Fun Low-power Observer-interactive Waterfall

Sponsored by Orlando Utility Commision

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

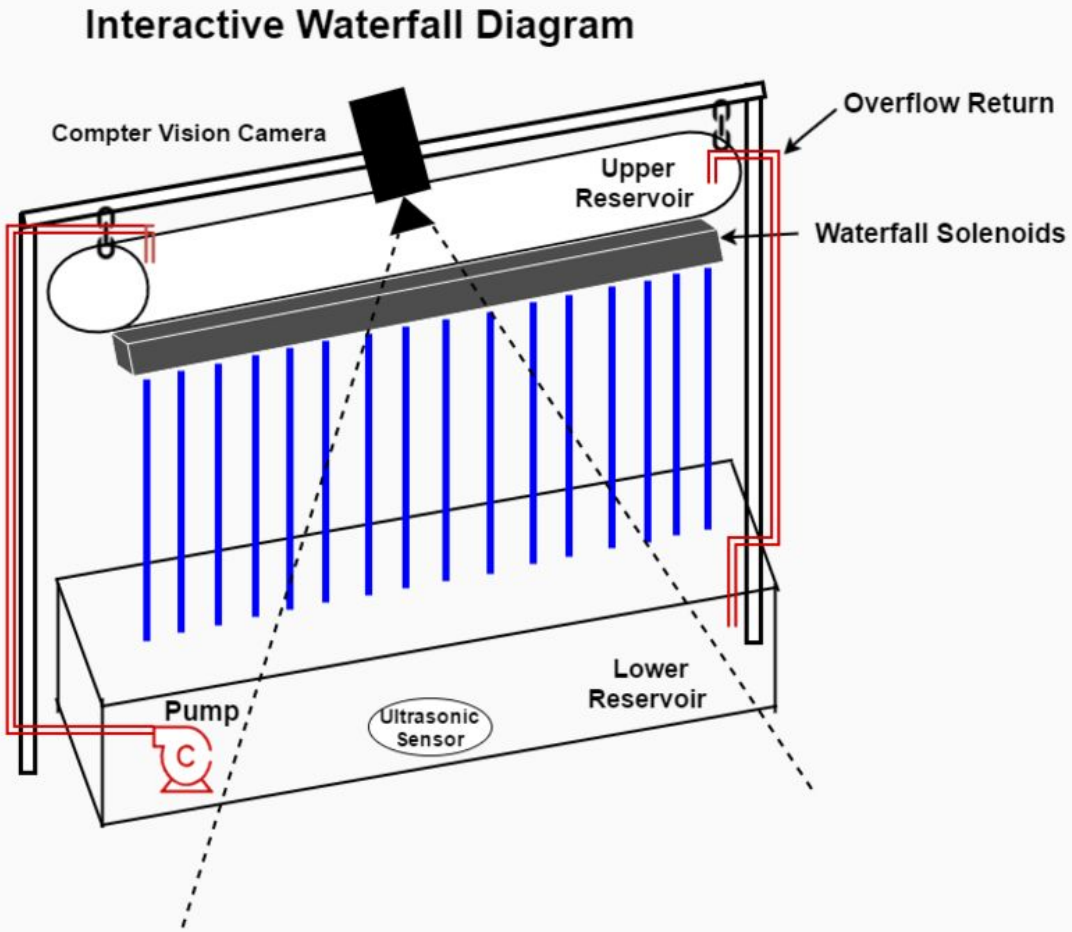

OUC

Goals and Objectives

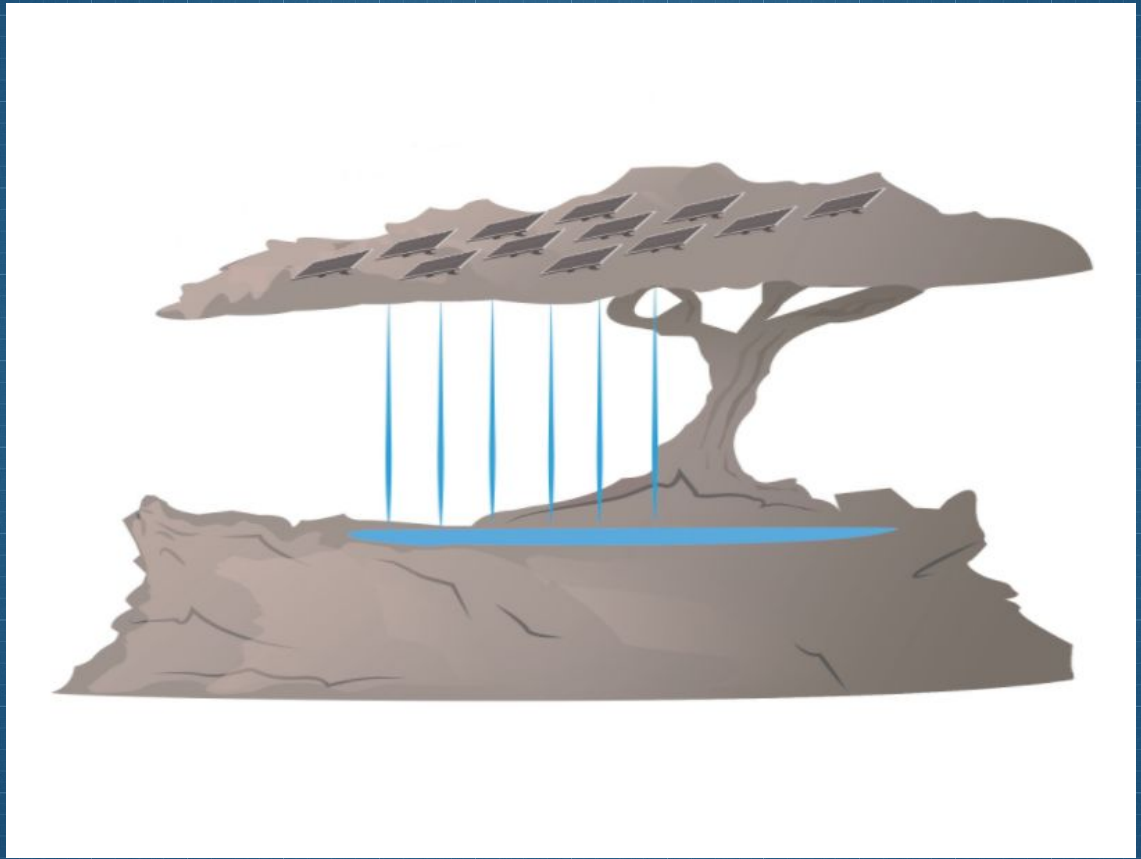
- Design an interactive feature for a solar sculpture
  - Draw attention and entertain onlookers
- Power interactive feature while maintaining net gain
- Design with reliability and maintenance in mind
- Collaborate with mechanical engineering and art teams

