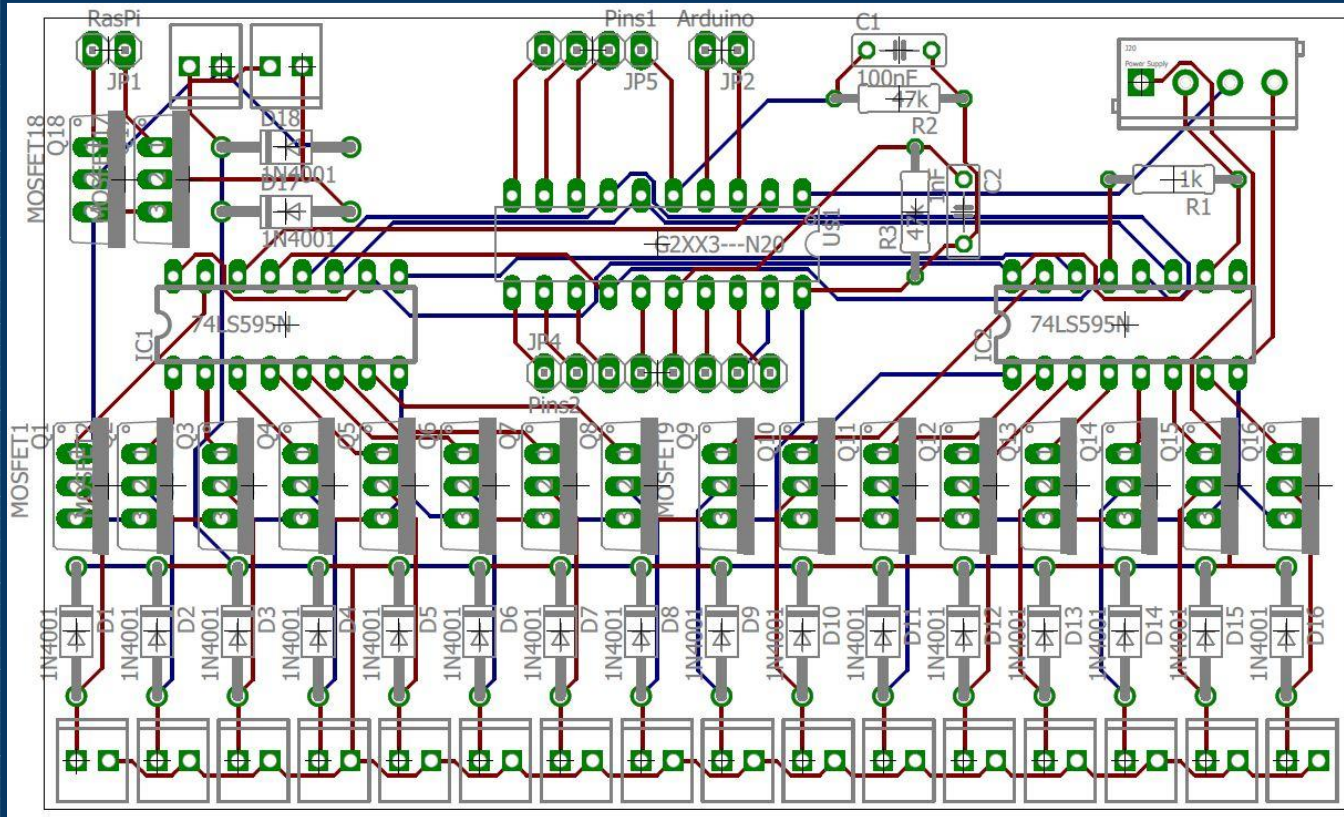


Inverter and Solar Panels

- Custom inverter design not needed by customer
- Sponsor requires UL listed inverter that is up to code
- Price prohibitive
- High complexity



