AutoBott

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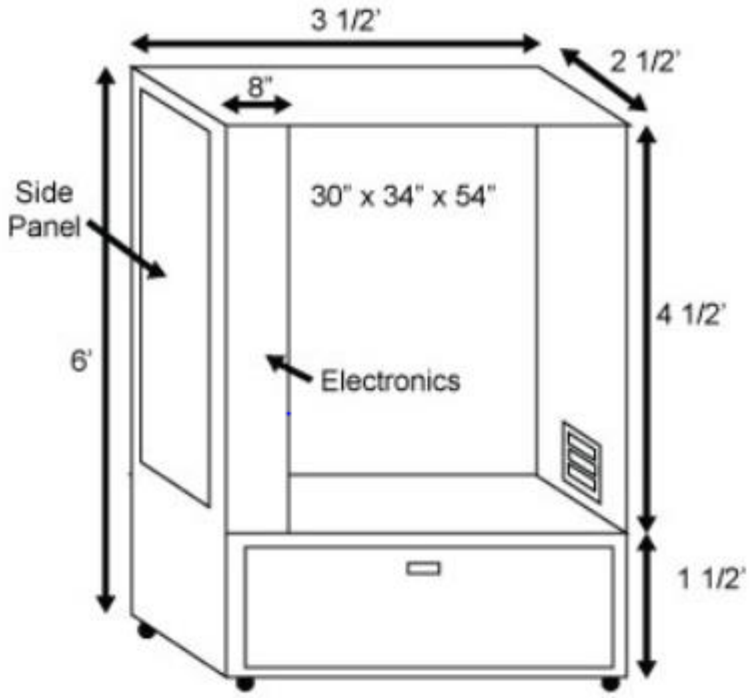
Motivation

- It is common for people to grow their own crops at home, either as a hobby, or to grow and eat themselves
- A vast majority of crops are grown outside, where they are exposed to dramatic climate changes and insects
- Plants are becoming less likely to thrive in the record breaking seasonal temperatures around the world
- Water is a scarce resource and not easily accessible in certain areas of the globe
- Plants grown in soil are more vulnerable to diseases and pests
- It would be best to have a closed environment with ideal growing conditions
- Growing hydroponically allows for optimization of the plant’s growing environment, providing higher yields in shorter time

Goals and Objectives

- Save water in areas where water is a scarce resource
- Grow plants indoors
- Grow plants year round
- Plants will always grow in optimal conditions
- Maximize harvest or bloom
- Eliminate the chance of diseases and fungus growing on the plants by using hydroponics

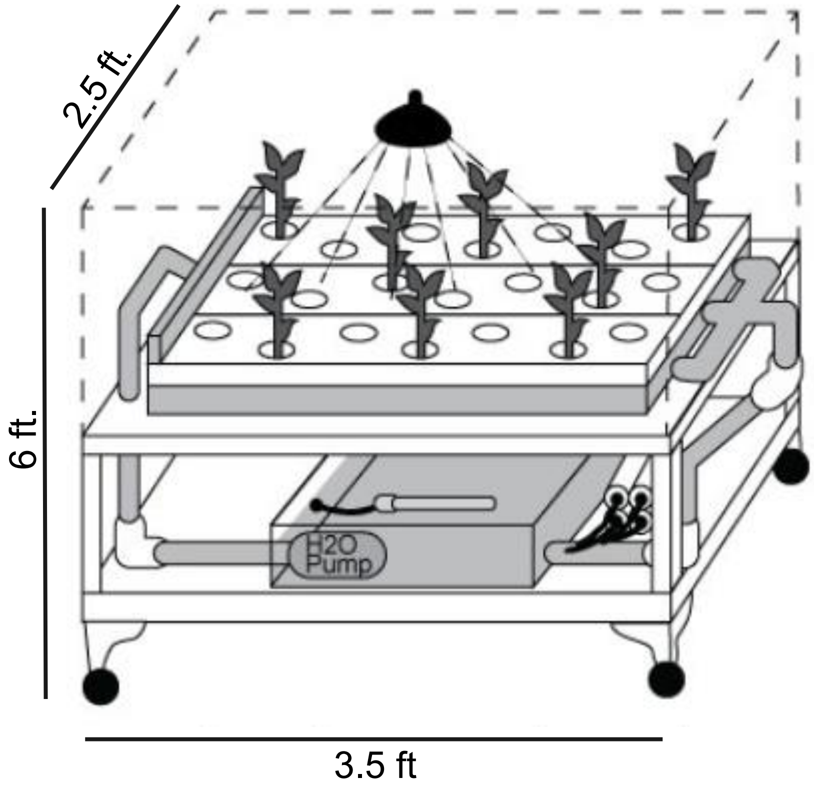
AutoBott: An Automated Botanical System



Physical Enclosure

- Main Plant Compartment
  - Will house Lights, Fan, Plants, and majority of hydroponic system
  - Will be coated with a layer of Mylar: a reflective material made into sheets that also has insulating properties
- Water/Nutrient Compartment
  - Will house water and nutrient reservoirs
  - Water pump and Nutrient pumps
- Electronics Compartment
  - Will hold PCB board and components

AutoBott: An Automated Botanical System (cont.)



Hydroponic System

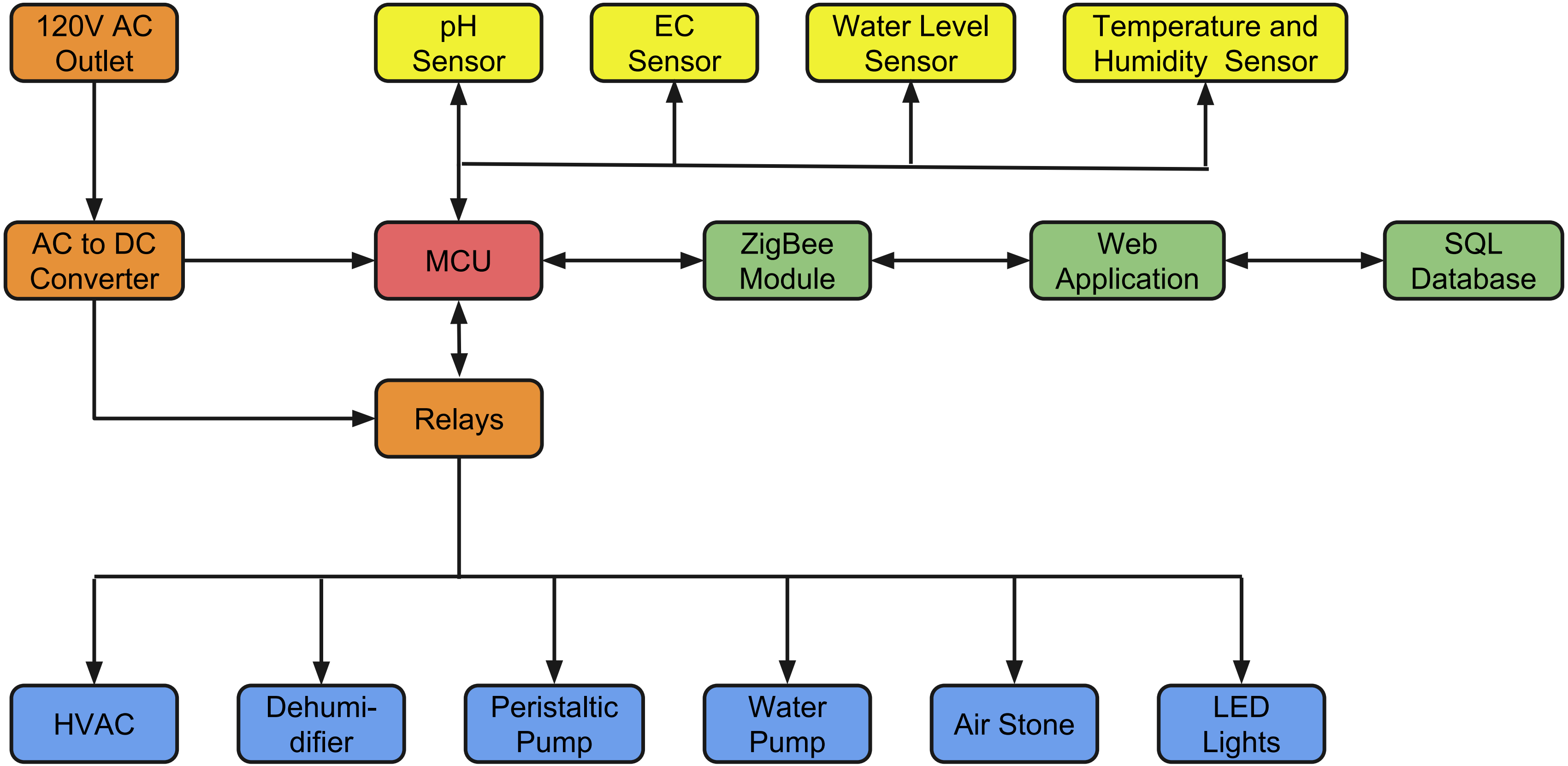
- Nutrient Film Technique
  - Pump will run constantly, providing the plants with a stream of nutrient solution
  - Plants will sit in individual grow cups along the top of each plant tray, where their roots will absorb the nutrients
  - Once the nutrient solution leaves the plant trays, it will drain back to the reservoir
- Water/Nutrient Compartment
  - pH, EC, and water level sensors will regulate our water reservoir
  - As the nutrient solution is returning to the reservoir, our pumps will automatically inject nutrients, and pH altering solution as our system needs it

Specifications

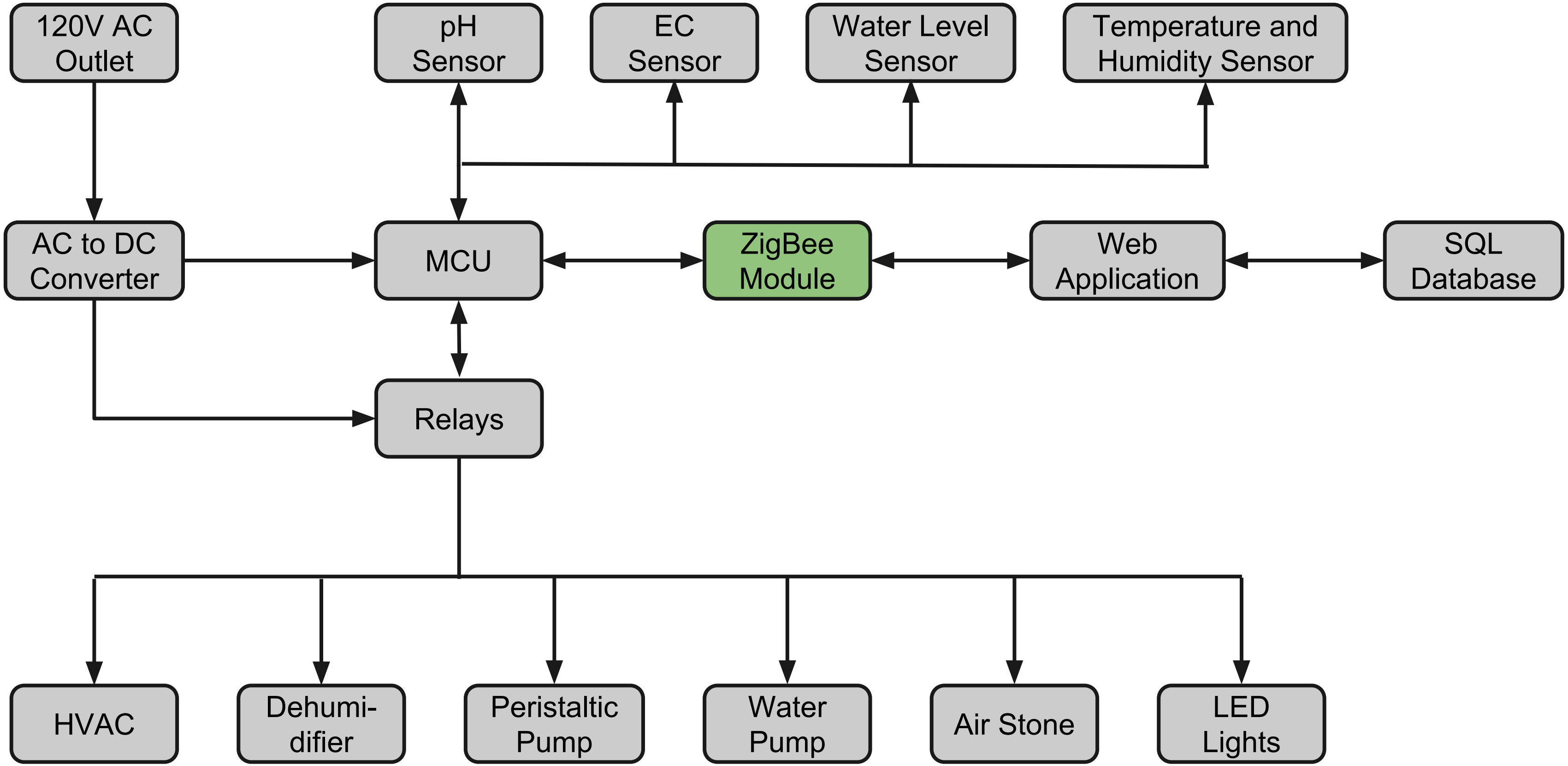
Sensors	Unit of Measure	Accuracy
pH Levels	pH	Range within .5 pH
EC Levels	S/m (siemens per meter)	Range within 20 S/m
Temperature	°C	Range within 5°C
Humidity	Percentage	Range within 8%