Prototype Diagram

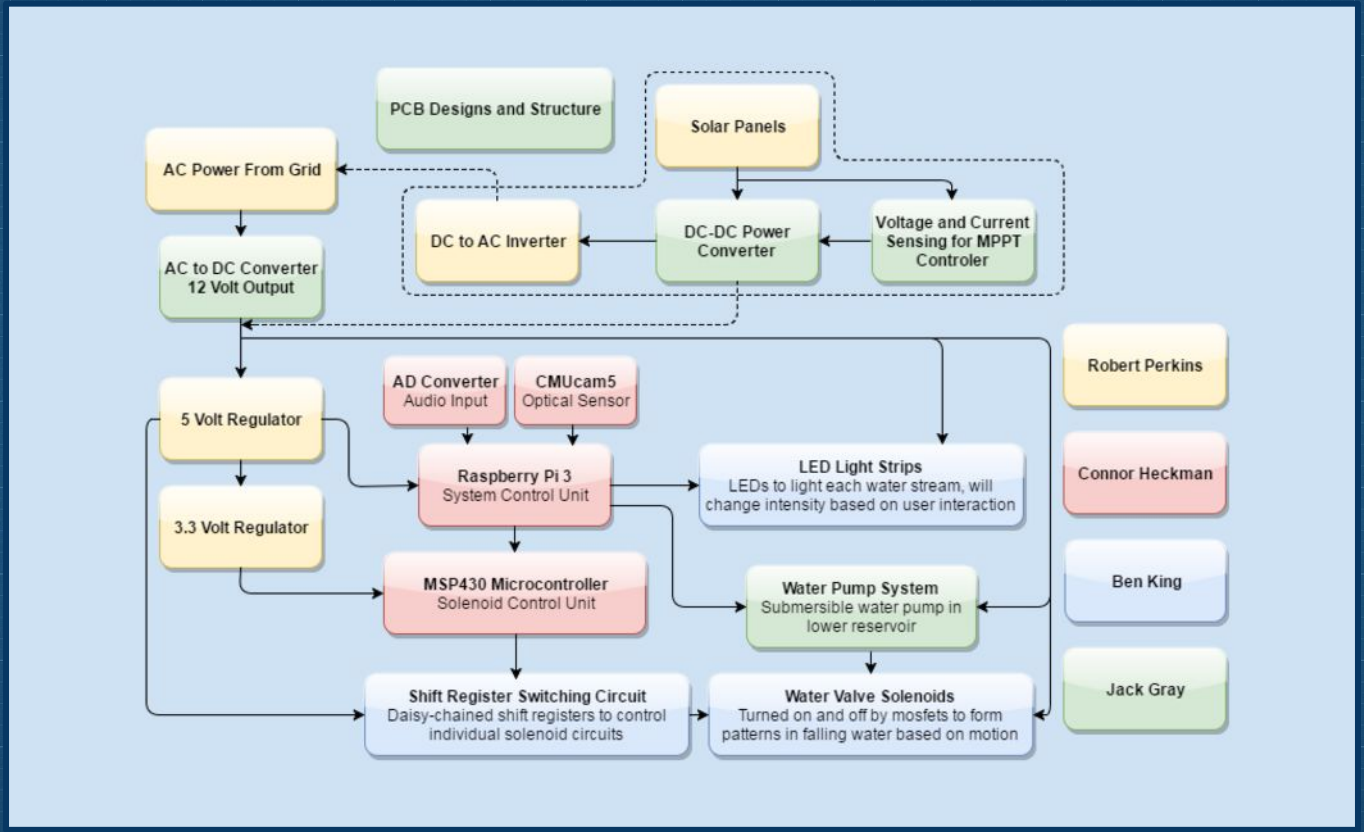
- Computer Vision Camera
  - Capture motion of onlookers
  - PixyCam to Raspberry Pi
- Water Solenoid Array
  - Motion data sent to MSP430
- Submersible Pump
  - Supplies upper reservoir
- Overflow Return
  - Maintain pressure in upper reservoir



Artist Incorporation - “Rain Forest”