PCB Board Layout



Administrative Content

Budget

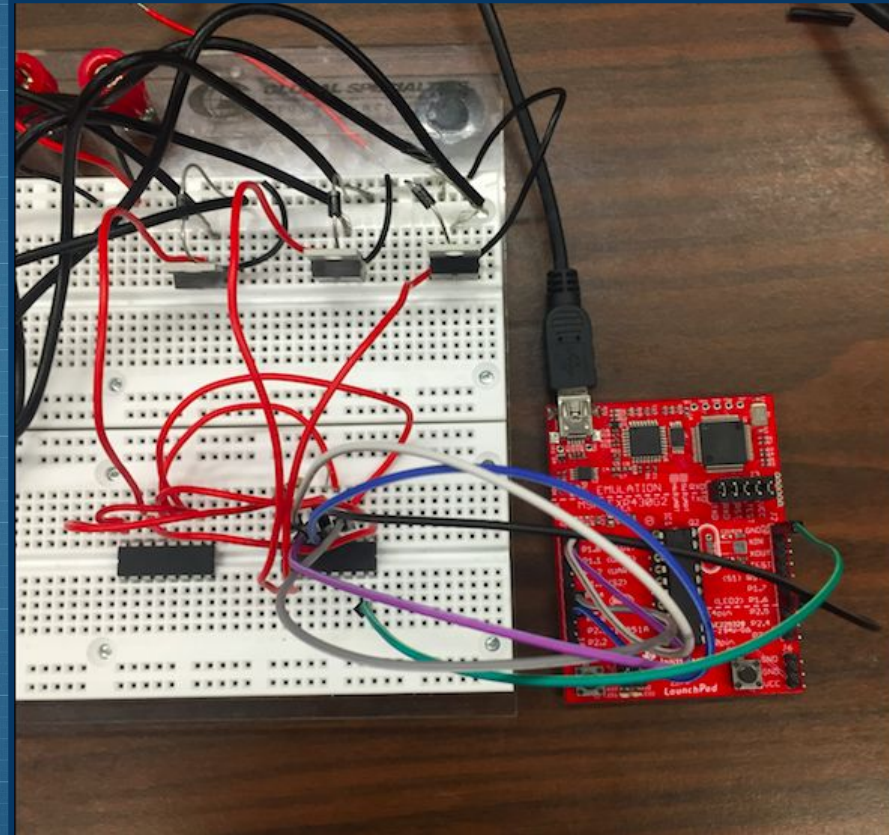
| Item | Supplier | Quantity | Price Each | Item Total | Item | Supplier | Quantity | Price Each | Item Total |
|--|----------|----------|------------|------------|----------------------------|------------|----------|------------|------------------|
| Waterfall Electronics | | | | | Waterfall Materials | | | | |
| Pixy Cam | Amazon | 1 | \$ 69.00 | \$ 69.00 | Quick Connects (Pack of 5) | Amazon | 10 | \$ 4.79 | \$ 47.90 |
| MSP430G2553 | TI | 1 | \$ - | \$ - | PVC Caps | Home Depot | 2 | \$ 7.94 | \$ 15.88 |
| Raspberry Pi | Amazon | 1 | \$ 39.96 | \$ 39.96 | PVC Tubes | Home Depot | 1 | \$ 20.97 | \$ 20.97 |
| Arduino R3 Uno | Amazon | 1 | \$ 27.99 | \$ 27.99 | Pump Tubing | Home Depot | 1 | \$ 16.89 | \$ 16.89 |
| Aubig DC 12V Water Pump | Amazon | 2 | \$ 25.76 | \$ 51.52 | | | | | |
| Screw Terminals 2.54mm Pitch (2-Pin) | Sparkfun | 20 | \$ 0.75 | \$ 15.00 | Power Components | | | | |
| Break Away Headers | Sparkfun | 1 | \$ 1.50 | \$ 1.50 | Power Supply 12V 20A | Amazon | 1 | \$ 21.88 | \$ 21.88 |
| Screw Terminals 3.5mm Pitch (2-Pin) | Sparkfun | 4 | \$ 0.95 | \$ 3.80 | Power Cord 12ft | Amazon | 1 | \$ 6.85 | \$ 6.85 |
| Female Headers | Sparkfun | 1 | \$ 1.50 | \$ 1.50 | Printed Circuit Board | Elecrow | 3 | \$ 34.50 | \$ 103.50 |
| Electric Solenoid Valve 12VDC | Amazon | 16 | \$ 11.77 | \$ 188.32 | Power PCB Components | Mouser | 1 | \$ 30.00 | \$ 30.00 |
| MOSFT 30V 62A 9mOhm 8nC | Mouser | 16 | \$ 0.92 | \$ 14.72 | | | | | |
| 1N4001 Diodes | Mouser | 16 | \$ 0.11 | \$ 1.76 | | | | | |
| Ultrasonic Sensor (Pack of 5) | Amazon | 1 | \$ 8.99 | \$ 8.99 | | | | | |
| 74HC595 8-bit Shift Register (Pack of 5) | Addicore | 1 | \$ 5.95 | \$ 5.95 | Total | | | | \$ 693.88 |