Component	Parameter	Design Specification
Web application	Update time	10 minutes
Water pump (full cycle)	Circulation	2 hours
LED Lights	Light exposure	6000 Lumens per square foot

Overall Block Diagram



Wireless Communication Module



Wireless Communication Module

Wifi vs. Bluetooth vs. Zigbee

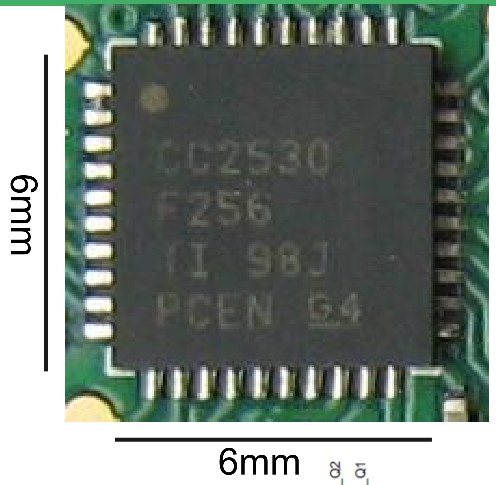
- Wifi has high data transfer rates and good range, but uses a lot of power
- Bluetooth has very short range and can connect to a maximum of 7 other devices
- ZigBee is designed for reliable wirelessly networked monitoring and control networks. Low power, long range, and can connect to over 65,000 devices

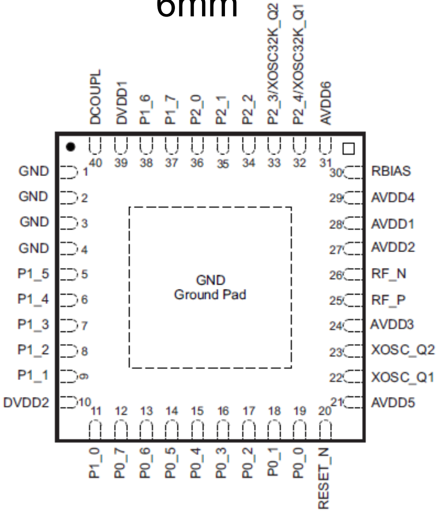
Standard	Bluetooth	Zigbee	Wi-Fi
IEEE spec..	802.15.1	802.15.4	802.11a/b/g
Frequency band	2.4GHz	868/915 MHz; 2.4 GHz	2.4 GHz; 5 GHz
Max signal rate	1 Mb/s	250kb/s	54Mb/s
Nominal range	10 m	10-100 m	100 m
Nominal TX power	0 - 10 dBm	(-25) - 0 dBm	15 - 20 dBm
Number of RF channels	79	1/10;16	14(2.4GHz)
Channel bandwidth	1MHZ	0.3/0.6 MHz; 2 MHz	22MHz
Modulation type	GFSK	BPSK (+ ASK), O-QPSK	BPSK, QPSK COFDM, CCK, M-QAM
Spreading	FHSS	DSSS	DSSS, CCK, OFDM
Coexistence mechanism	Adaptive freq. hopping	Dynamic freq. selection	Dynamic freq. selection transmit power control (802.11h)
Basic cell	Piconet	Star	BSS
Extension of the basic cell	Scatternet	Cluster tree-mesh	ESS
Max number of cell nodes	8	> 65000	2007
Data protection	16-bit CRC	16-bit CRC	32-bit CRC

ZigBee

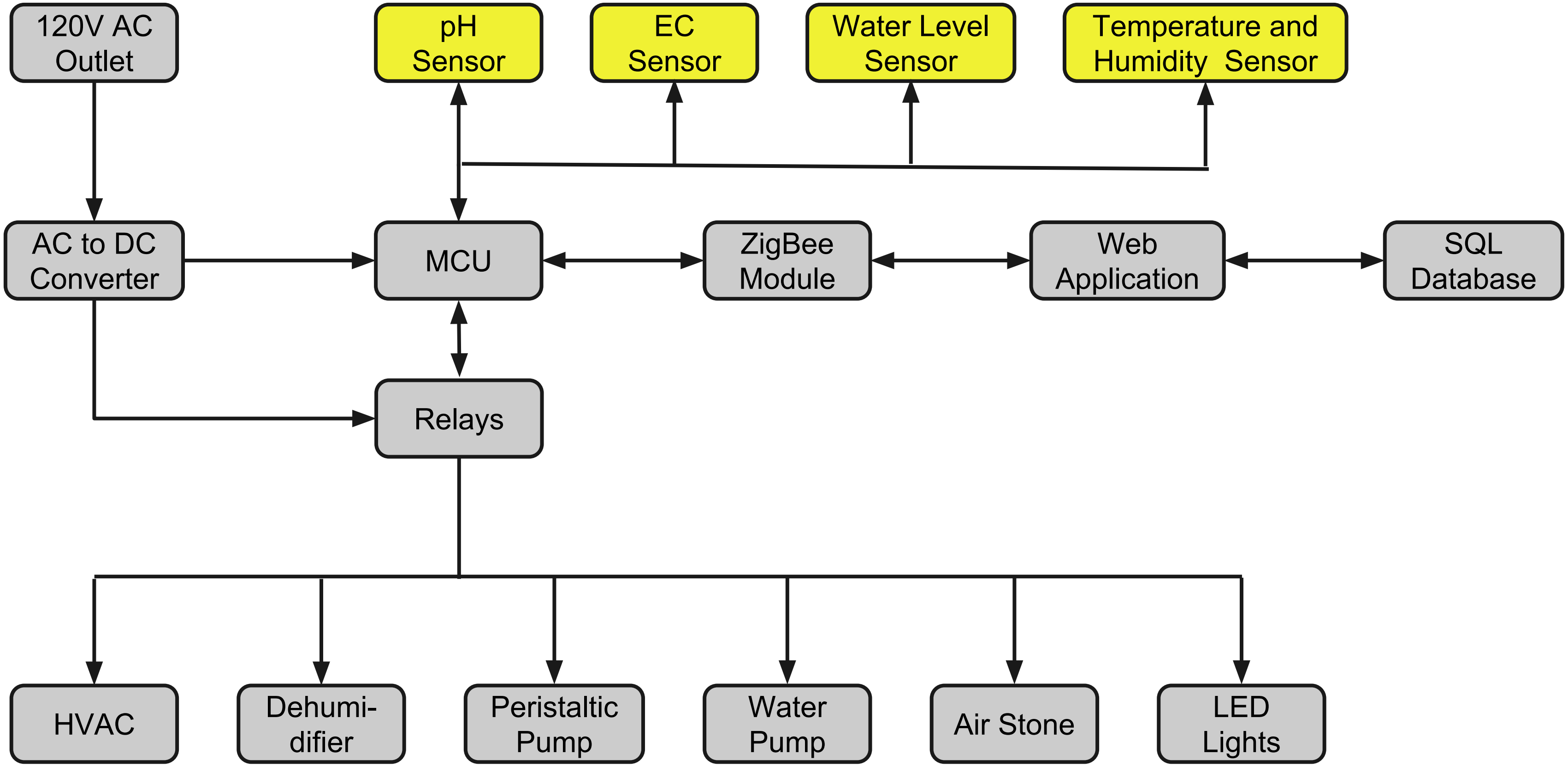
Texas Instruments CC2530 Zigbee Module

- Follows IEEE Standards 802.15.4
- Low power, and range up to 100 meters
- Can connect with over 65,000 nodes
- Will communicate with our mcu and share the sensors' data readings wirelessly through the standard **2.4 GHz frequency band**, transferring data at a **Max of 250 kbps**
- 256KB in-system programmable flash, 8KB RAM
- Long-life battery, and wide Supply-Voltage Range of (2V - 3.6V)
- Development board is needed to install software and set up the module for the first time; provided by UCF, Prof. Lei Wei, and his graduate students



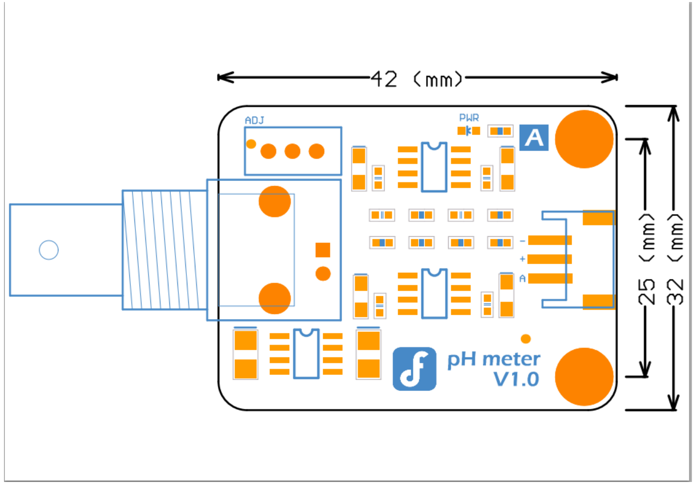


Sensors



120V AC Outlet
pH Sensor
EC Sensor
Water Level Sensor
Temperature and Humidity Sensor
AC to DC Converter
MCU
ZigBee Module
Web Application
SQL Database
Relays
HVAC
Dehumi-difier
Peristaltic Pump
Water Pump
Air Stone
LED Lights

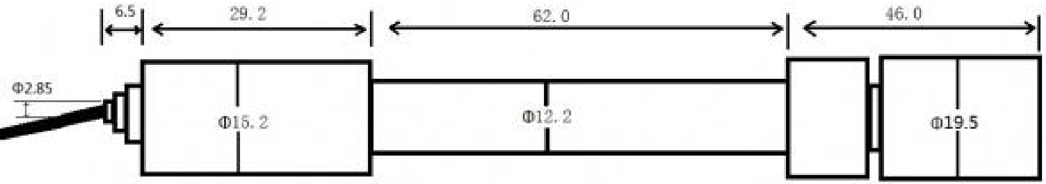
Analog pH Meter Kit



PCB Design Layout from DFRobot

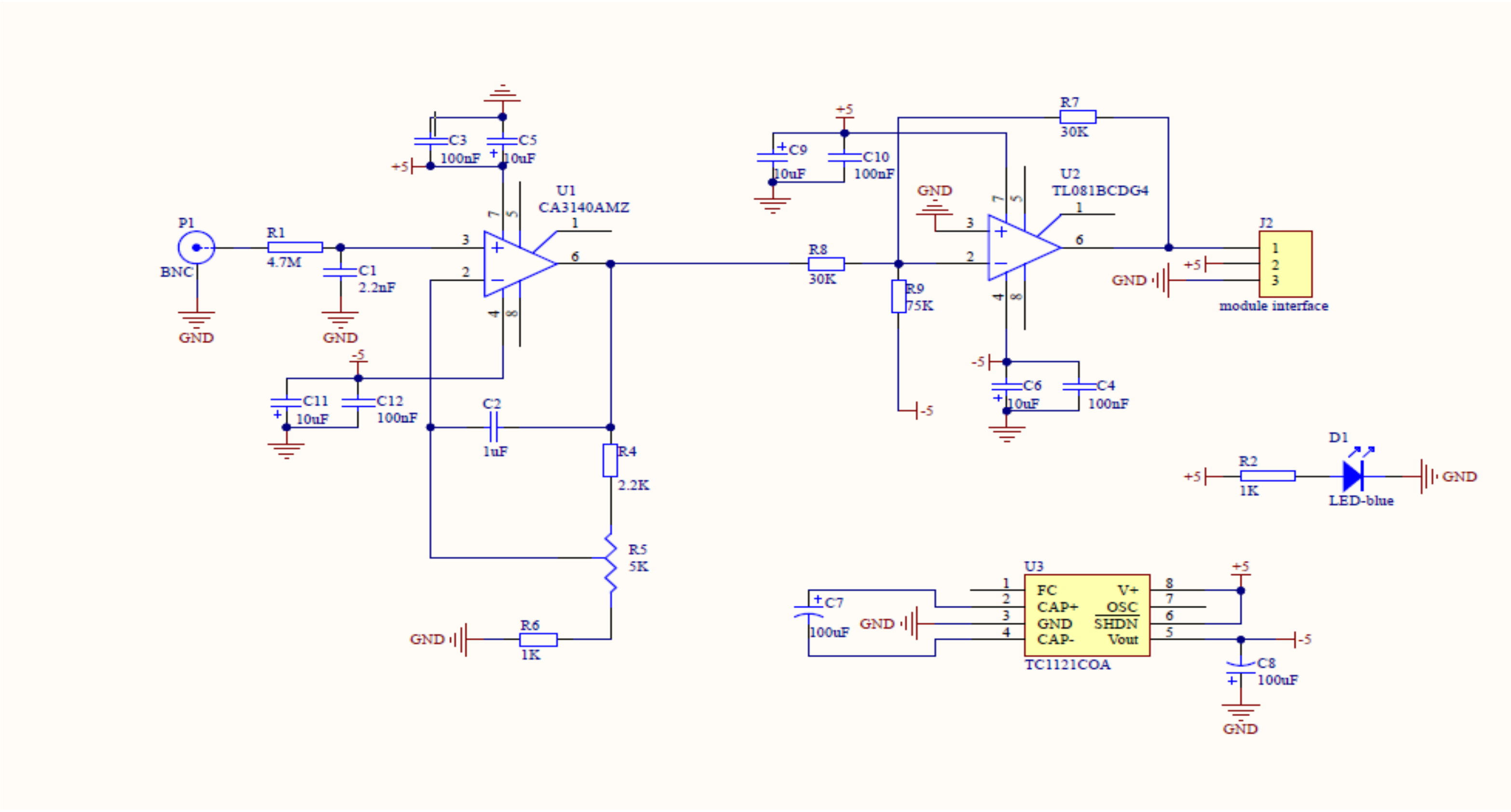
Specifications

Module Power	+5.00 V
Measuring Temperature	0-60℃
Response Time	Less than 1 minute
Measuring Range	0-14 pH
Accuracy	± 0.1pH