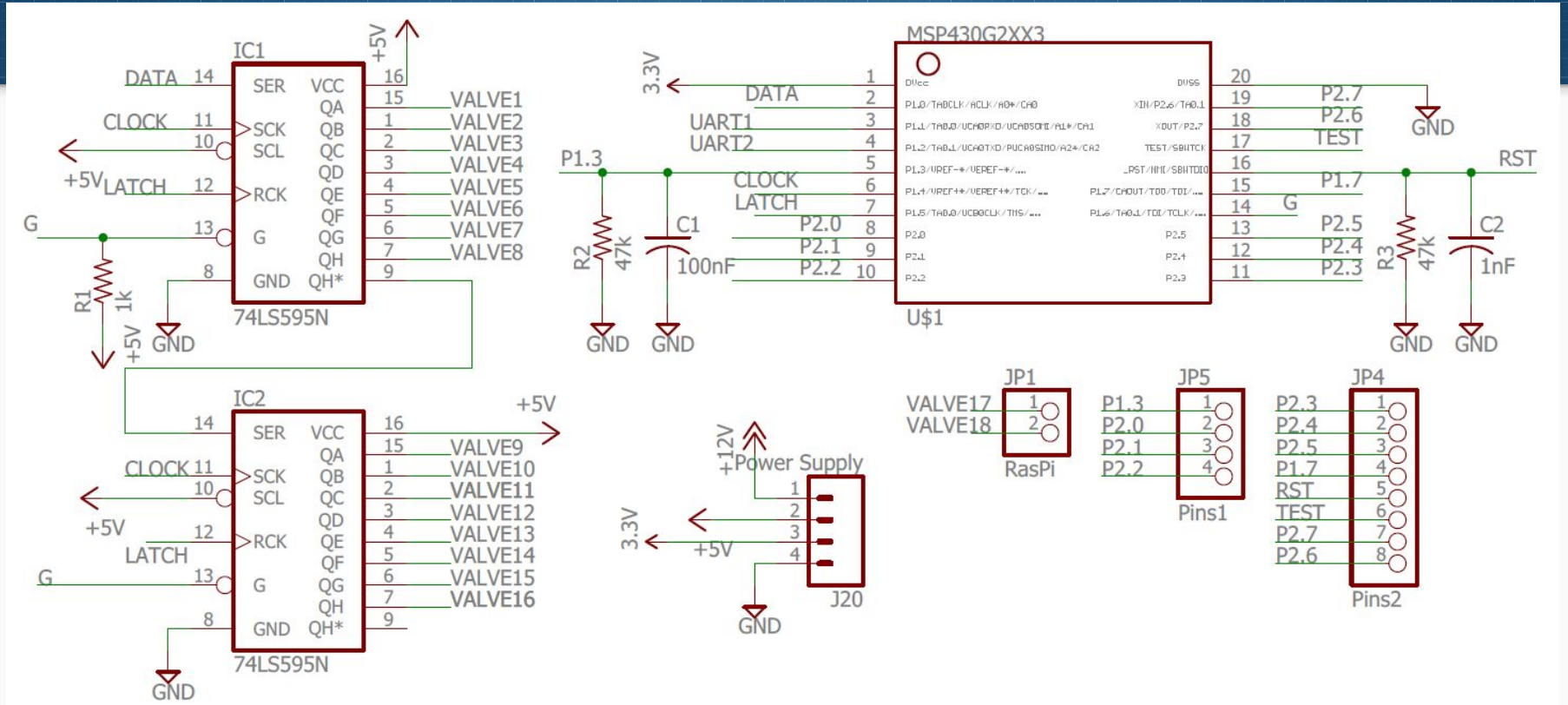
Block Diagram



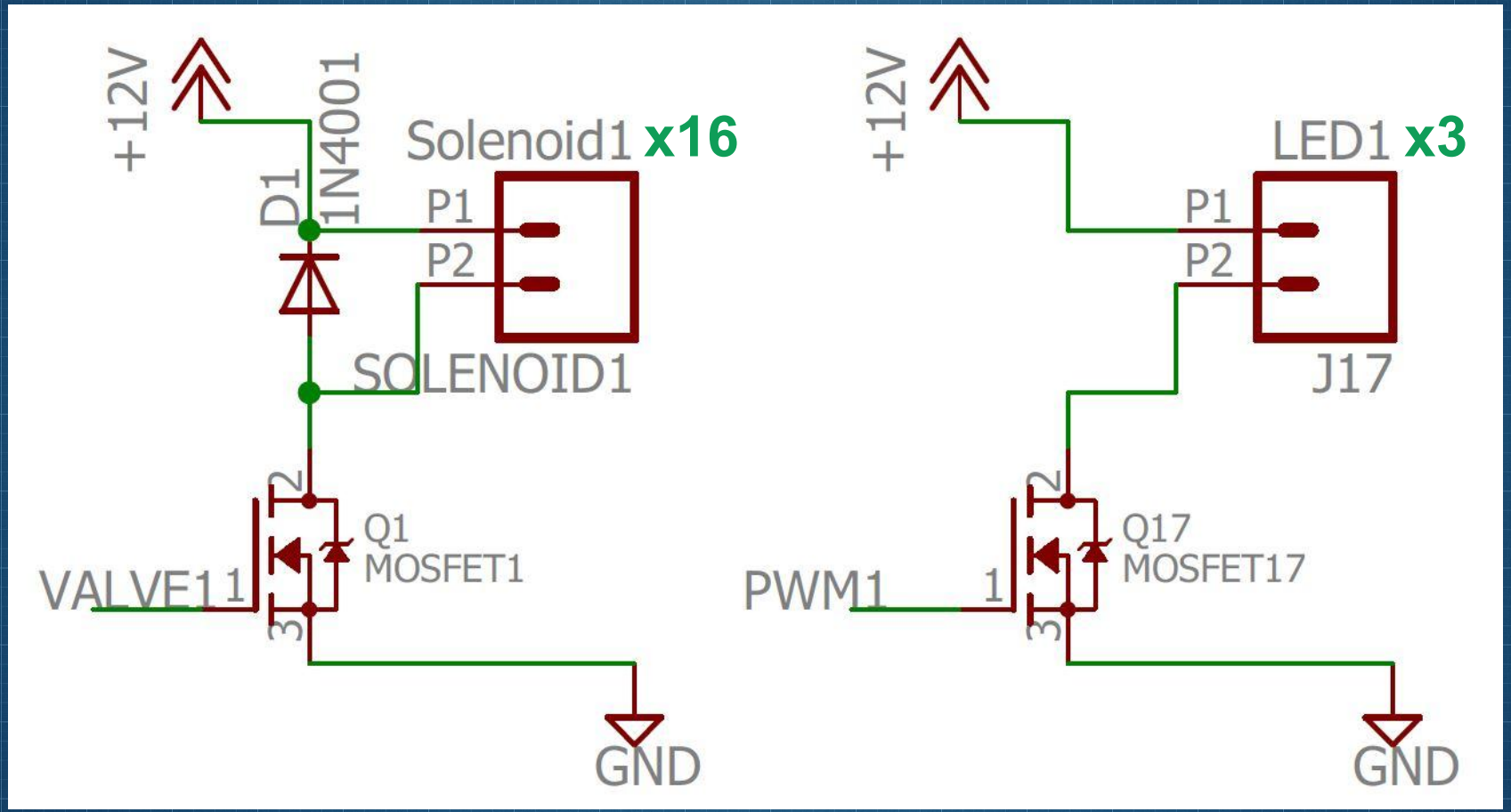
Project Specifications

Parameter	Specification	Prototype Results
Location	Laureate Park Lake Nona	Senior Design Lab
Dimensions	Scale Model (2.25ft x 4ft)	3.5ft x 5.75ft
Prototype budget	$1,000	$793.31
Max power consumption	180 W	150 W
Max motion recognition range	8ft	10ft
Solenoid Response time	< 25 ms	50ms

PCB Schematic



PCB Schematic: Solenoid and LED Circuit



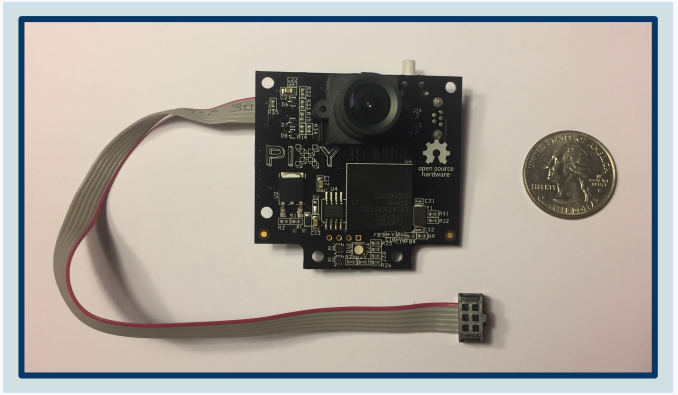
Vision System Component Selection

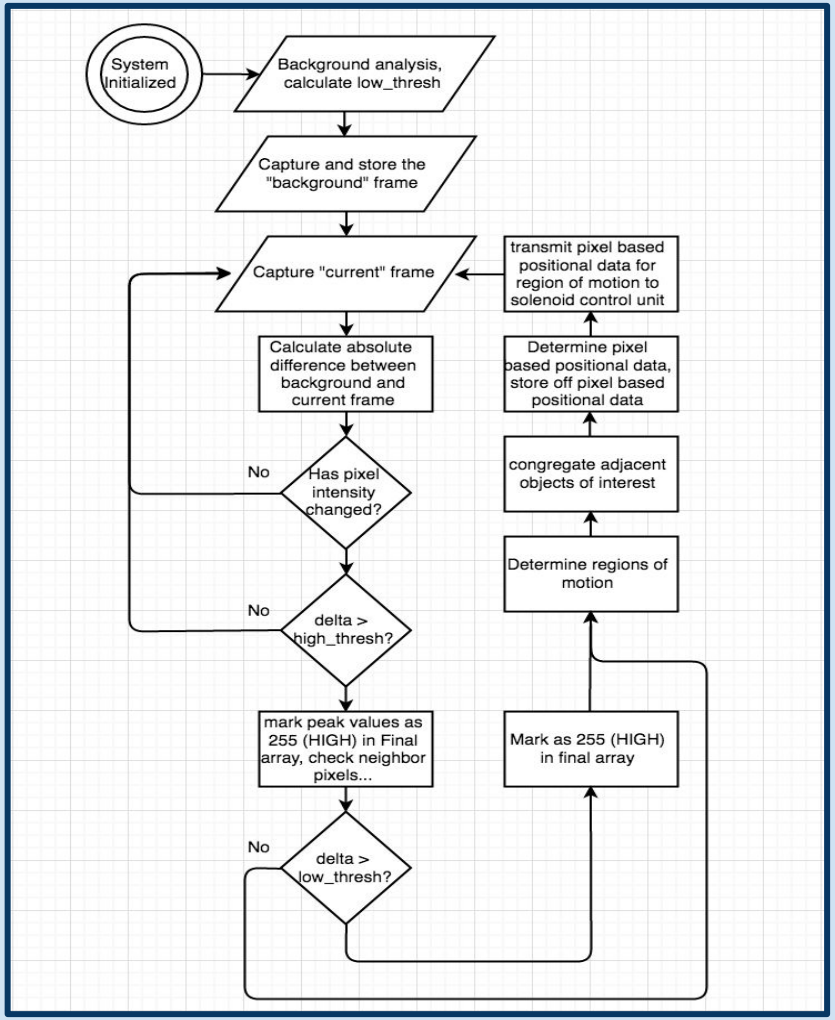
- Onboard processor and open source software/firmware preferable
- Power consumption and unit maintenance
- Resolution concerns (scalability)