TOTAL:
\$693.88

Work Distribution

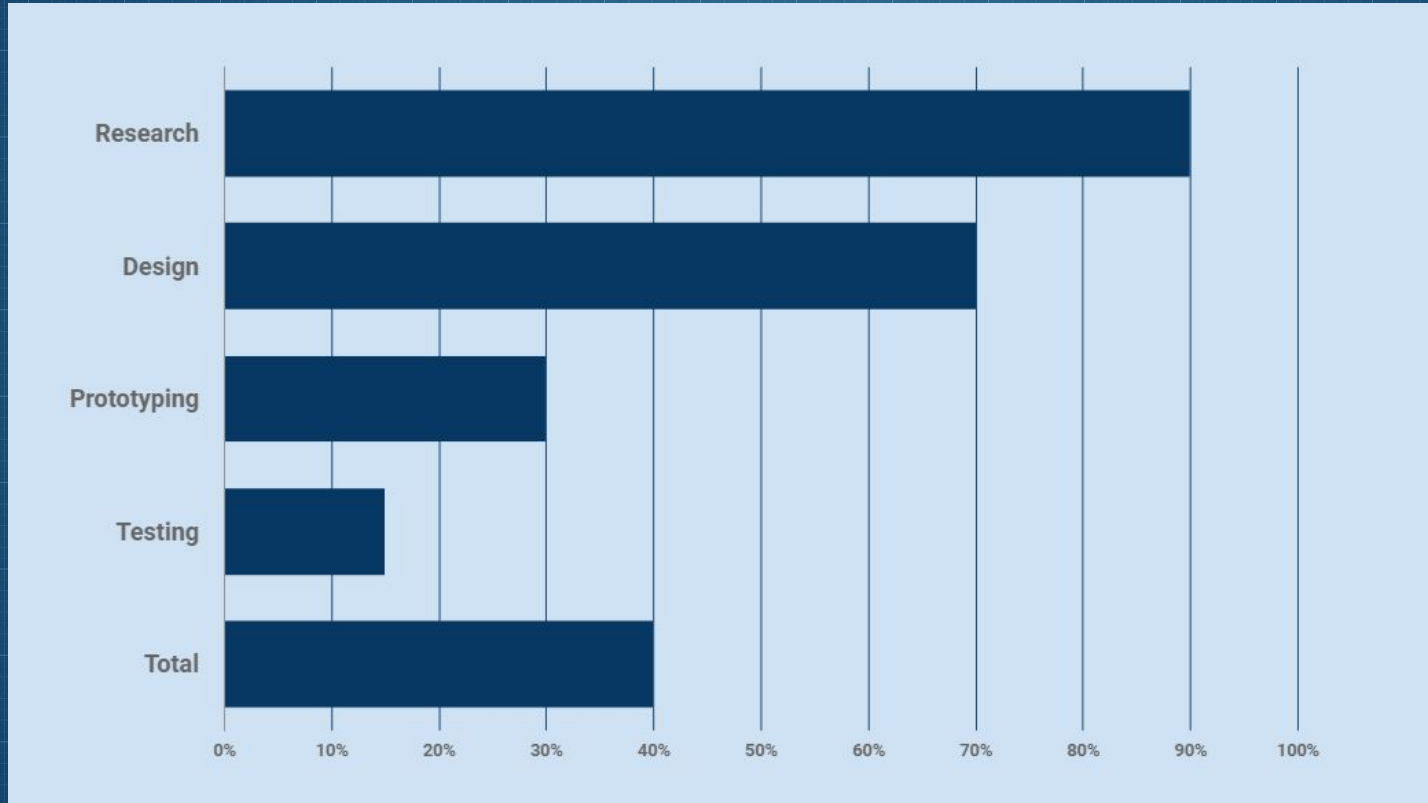
| Name | Computer Vision | Power Supply | PCB Layout | Water Feature Design |
|----------------|-----------------|--------------|------------|----------------------|
| Connor Heckman | X | | | |
| Tahte Perkins | | X | | |
| Ben King | | | | X |
| Jack Gray | | | X | |

Prototype Progress



```
block 0: sig: 1 x: 161 y: 127 width: 29 height: 28
Detected 1:
block 0: sig: 1 x: 164 y: 126 width: 28 height: 28
Detected 1:
block 0: sig: 1 x: 163 y: 126 width: 30 height: 30
Detected 1:
block 0: sig: 1 x: 163 y: 120 width: 30 height: 28
Detected 1:
block 0: sig: 1 x: 163 y: 122 width: 30 height: 30
Detected 1:
block 0: sig: 1 x: 165 y: 120 width: 30 height: 31
Detected 1:
block 0: sig: 1 x: 165 y: 113 width: 31 height: 31
Detected 1:
block 0: sig: 1 x: 163 y: 109 width: 29 height: 30
```

Overall Progress



Questions?