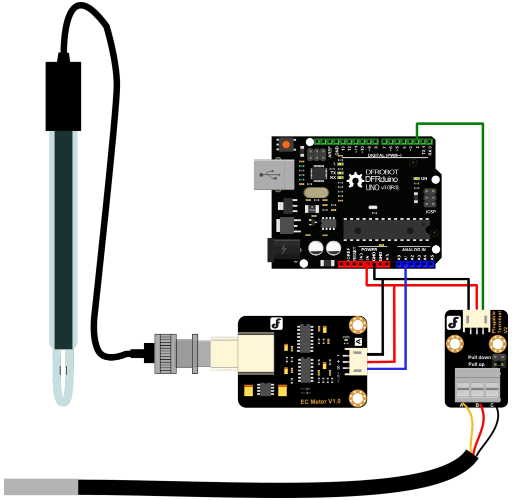
pH Electrode Dimensions (in mm) from DFRobot

pH Meter Kit Schematic

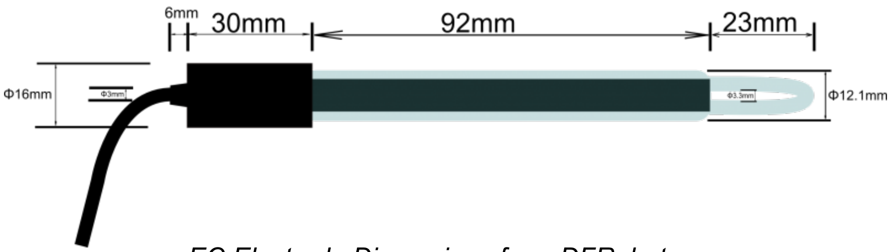


Schematic from Analog pH Meter Kit data sheet

Electrical Conductivity (EC) Kit



Connecting Diagram from DFRobot

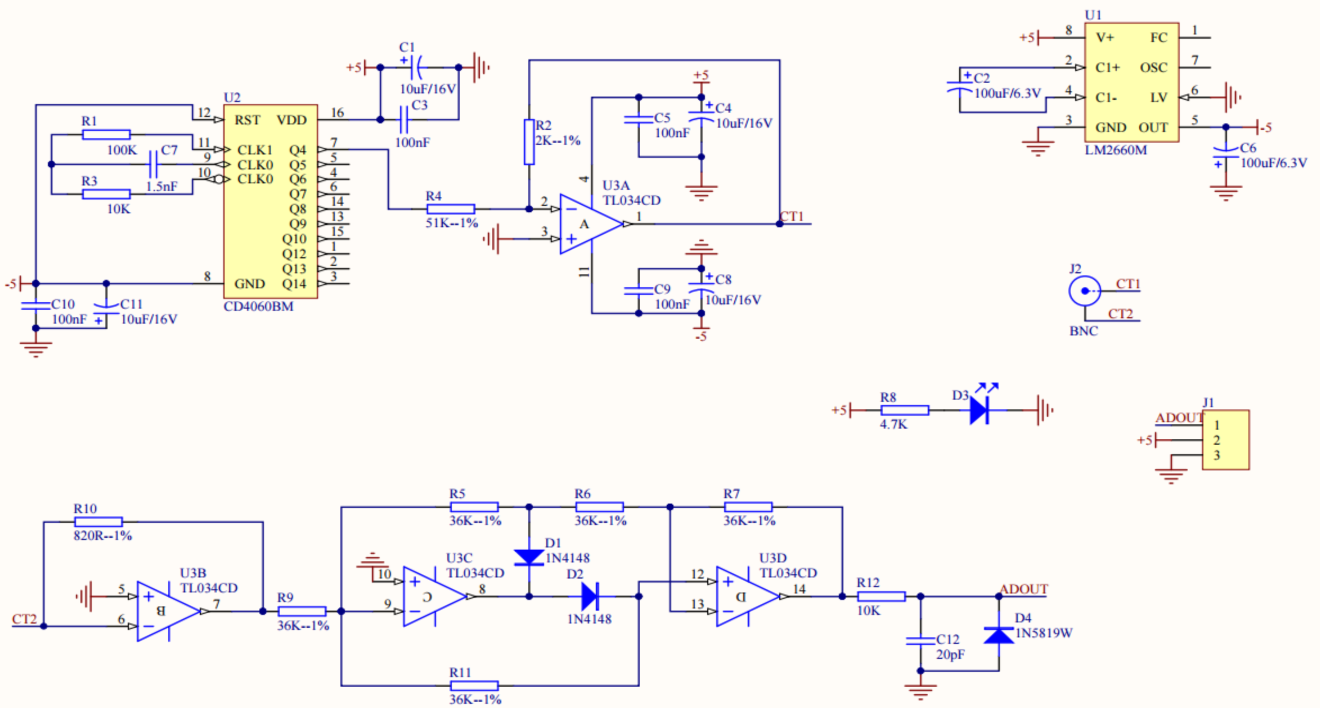


EC Electrode Dimensions from DFRobot

EC Kit Specifications

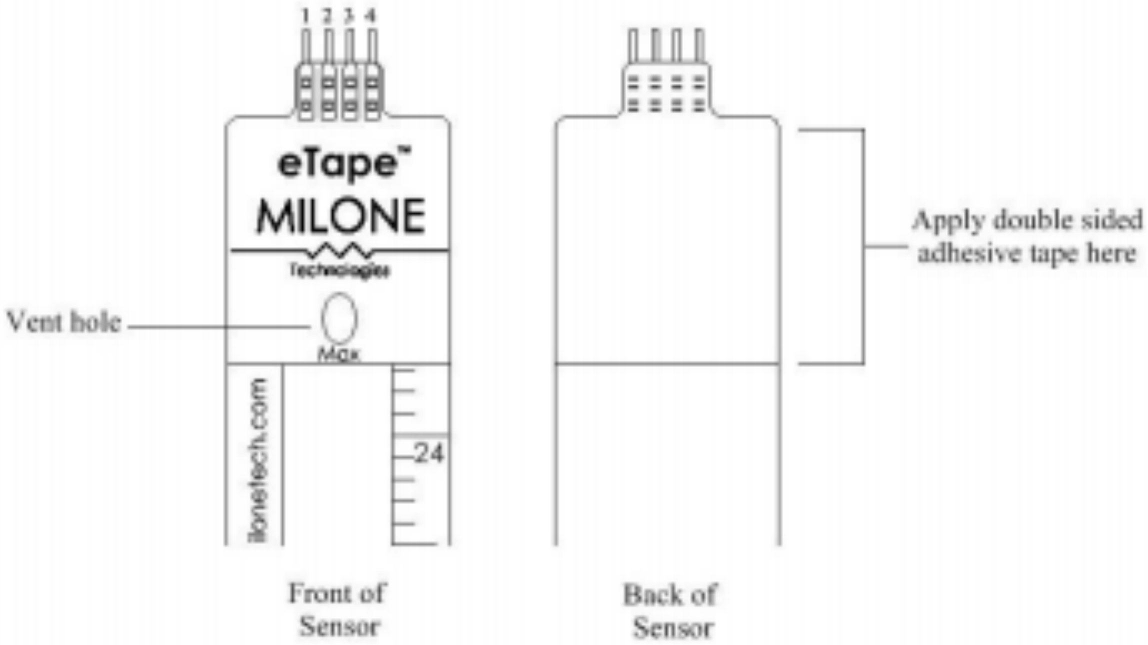
Operating Voltage	+5.00 V
Measuring Range	1ms/cm -20ms/cm
Operating Temperature	5 - 40 ℃
Accuracy	<±10% F.S (dependent on calibration solution)
Module Size	43mm×32mm

Electrical Conductivity (EC) Kit Schematic



Schematic for Electrical Conductivity Kit in datasheet

Water Level Sensor



eTape sensor layout from datasheet

Water Level Sensor

Part Number	PN-12110215TC-8	PN-12110215TC-12
Nominal Length	8-inch	12-inch
Sensor Length	10.2" (259 mm)	14.2" (361 mm)
Active Length	8.4" (213 mm)	12.4" (315 mm)
Sensor Output	400-1500Ω ±20%	400-2000Ω ±20%
Ref Resistance	1500Ω ±20%	2000Ω ±20%

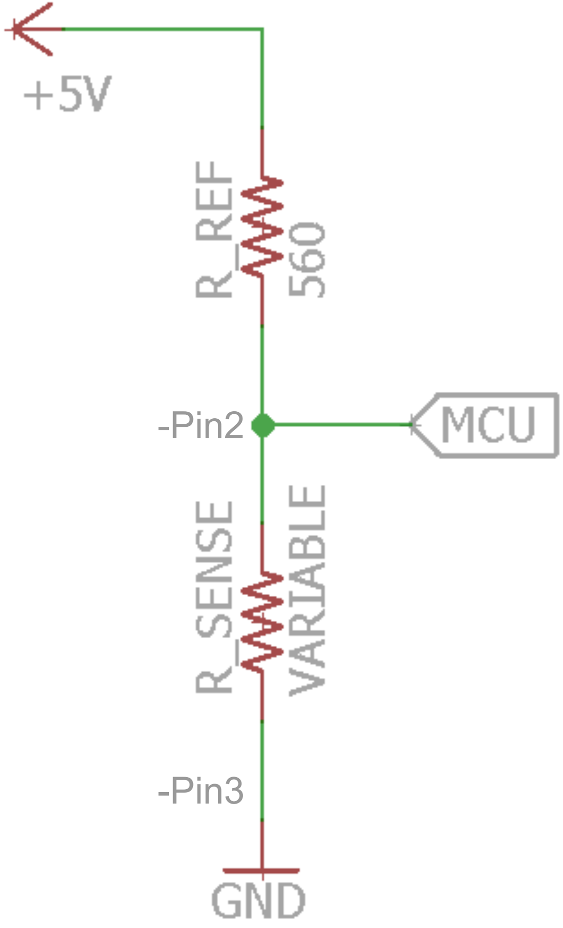
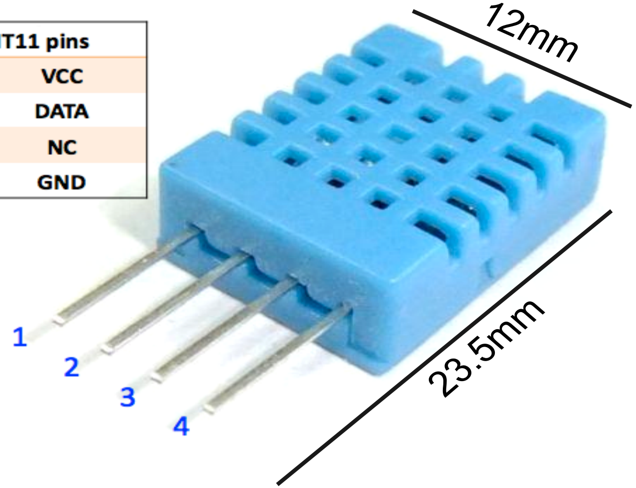


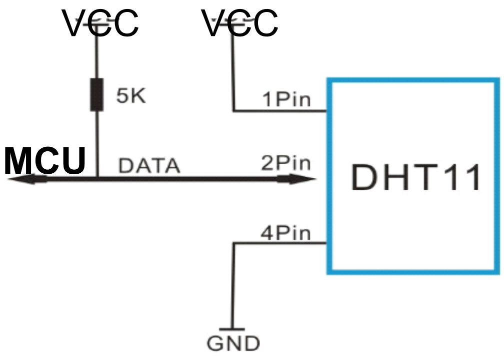
Table from eTape sensor data sheet.

Circuit designed in Eagle CAD. Pin 2 and 3 from the eTape sensor connect to the voltage divider circuit. Pins 1 and 4 are not needed for our application of this sensor.