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

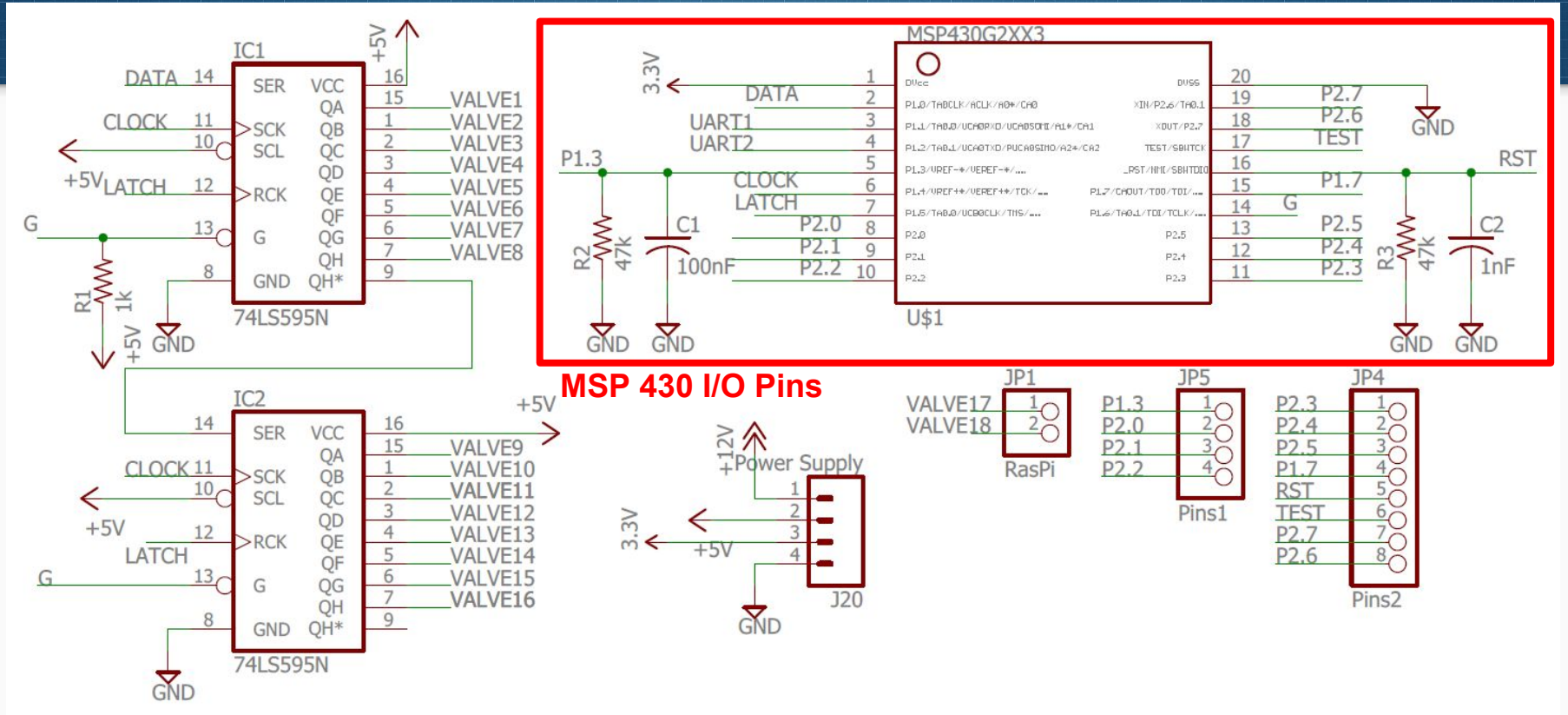




Computer Vision System Design

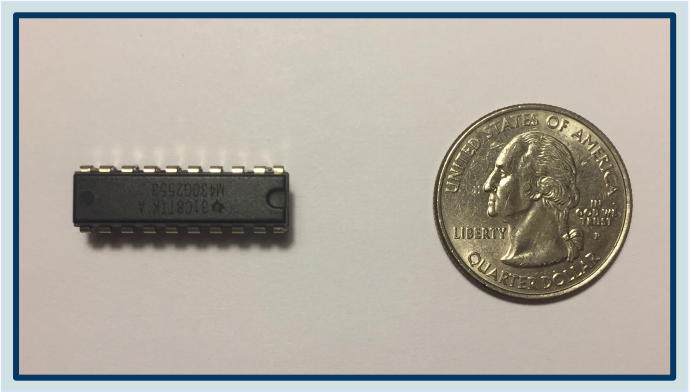
- Motion segmentation
  - Foreground Subtraction
- Background analysis
  - Dynamic low threshold calculation
- Hysteresis thresholding
  - Eliminate background “noise”
- Aggregating regions of motion

PCB Schematic: MCUs

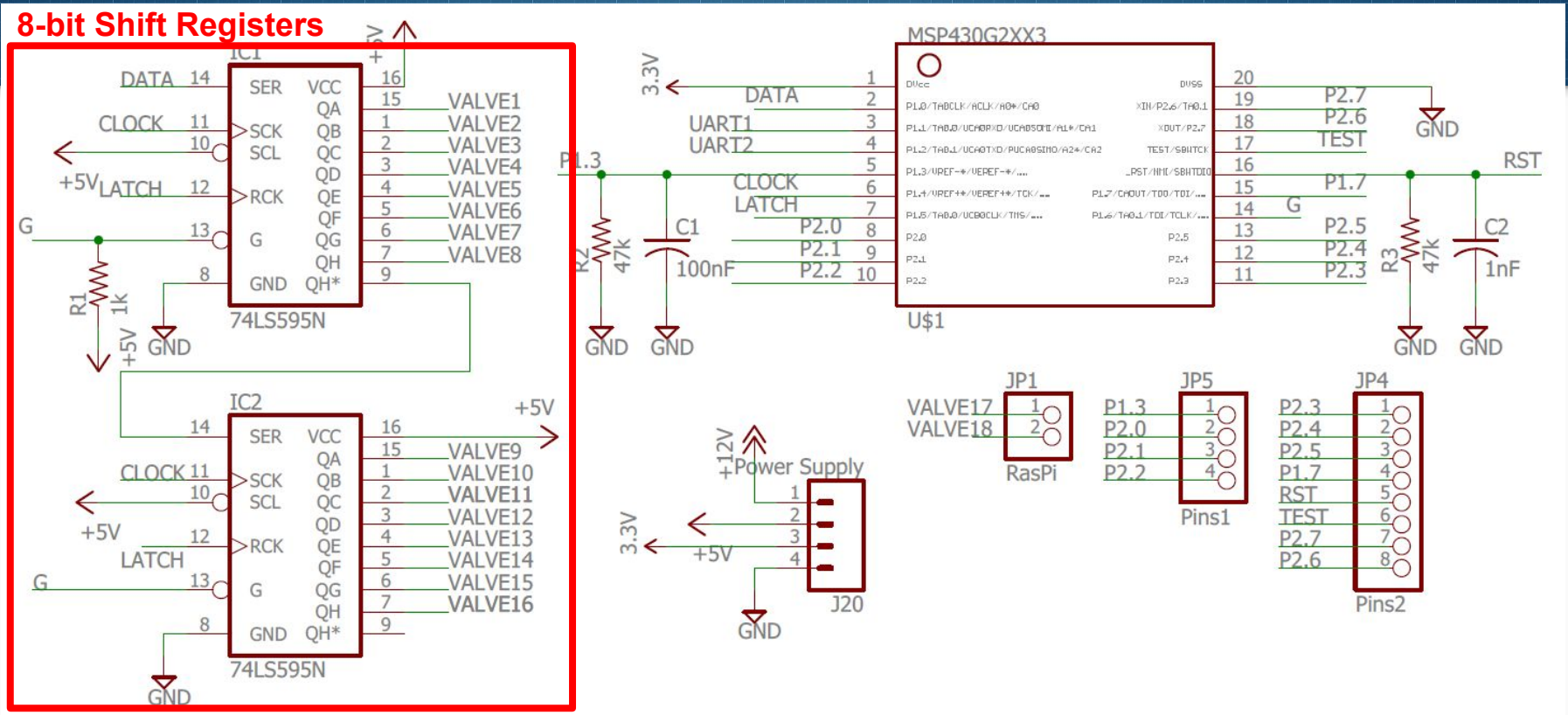


MSP430G2553 Specifications

- Increases modularity in the system
- TI ultra low power instrument - 230 uA @ 3.3V
  - Running at 1MHZ
- Serial communication - I2C, SPI, **UART**
- 16 bit architecture
- Code composer IDE
- Cost - $19.75 (launchpad included)