Temperature and Humidity Sensor

DHT11 pins	
1	VCC
2	DATA
3	NC
4	GND





Circuit from DHT11 datasheet

Temperature and Humidity Sensor Specifications

Measurement Range	20 - 90% RH (Relative Humidity) @ 0 - 50℃
Temperature Accuracy	Min: ±1℃ Max:±2℃
Temperature Response Time	Min: 6s Max: 30s
Humidity Accuracy	Condition 0℃-50℃ Max: ±5%RH
Humidity Response Time	Min: 6s Typical: 10s Max: 15s

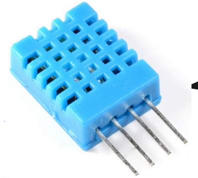
Sensor Interaction

Check pH

- Within Range
- Too high / Add pH Down
- Too low / Add pH Up

Check EC

- Within Range
- Add Nutrient Solution



Check Temp

- Within Range / Turn off fan
- Too hot / Turn on Fan

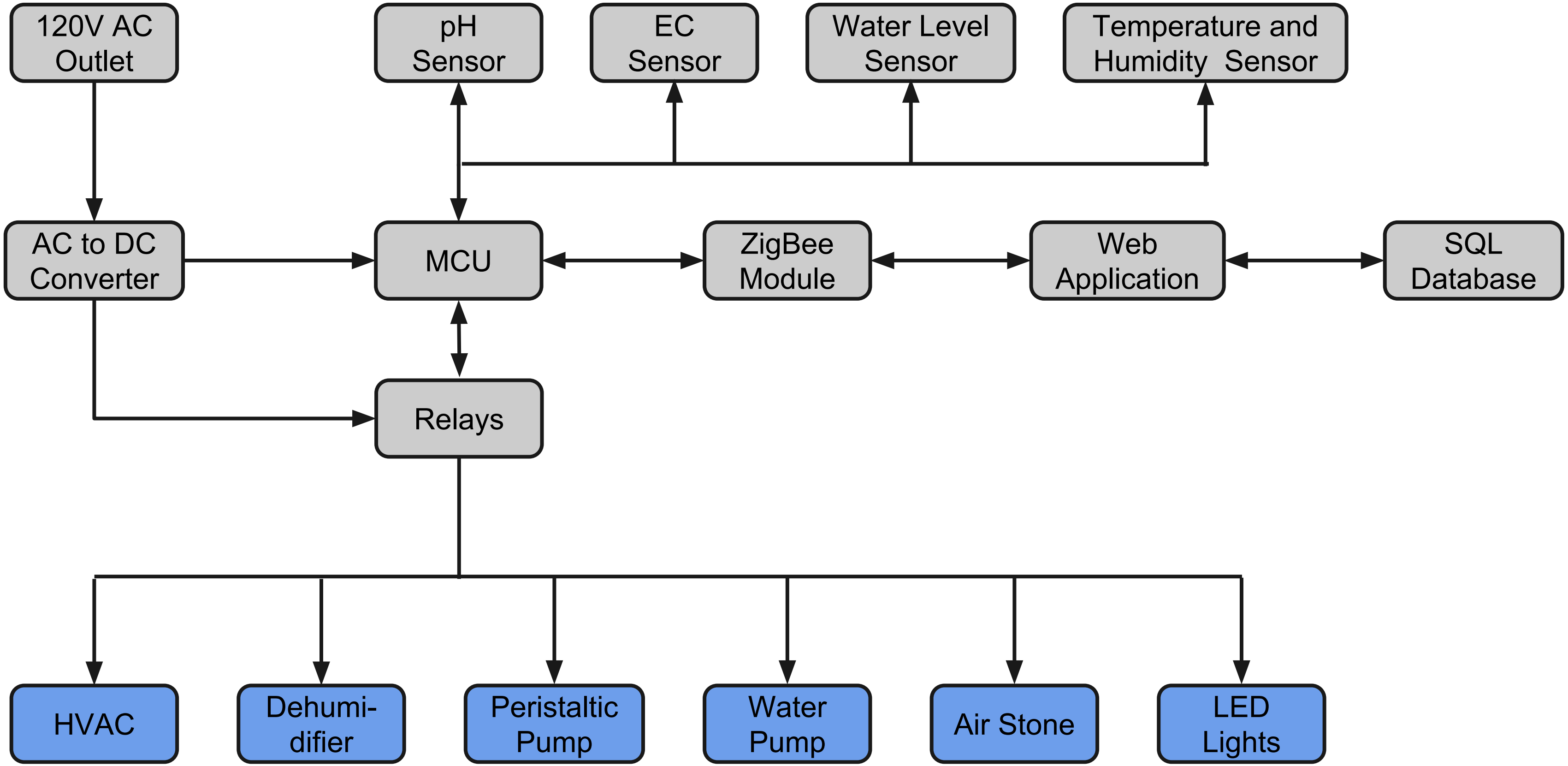
Check Humidity

- Within Range / Turn off Dehumidifier
- Too humid / Turn on Dehumidifier

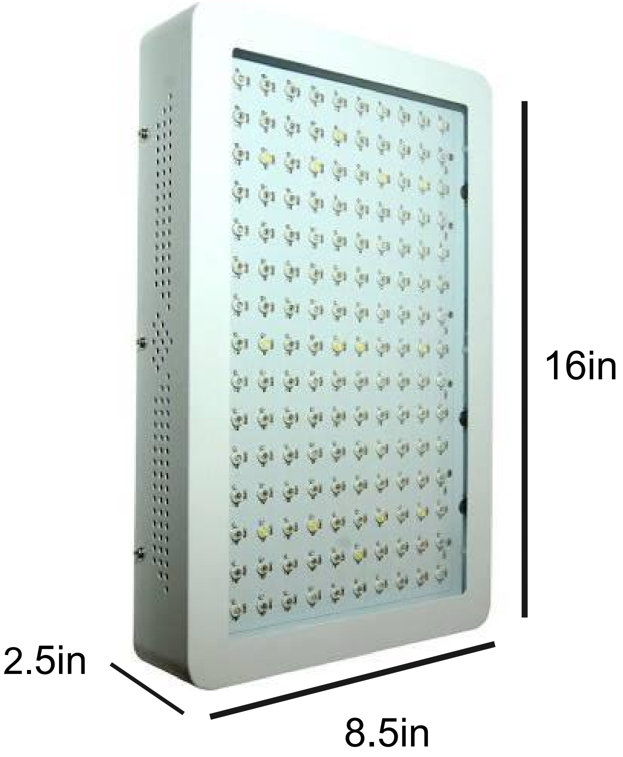
Check Level

- Within Range
- Too low / Send Notification to the User

Peripherals



Lights



A full spectrum LED light panel will be the plant's main source of energy. The lights will run on an 18 hours on / 6 hours off, or 12 hours on / 12 hours off cycle to mimic natural sunlight.

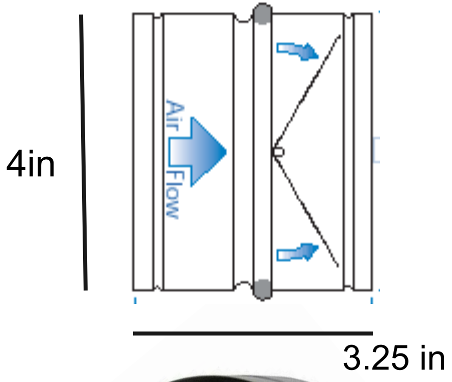
Specifications	
Power	180 Watts
Input	110V / 60Hz
LED Lens Angle	90^0
Light Coverage	7.5ft^2 (3' X 2.5')

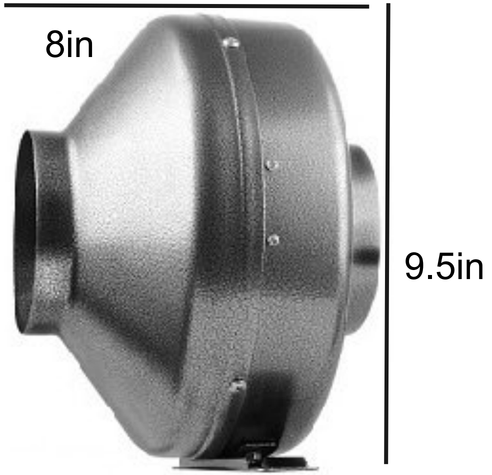
Lights

Type	Lifespan	Avg. Temperature	Distance From Plants	Efficiency	Cost
HID Grow Lights	10,000 hours	600 degrees F	6" – 10"	125 lumens per watt	~$15 per bulb
HPS Grow Lights	18,000 hours	500 degrees F	4" – 6"	140 lumens per watt	~$150 per bulb and ballast
LED Grow Lights	50,000 hours	70 degrees F	10" – 16"	25 lumens per watt	~$200 per square foot panel
T8 Fluorescents	25,000 hours	100 degrees F	2" – 4"	90 lumens per watt	$3 – $5 per bulb

HVAC

The backdraft damper remains closed until the exhaust fan is turned on. Once on, the damper opens allowing cool air to enter and warm air to exit. Cycles air 5 times per min.





Air Flow	190 CFM
Duct Size	4 inches
Fan Speed	2565 RPM
Power	65 watts
Input	AC 110v/60Hz

Dehumidifer

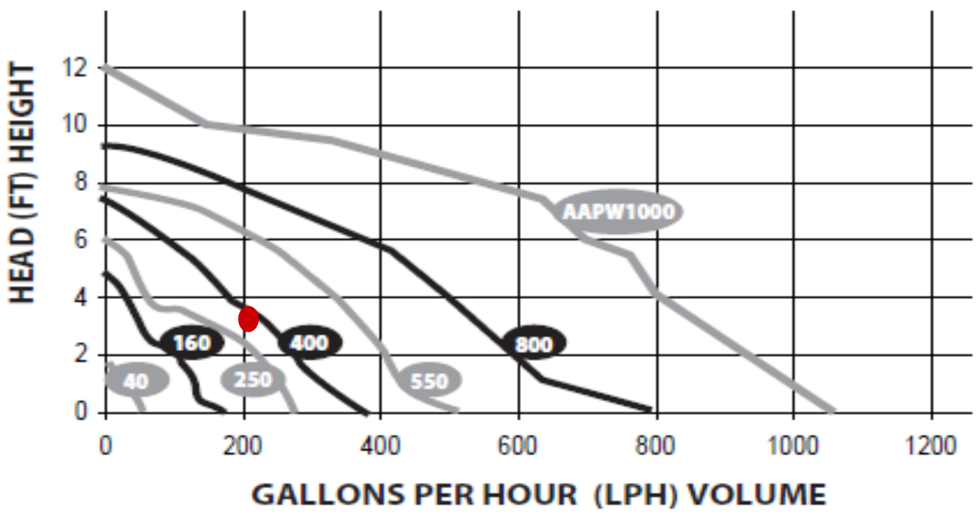
The dehumidifier will balance the environment's climate and dehumidify the space inside the enclosure. The water collected from this item will be filtered back into the reservoir to create an efficient way of keeping water levels high in the hydroponic system.

Eva-Dry 1100 Petite Dehumidifier	
Capacity	16 oz
Work Area	1100 Cubic feet
Effectiveness	approx. 8 oz at 86°F and 80% Humidity
Power	22.5 watts
Input	9V DC at 2.5 Amp

Water Pump

- For hydroponic systems, it's recommended to turn over 100% of the water every 2 hours
- We decided to use the AAPW400 model so that we can pump the proper amount of water while compensating for the vertical distance it needs to push the water
- Pump runs on standard 120V from the wall outlet, and will be switched on/off by a relay switch in case of maintenance

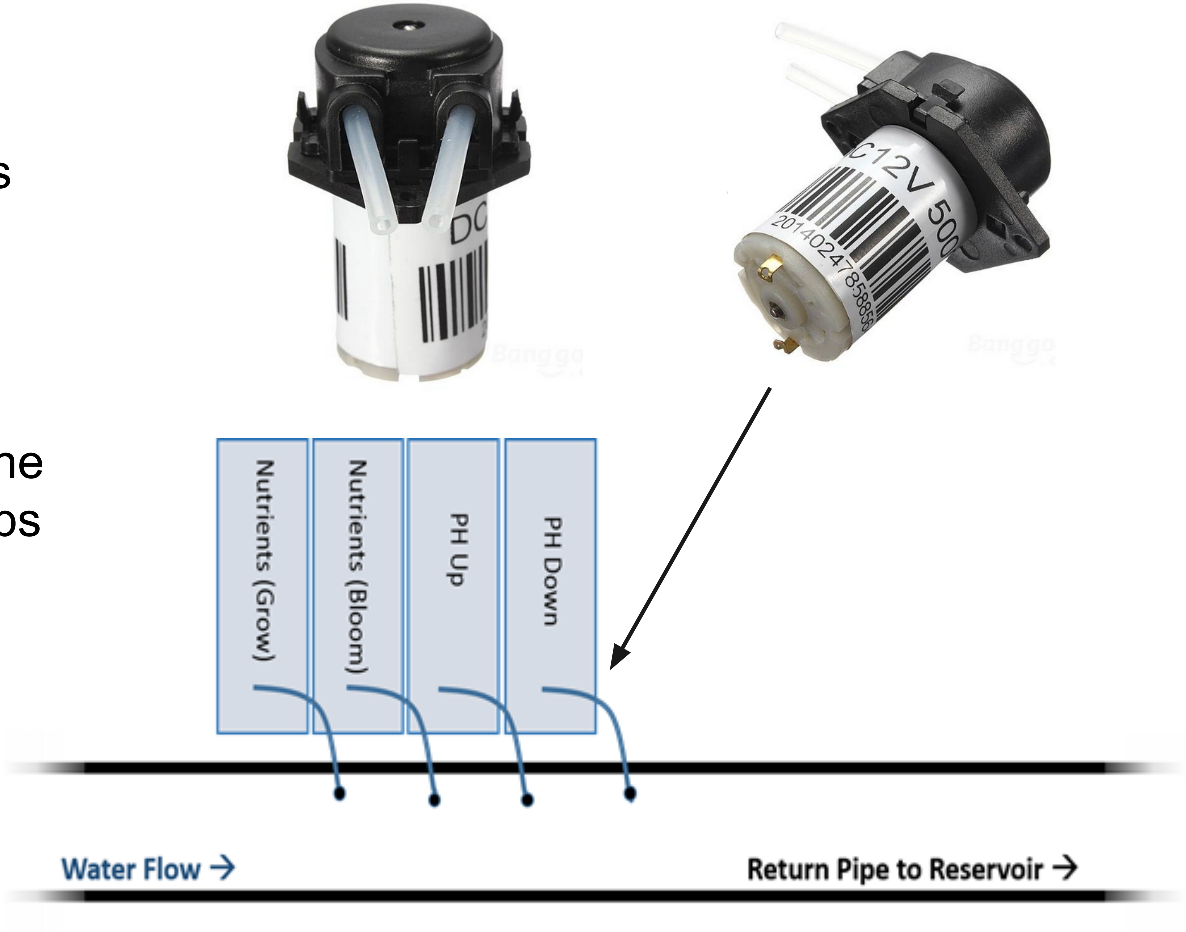
ACTIVE AQUA SUBMERSIBLE PUMP COMPARISON CHART