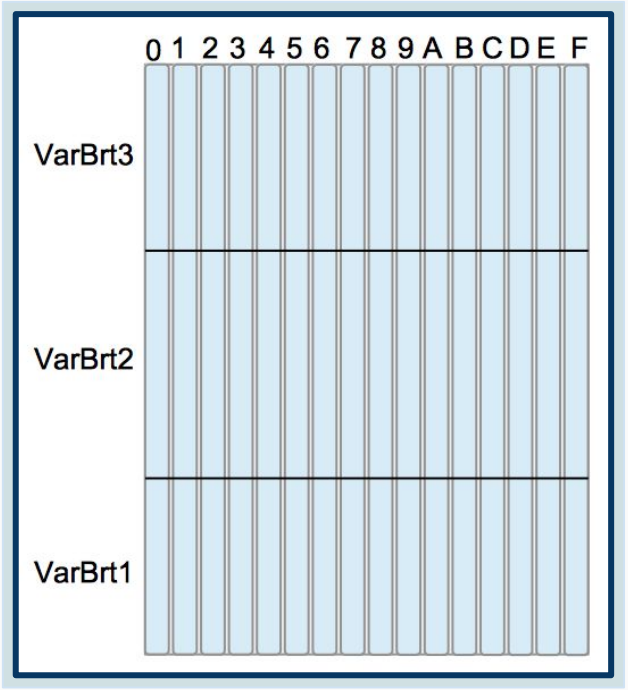


PCB Schematic: Solenoid Switching Circuit

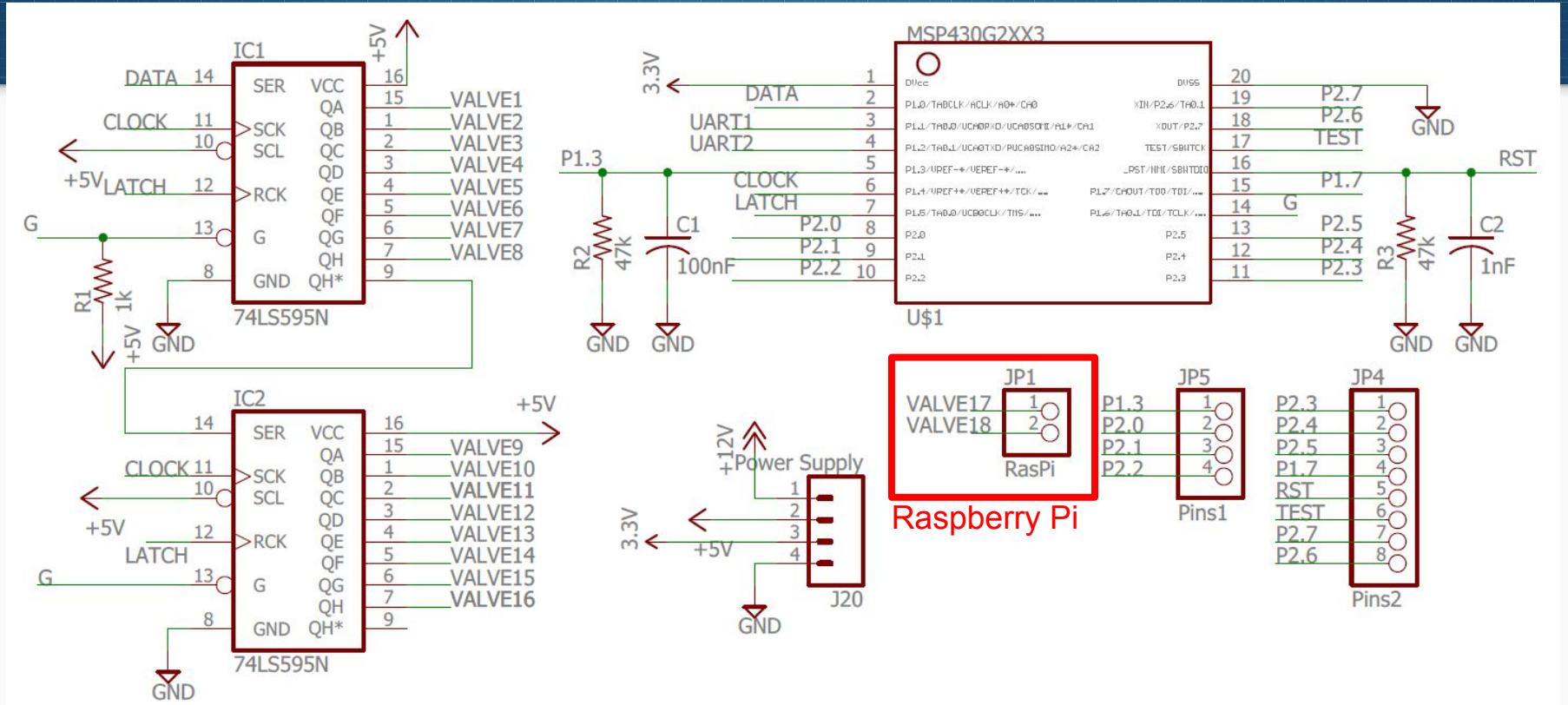


Solenoid Control Unit

- Configures Shift registers with serial data
- Graphical waterfall array visualized on right
- LEDs light waterfall varying brightness with PWM modulation
- Variable brightness regions are each a unique color
- Resolution scaling
- Preprogrammed aesthetic functions

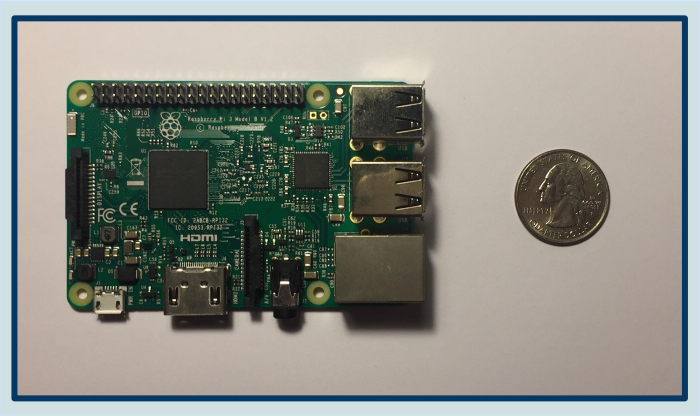


PCB Schematic MCUs

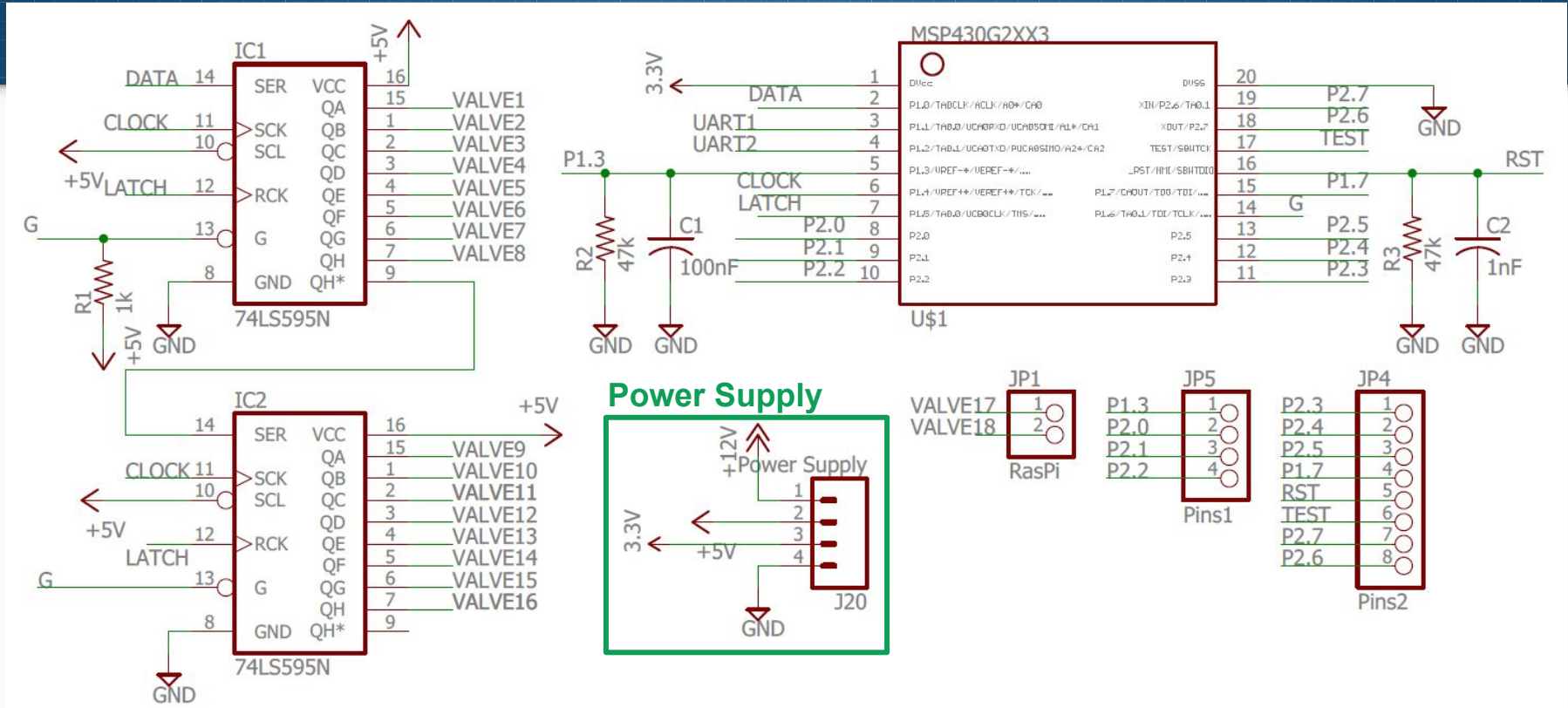


Raspberry Pi 3 Specifications

- 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



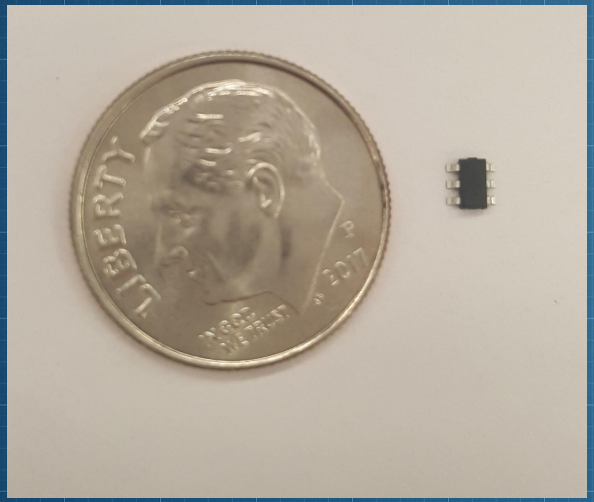
Power Needs

Voltage	Component(s)
12V	(16)Solenoid Array, (3) LED strips, Water Pump
5V	Raspberry Pi 3
3.3V	MSP430G2553, 8-bit Shift Registers

Power Limitations

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

Integrated Step-Down Chips

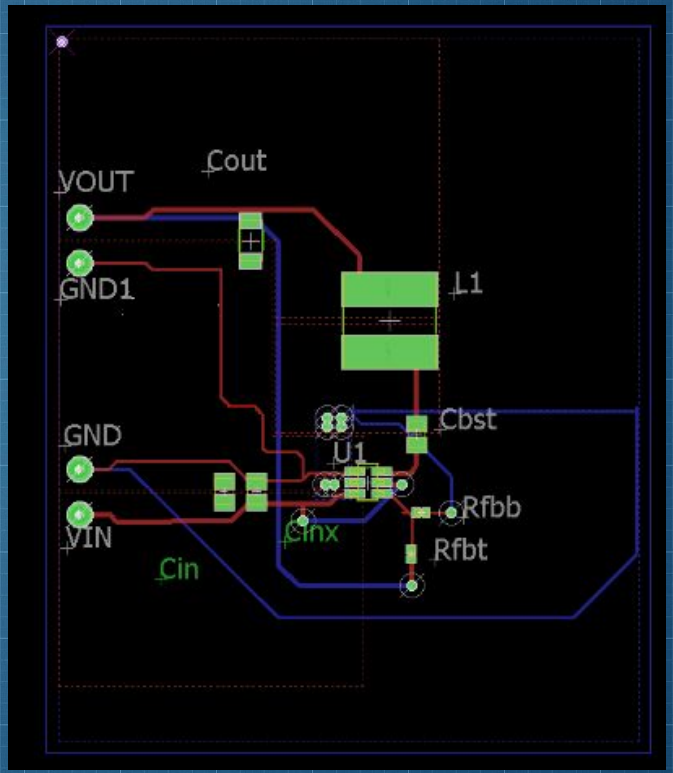


TPS562200 / TPS563200

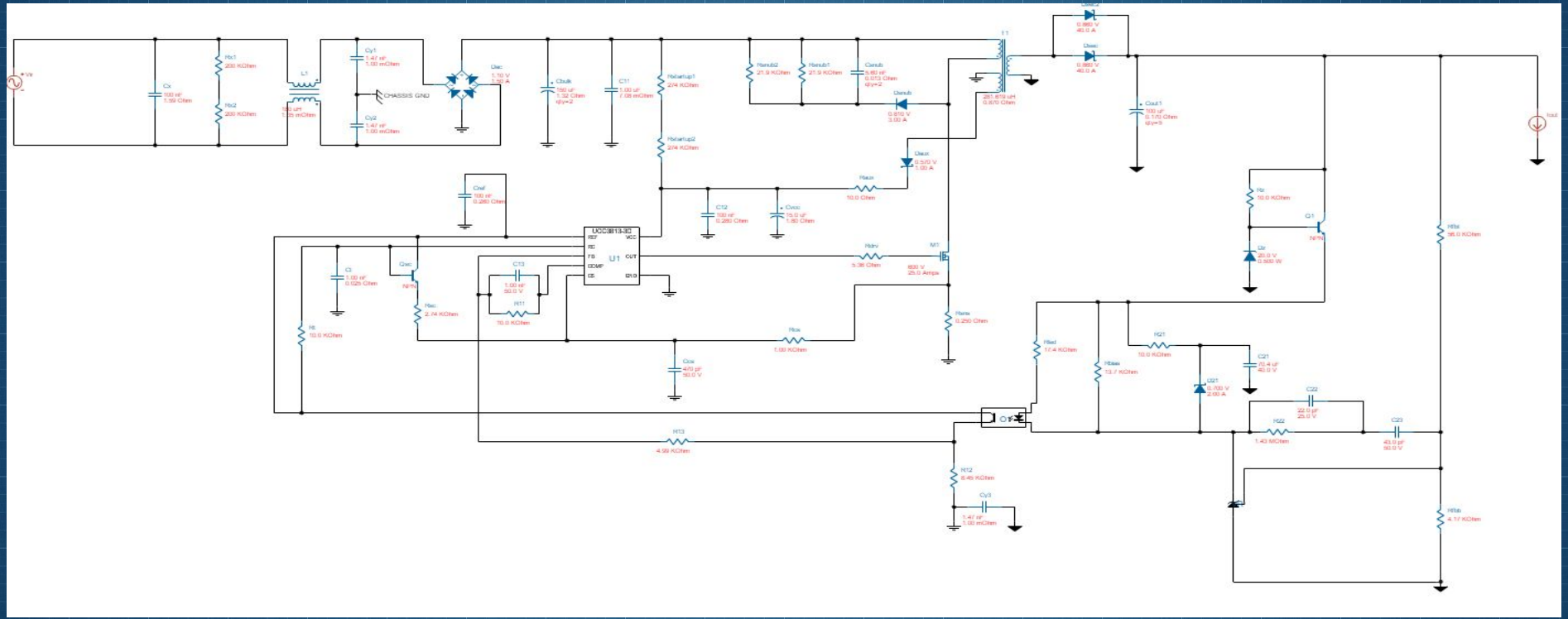
- 4.5V to 17V input
- 0.76V to 7V output @ 2A / 3A
- Eco friendly mode for low power consumption
- 650 kHz switching frequency

Power PCB Design

- 5V and 3.3V similar layout
- Different passive components
- Power planes used
- Small footprint