Product Item Code	Rated GPH	(LPH)	Recommended Size gallons	(litres,litros)	Watts	Fitting Sizes Included inches	(milimeters)
AAPW40	43	(163)	5	(19)	3	5/16"	(8mm)
AAPW160	172	(650)	15	(57)	9.5	1/2"	(12.7mm)
AAPW250	291	(1,100)	25	(95)	16	1/2", 3/4"	(12,7mm, 19mm)
AAPW400	370	(1,400)	40	(151)	24	1/2", 3/4"	(12.7mm, 19mm)

Peristaltic Pumps

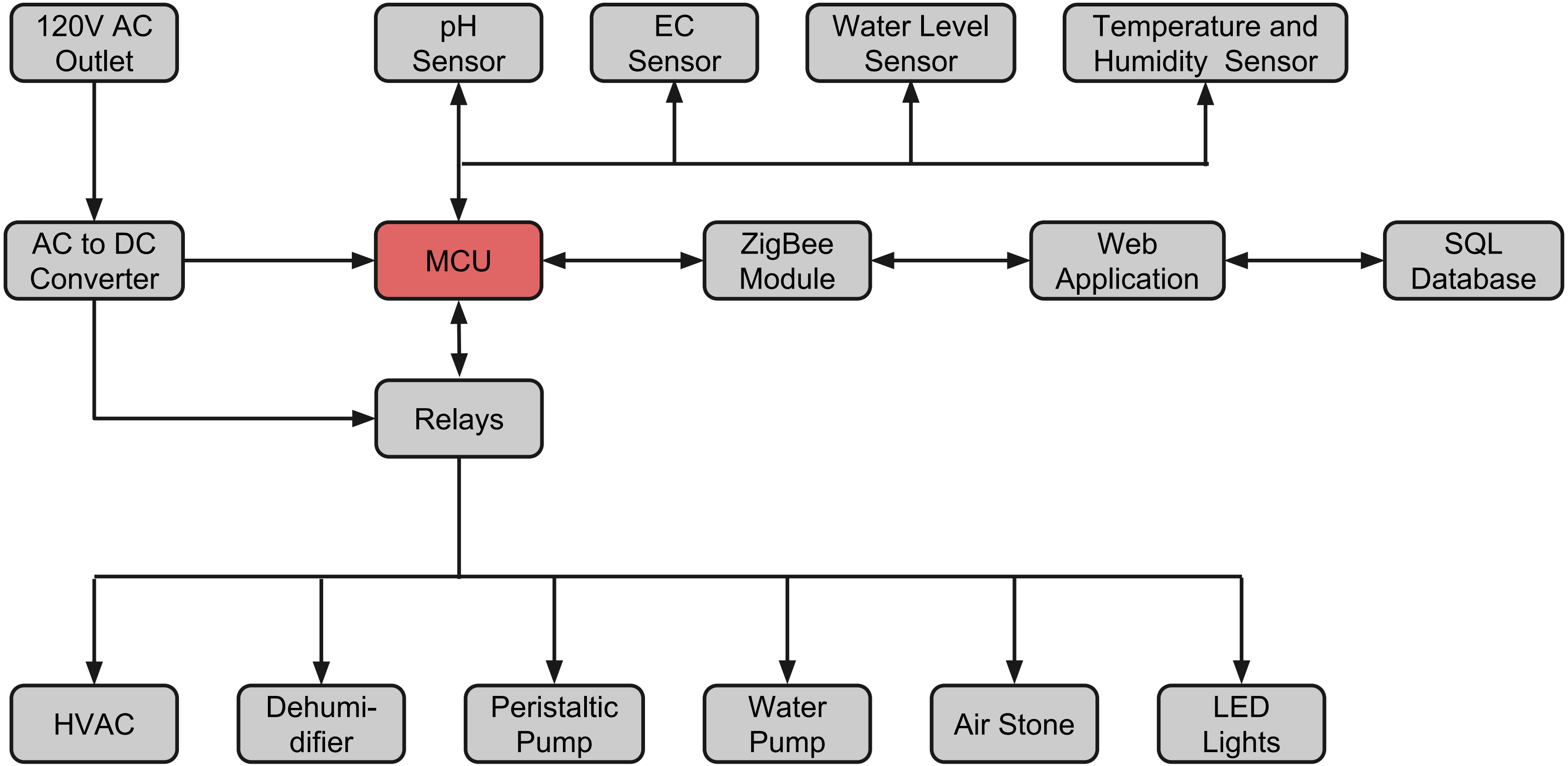
- Runs on 12V DC supply draws 200mA
- Small 5mm diameter tubes
- When activated, 1mL/s of solution is delivered to the flow
- Flow can be altered by increasing or decreasing the voltage to the dosing pumps



Air Pump

- Within our water reservoir, we will have an air pump that will push air out of an air stone placed at the bottom of our water reservoir
- Will produce bubbles that will aerate the system’s nutrient solution
- This is important so that the plants’ roots can readily absorb the oxygen they need through their water

MCU


120V AC Outlet
pH Sensor
EC Sensor
Water Level Sensor
Temperature and Humidity Sensor
AC to DC Converter
MCU
ZigBee Module
Web Application
SQL Database
Relays
HVAC
Dehumi-difier
Peristaltic Pump
Water Pump
Air Stone
LED Lights

ATMega 2561 vs. MSP430F5659

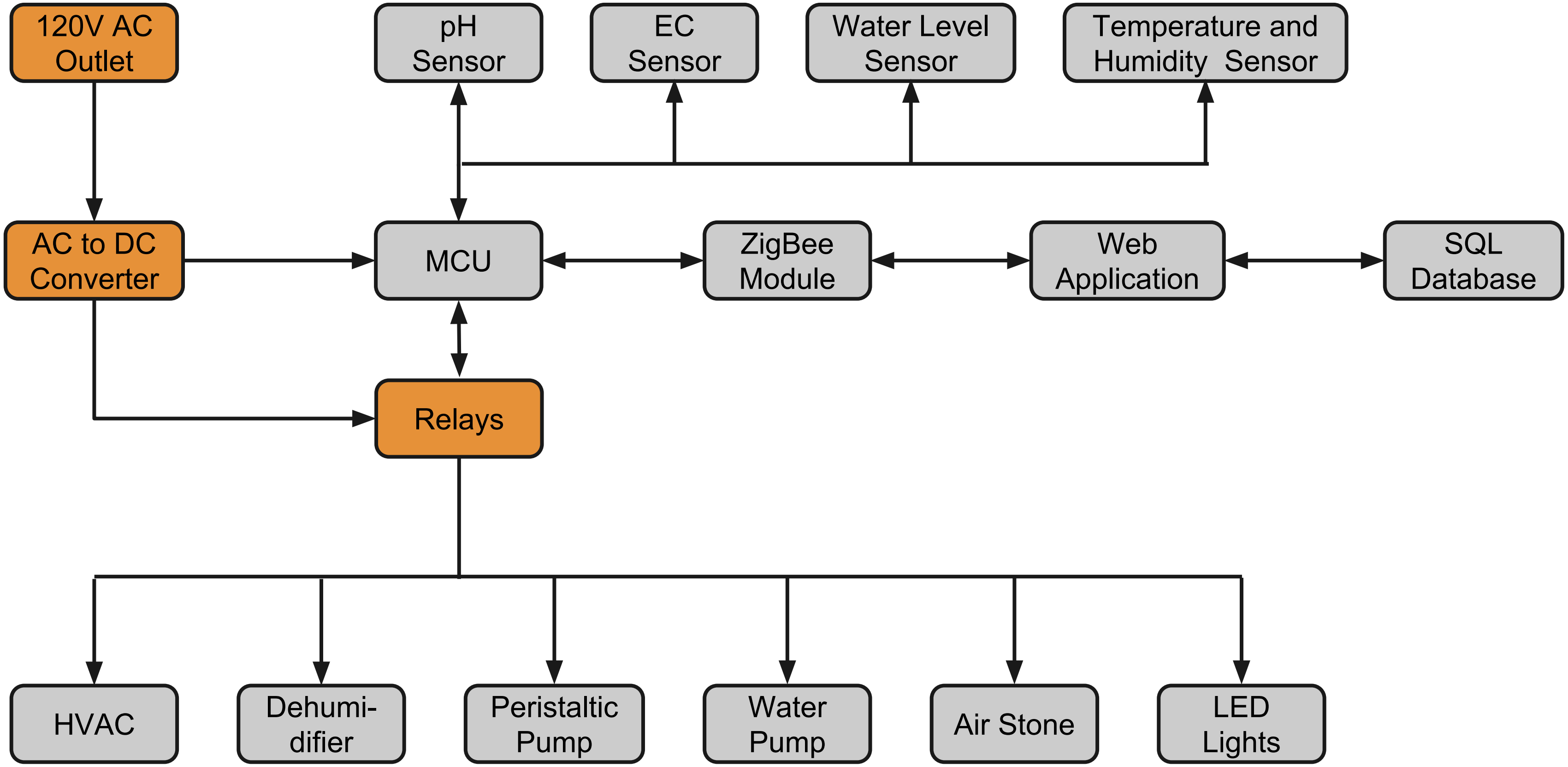
Atmel ATMega 2561 Specifications

Parameter	Value
Flash Memory (Kbytes)	256
Pin Count	64
Max Operating Frequency (MHz)	16
Operating Voltage	Min: 1.8V Max: 5.5V
Max I/O Pins	54
SPI	3
I2C	1
UART	2
Coding Environment	Arduino IDE

TI MSP430F5659 Specifications

Parameter	Value
Flash Memory (Kbytes)	512
Pin Count	100
Max Operating Frequency (MHz)	20
Operating Voltage	Min: 1.8V Max: 3.6V
Max I/O Pins	74
SPI	6
I2C	3
UART	3
Coding Environment	Code Composer Studio

Power Components

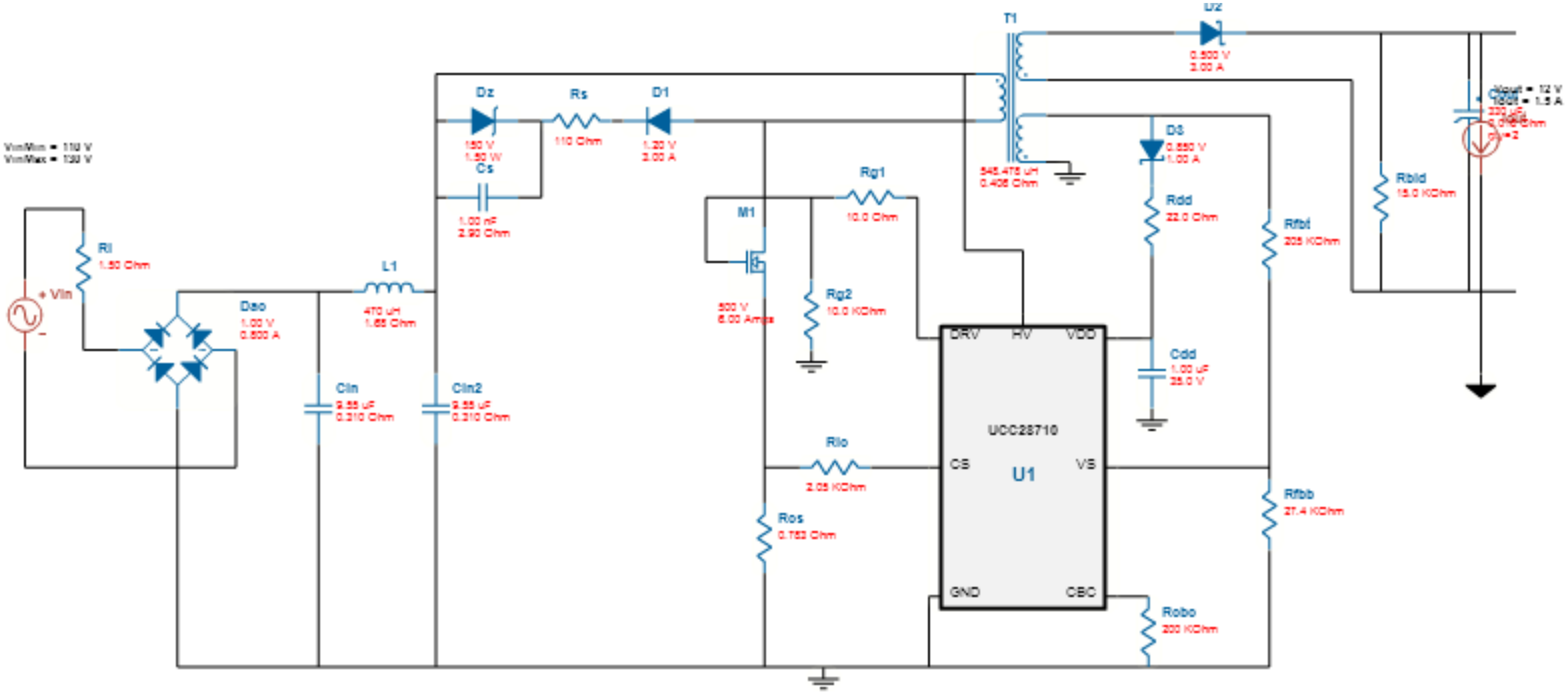


AC to DC Converter

A standard wall mounted AC to DC converter will be used to power the PCB. Total current draw of PCB IF all components were on would be just over 1.08Amps.

Specifications	
Input	110VAC / 60HZ
Output	12 V @ 1.5Amps
Jack size	2.1mm

AC to DC schematic



110VAC 60Hz input to 12V @ 1.5Amp output schematic, TIwebench

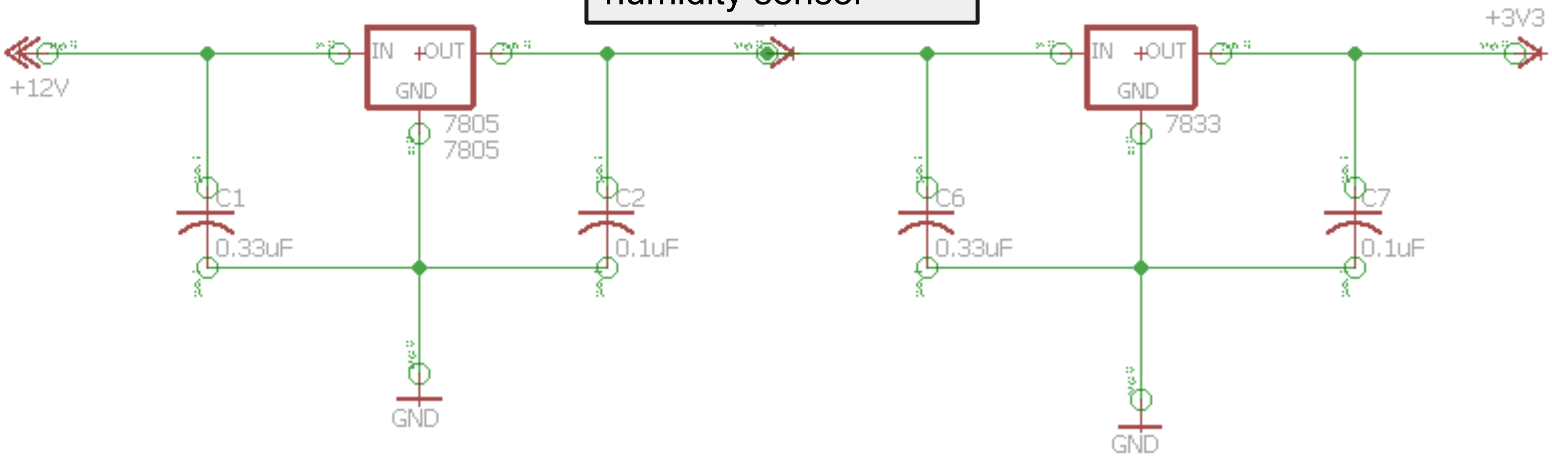
DC to DC converter

Linear voltage regulators are used to supply the smaller voltages through the PCB and save board space.

<u>12 Volts</u>
relays
Peristaltic pump motors

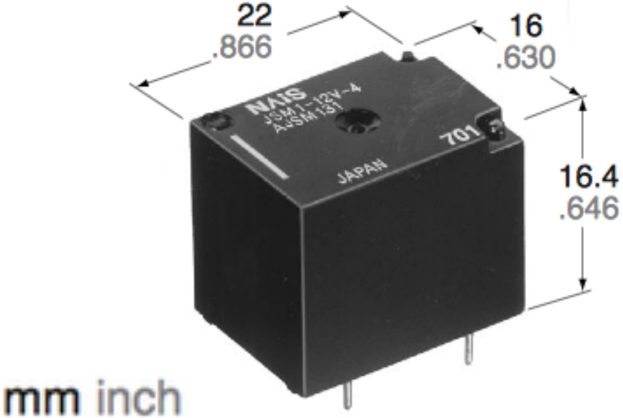
<u>5 Volts</u>
MCU
EC sensor
pH sensor
Water level sensor
Temperature and humidity sensor

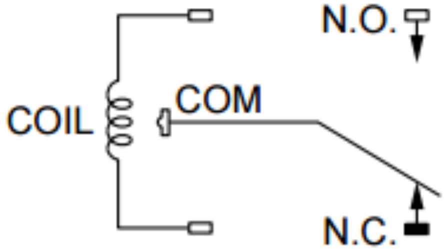
<u>3.3 Volts</u>
Zigbee Chip



Relays

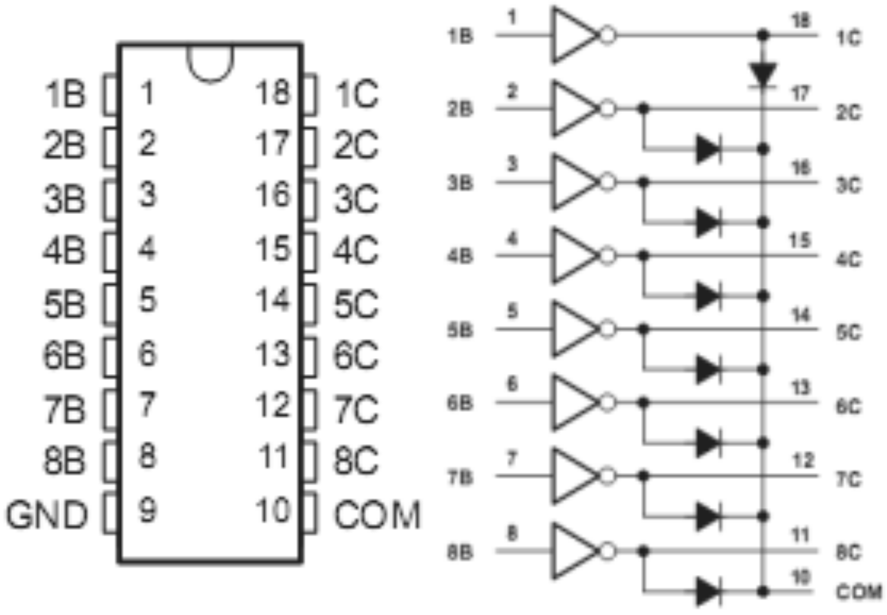
Relays will be used to turn on or off the high power components; LED light, Exhaust fan, Air+Water pump, and the dehumidfier.





Specifications	
Coil Voltage	12 volts
Coil Resistance	400Ω
Contact rating	10A / 125VAC
Trigger Time	5-10ms

Relay and motor driver



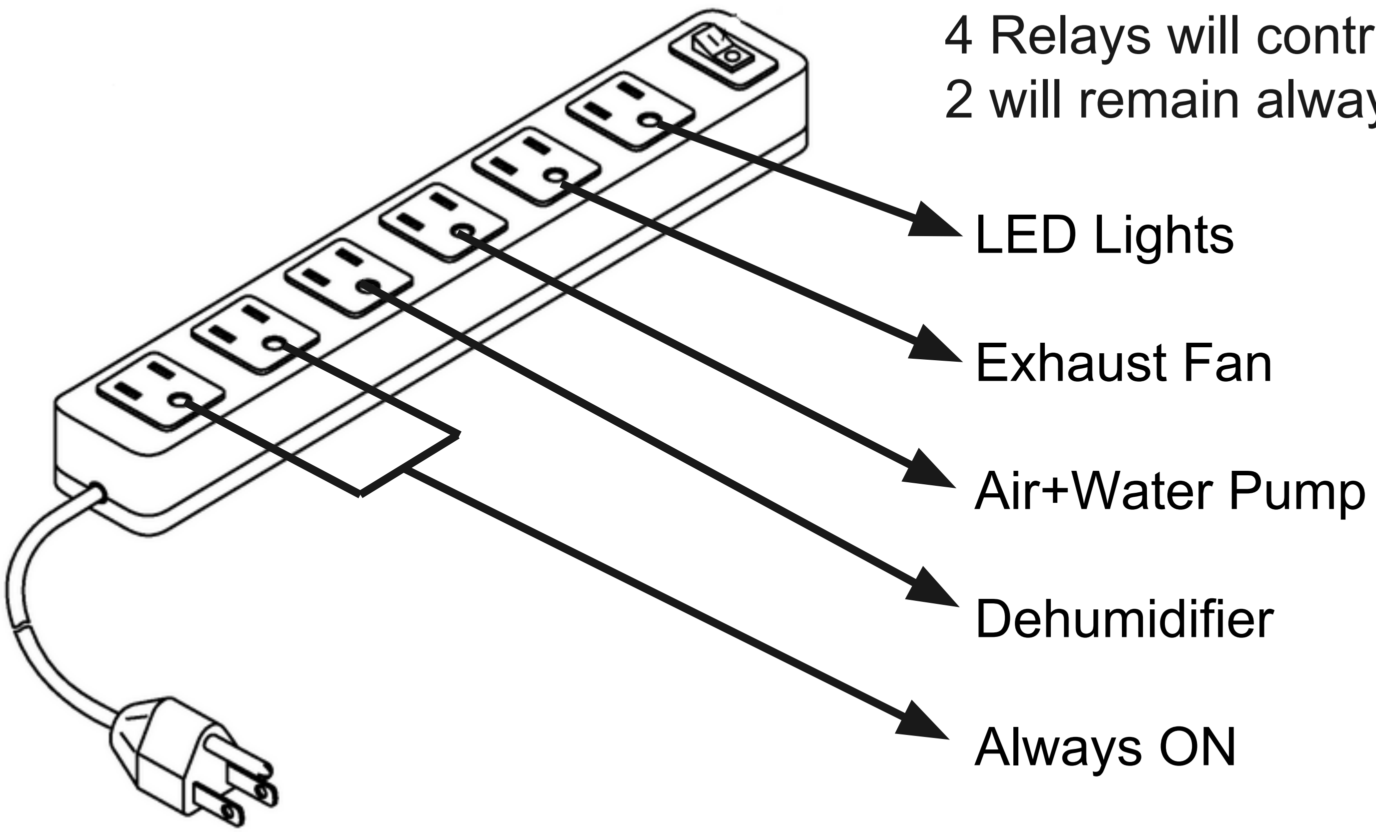
ULN2803 chip and schematic from TI datasheet

A ULN2803 Darlington Transistor array will be used as the relay and motor driver. 8 NPN darlington Pairs with high voltage and current output, as well as common cathode clamps for protection from back current when the inductive loads are switched off.