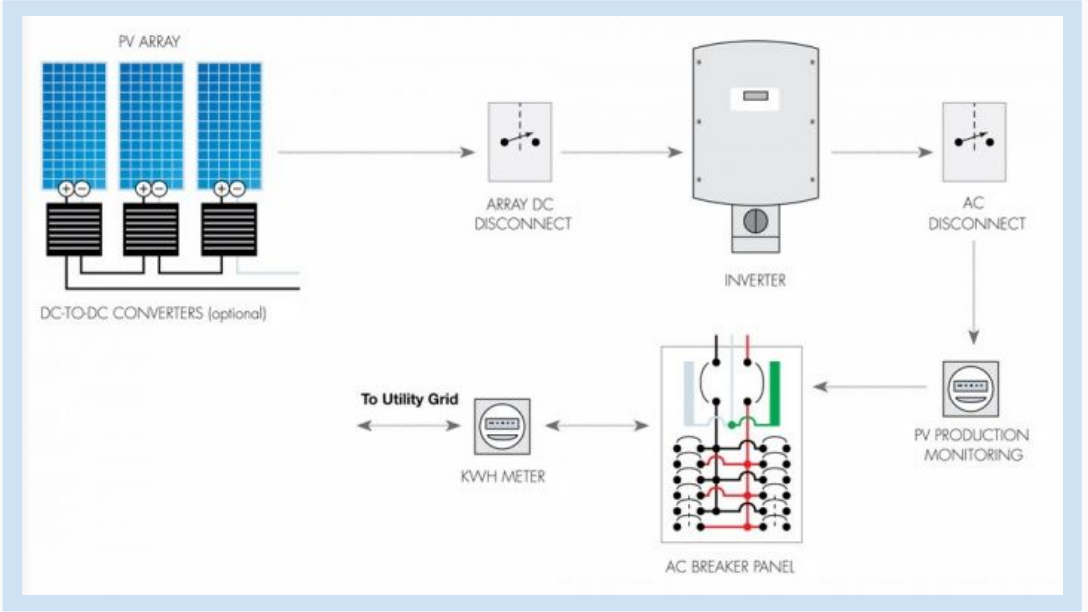


Power Rectifier

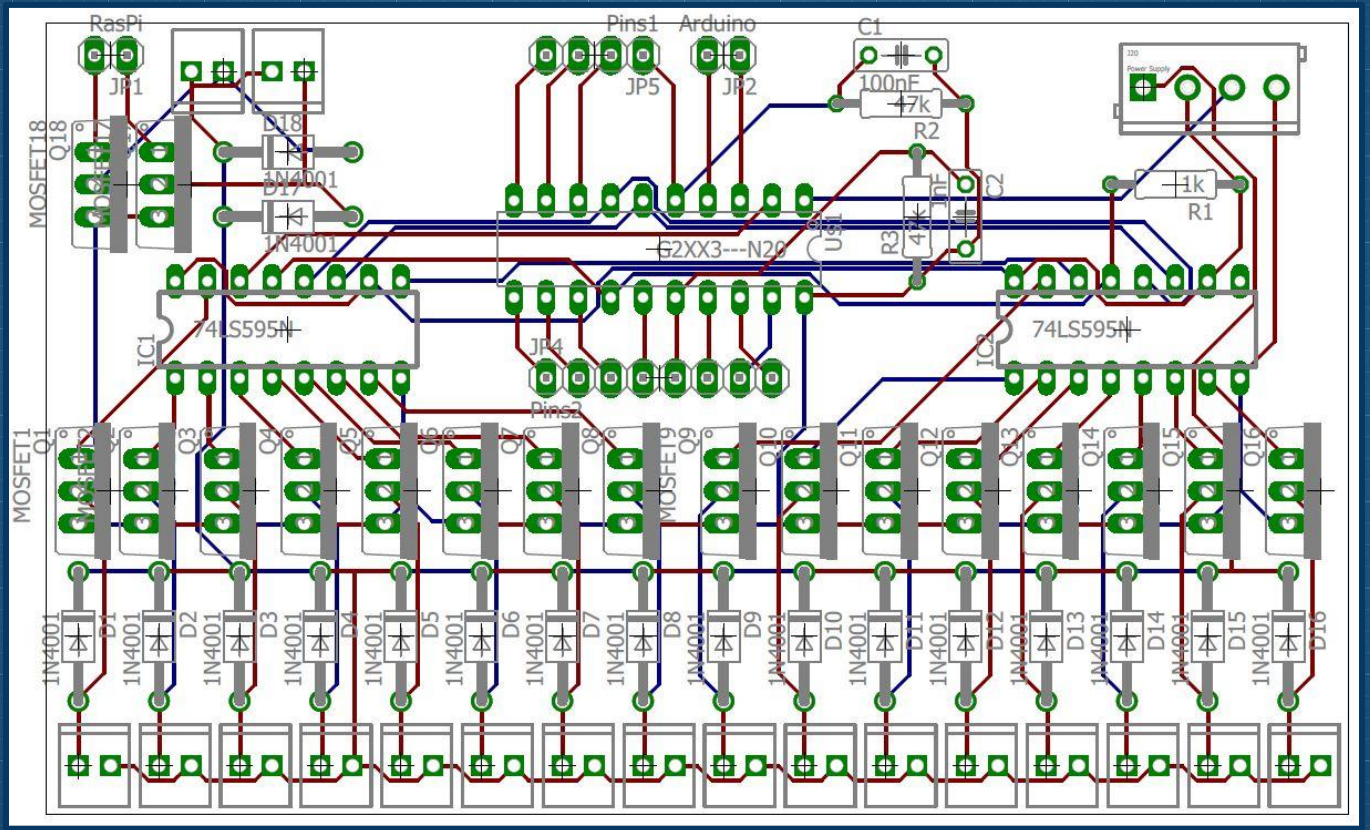


Inverter and Solar Panels

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



PCB Layout


RasPi
JP1
Pins1
Arduino
JP5
JP2
C1
100nF
47k
R2
1k
R1
C2
10nF
R3
4.7k
D18
1N4001
D17
1N4001
MOSFET18
Q18
G2XX3---N20
U$1
74LS595N
IC1
74LS595N
IC2
JP4
Pins2
MOSFET1
MOSFET9
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q16
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
D14
D15
D16
1N4001

Administrative Content

Budget

Item	Supplier	Quantity	Price Each	Item Total
Waterfall Electronics				
Pixy Cam	Amazon	1	$ 69.00	$ 69.00
MSP430G2553	TI	1	$ -	$ -
Raspberry Pi	Amazon	1	$ 39.96	$ 39.96
Arduino R3 Uno	Amazon	1	$ 27.99	$ 27.99
Aubig DC 12V Water Pump	Amazon	2	$ 25.76	$ 51.52
Screw Terminals 2.54mm Pitch (2-Pin)	Sparkfun	40	$ 0.75	$ 30.00
Break Away Headers	Sparkfun	1	$ 1.50	$ 1.50
Screw Terminals 3.5mm Pitch (2-Pin)	Sparkfun	8	$ 0.95	$ 7.60
Female Headers	Sparkfun	1	$ 1.50	$ 1.50
20-pin DIP Socket	Digi-Key	3	$ 0.29	$ 0.87
MOSFT 30V 62A 9mOhm 8nC	Mouser	56	$ 0.92	$ 51.52
1N4001 Diodes	Mouser	66	$ 0.11	$ 7.26
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

Item	Supplier	Quantity	Price Each	Item Total
Waterfall Materials				
Quick Connects (Pack of 5)	Amazon	10	$ 4.79	$ 47.90
PVC Caps	Home Depot	2	$ 7.94	$ 15.88
PVC Tubes	Home Depot	1	$ 20.97	$ 20.97
Pump Tubing	Home Depot	1	$ 16.89	$ 16.89
LED Light Strips	Amazon	4	$ 8.99	$ 35.96
Solenoid Valve 12VDC	Amazon	16	$ 11.77	$ 188.32
16-pin DIP Socket	Digi-Key	6	$ 0.25	$ 1.50
Power Components				
Power Supply 12V 20A	Amazon	1	$ 21.88	$ 21.88
Power Cord 12ft	Amazon	1	$ 6.85	$ 6.85
Printed Circuit Board	Elecrow	3	$ 34.50	$ 103.50
Power PCB Components	Mouser	1	$ 30.00	$ 30.00
Total				**$ 793.31**

TOTAL: $793.31

Work Distribution

Name	Computer Vision	Power Supply	PCB Layout	Water Feature Design
Connor Heckman	**1st**			**2nd**
Tahte Perkins		**1st**	**2nd**	
Ben King	**2nd**			**1st**
Jack Gray		**2nd**	**1st**	

Future Functionality

- Real-time audio interaction with use of spectrometer
- Full scale water walkway/swing
- Increase number of solenoids for higher resolution water display
- Numerical and Alphabetical graphical output

Questions?