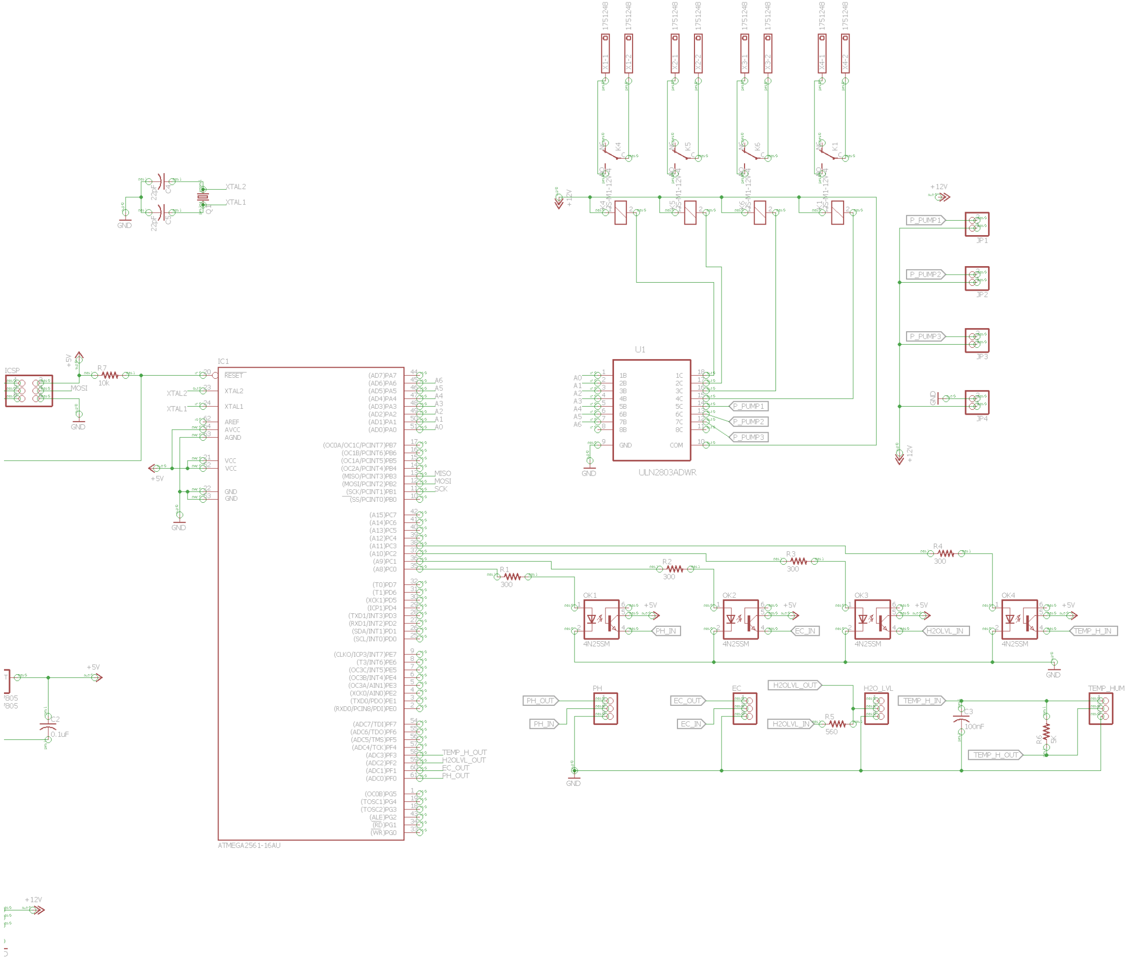
Specifications	
Input Voltage (COM)	30 Volts max
Trigger Voltage	5 Volts max
Output Current	500mA max

Power Strip

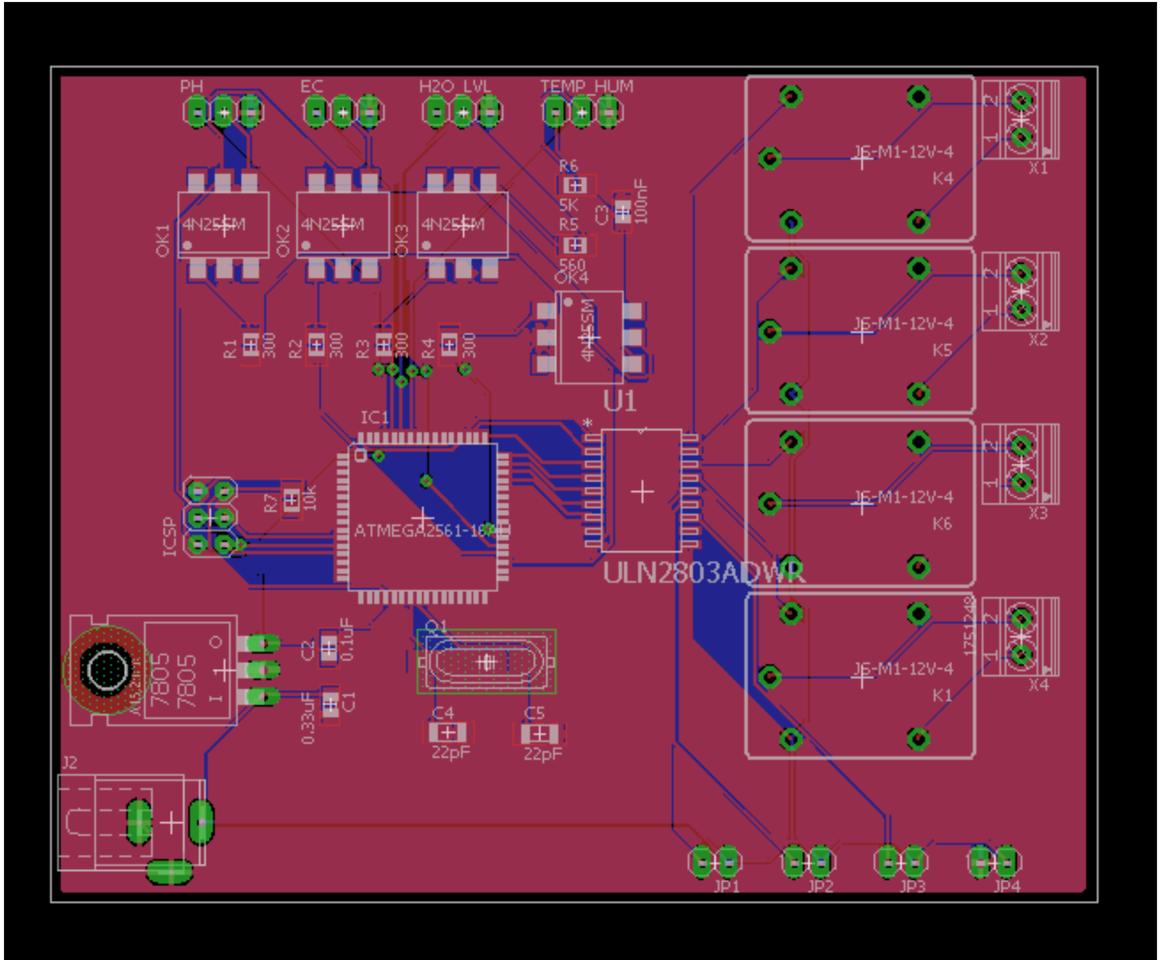
4 Relays will control 4 outlets while 2 will remain always on.



PCB Design

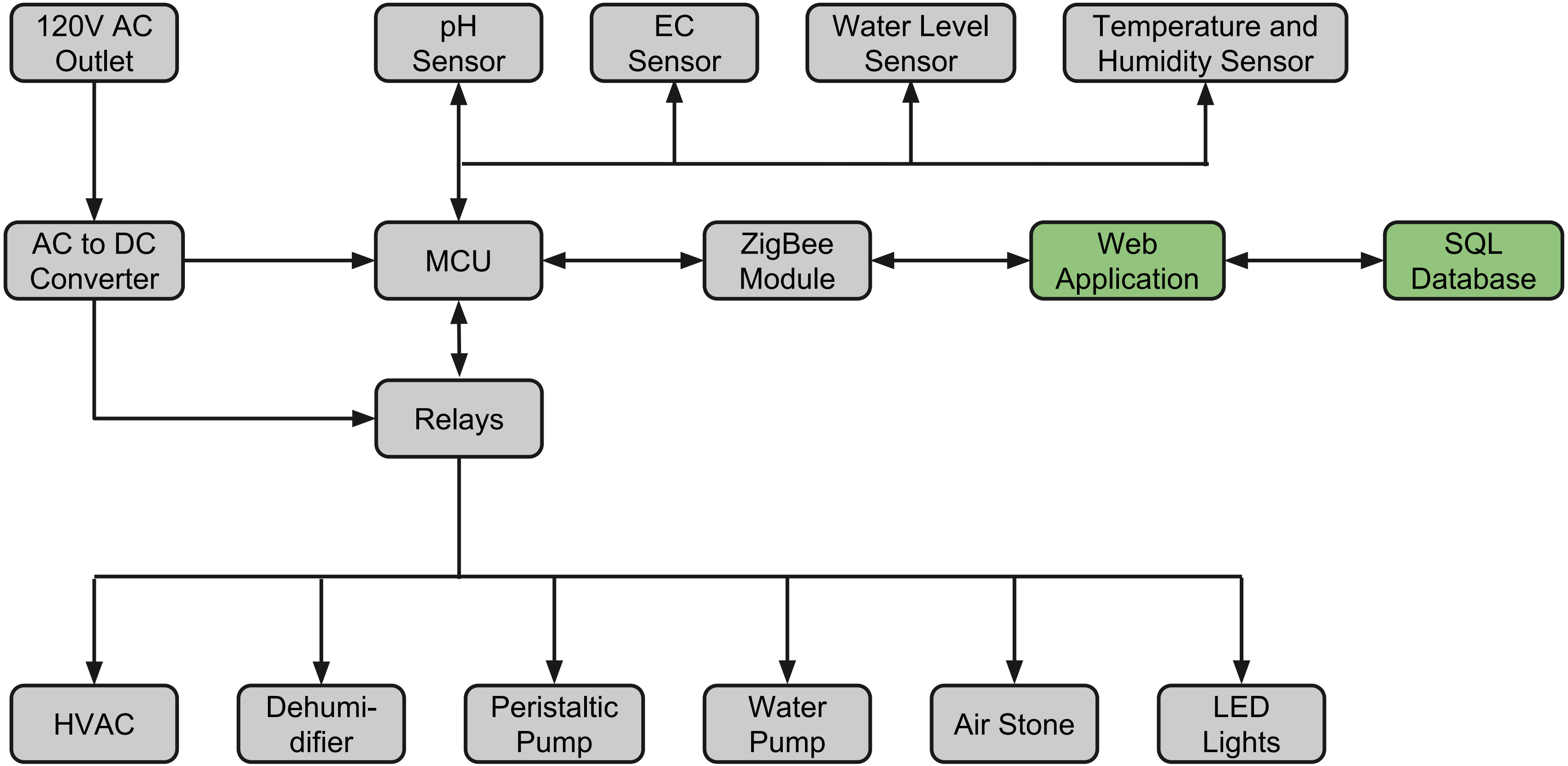


PCB



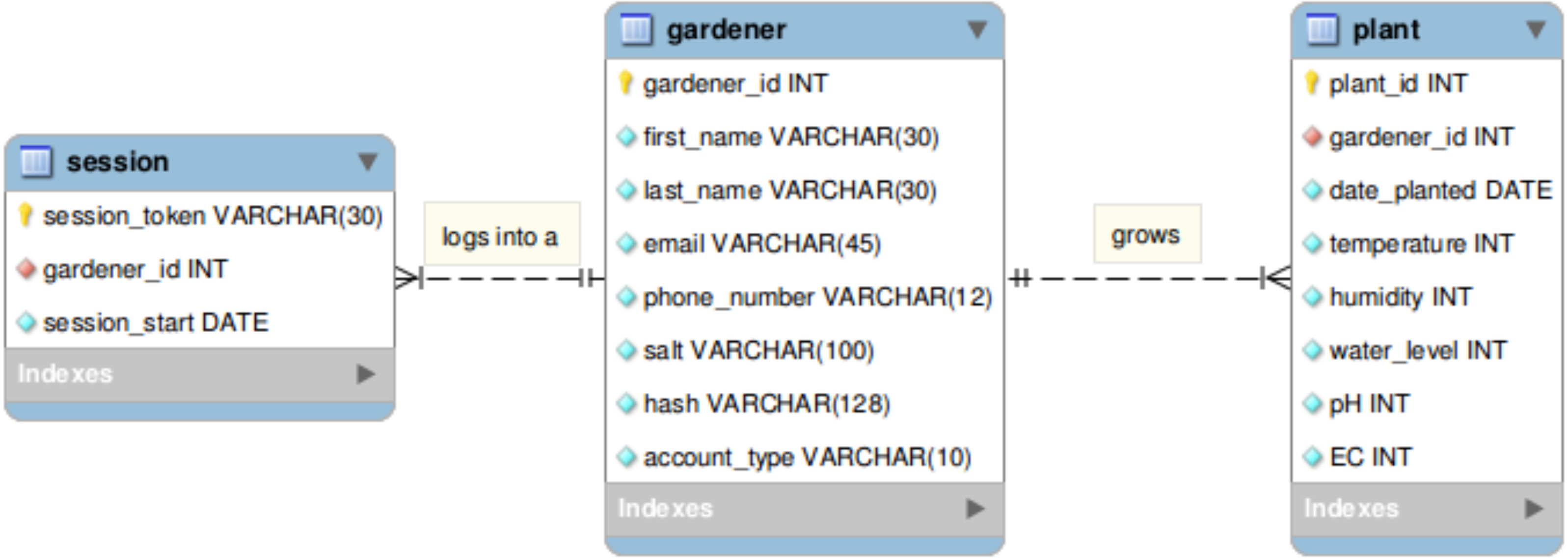
PH
EC
H2O_LVL
TEMP_HUM
OK1
OK2
OK3
OK4
4N25SM
R1
R2
R3
R4
300
R5
560
R6
5K
C3
100nF
U1
IC1
ATMEGA2561-16AU
ULN2803ADWR
ICSP
R7
10k
7805
C2
0.1uF
C1
0.33uF
Q1
C4
22pF
C5
22pF
J2
J6-M1-12V-4
K4
K5
K6
K1
X1
X2
X3
X4
JP1
JP2
JP3
JP4

Web Application



Database

SQL Database Design:



Mobile App vs. Web App

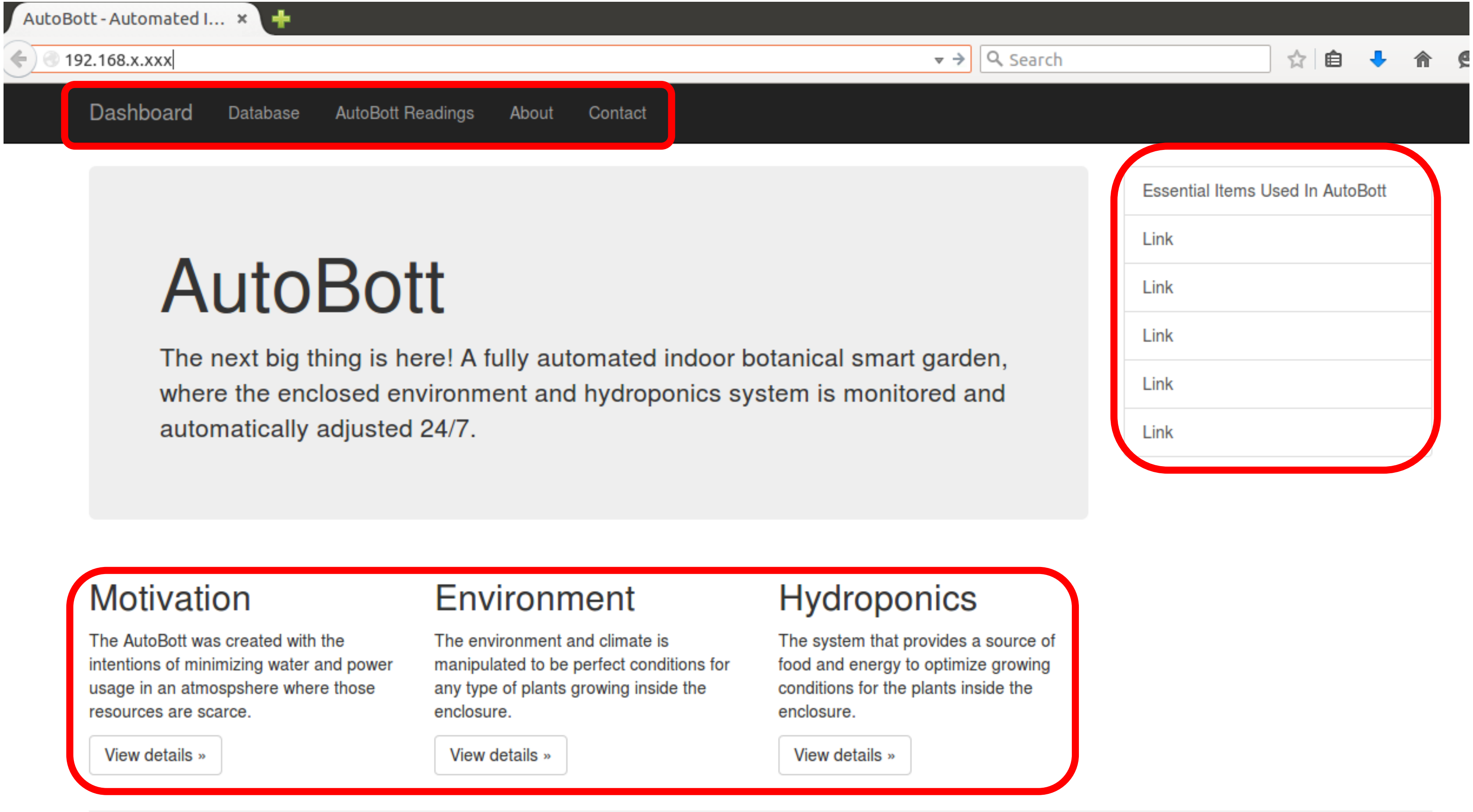
Mobile App:

- Cross-platform coding
  - iOS
  - Android
- Uses storage space on mobile devices

Web App:

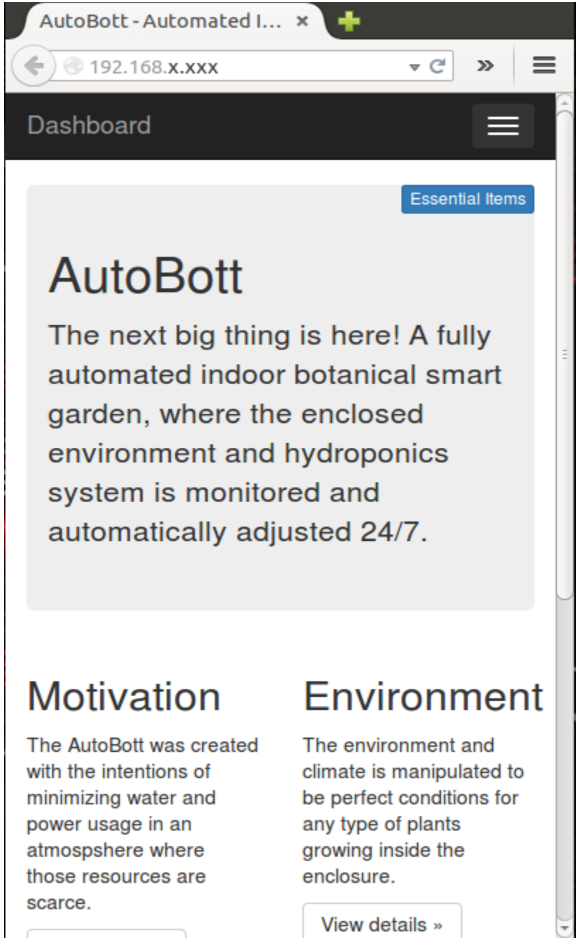
- Reaches all devices through internet
  - Support through different browsers, only the latest (safari, chrome, firefox)
- All data will be accessed through internet

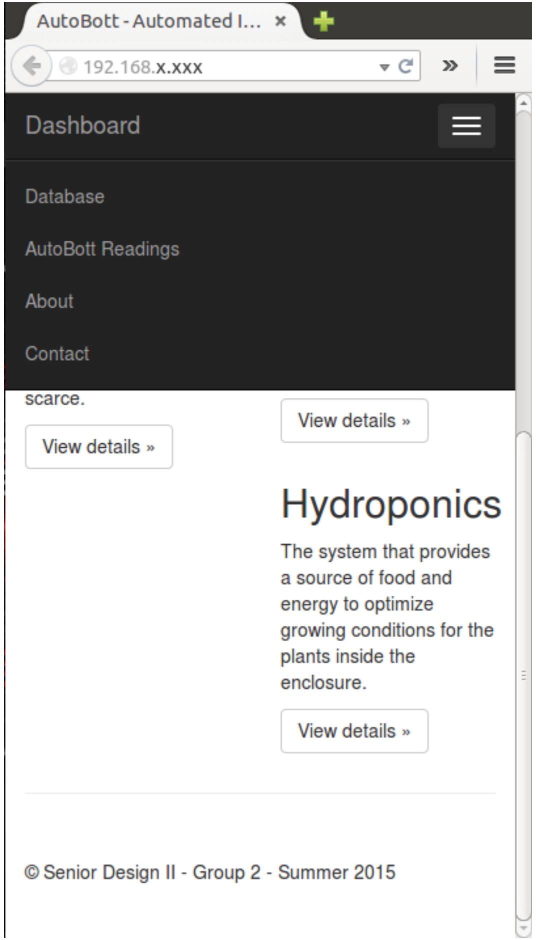
Web App Features



Web App Responsiveness

- The AutoBott web app is responsive with devices that have different size screens.
- The web app is created using Bootstrap, which is a mobile-first development tool





Administrative Content

Work Distribution:

AREAS OF WORK	David	Antonio	Eric	Steven
Power Supply and Distribution		X	X	
Web Application	**X**			X
PCB Design		X	**X**	
Sensor Interaction			X	**X**
MCU Programming	X			X
Hydroponic Research and Design	X	**X**		
Enclosed Environment Design			X	X
Physical Enclosure Design	X	X		

Budget

Parts and Materials	Quantity	Unit Cost	Cost
pH sensor	1	$34.00	$34.00
EC sensor	1	$75.00	$75.00
Water level sensor	1	$14.99	$14.99
Air temperature and humidity sensor	2	$4.00	$8.00
Strand Plywood	3	$24.00	$72.00
Plexi glass	1	$2.97	$2.97
Glue, tape, cocking	1	$15.00	$15.00
Screws/nails	1	$2.98	$5.96
Wires, cables, tubing	1	$16.00	$16.00
PVC pipes (corner pieces, straight pieces, etc.)	variable	n/a	$25.00
Wheels	1 (set)	$9.80	$9.80
MCU's (Arduino/MSP430)	1	$10.00	$10.00
Solid State Relays	4	$1.00	$4.00
Darington Driver 8 Channel	1	$9.99	$9.99
LED lights	1	$98.95	$98.95
Power circuit materials (power strip)	1	$23.99	$23.99

Parts and Materials	Quantity	Unit Cost	Cost
Air stone	1	$5.42	$5.42
Water pump	1	$12.50	$12.50
HVAC	1	$25.00	$25.00
De-humidifier	1	$44.35	$44.35
Reservoir	1	$30.00	$30.00
Nutrient pump	3	$9.99	$29.97
Grow pots	4	$5.99	$23.96
Plant trays	3	$8.00	$24.00
Miscellaneous PCB Components	variable	n/a	$20.00
Nutrients	4 (set)	$14.26	$14.26
Mylar	1	$23.48	$23.48
Grow rocks	1	$25.95	$25.95
Unaccounted materials	variable	n/a	$50.00

Total Cost: $754.54

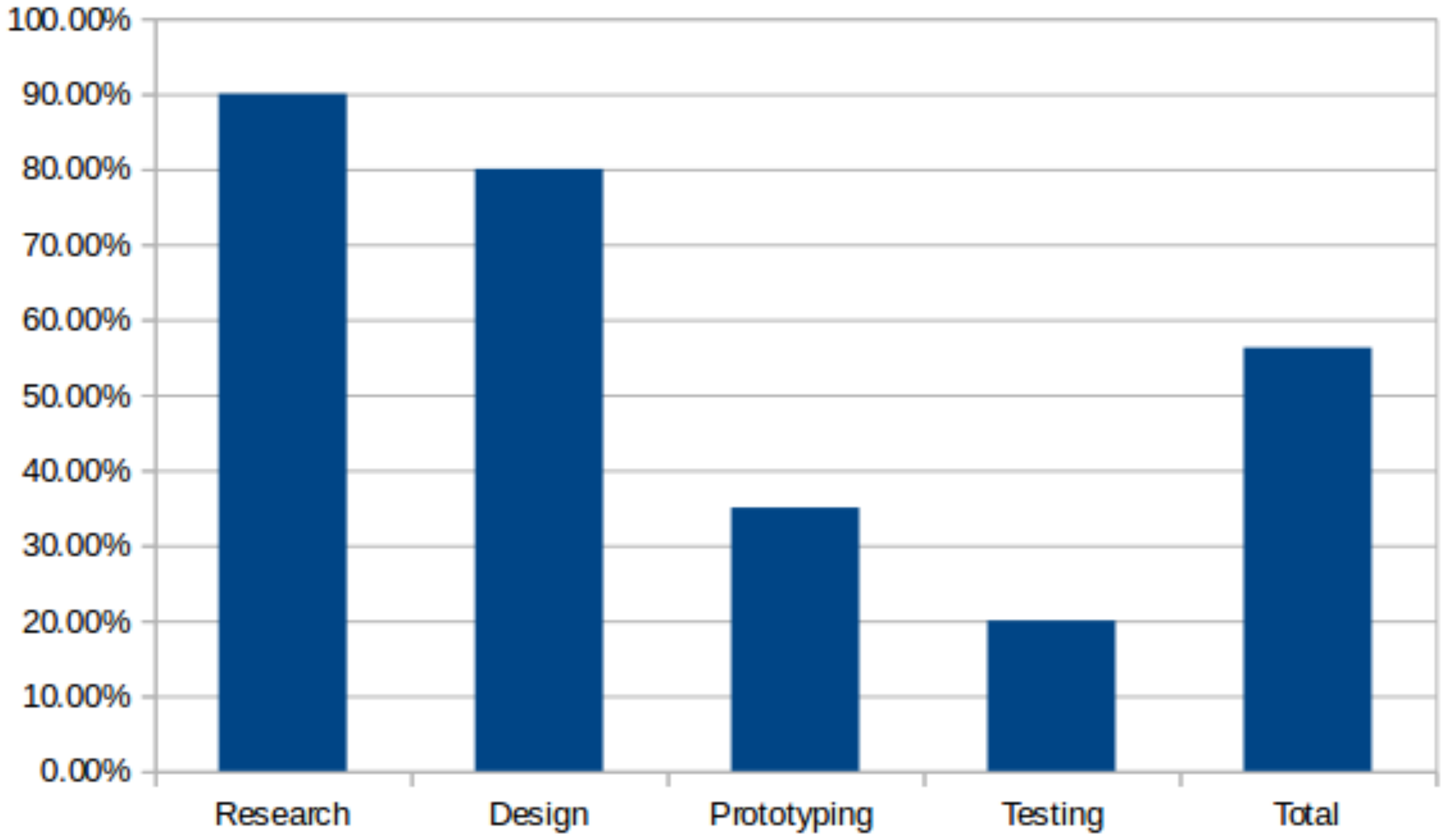
Financing

Seeking sponsorship for specific components:

- EC sensor supplier - nothing *at this time*
- ZigBee Module - sponsored by Professor Lei Wei and his graduate students
- Hydroponic items - unable to donate *at this time*

Otherwise, group has financed project.

Progress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Research
Design
Prototyping
Testing
Total

Issues

- EC probes and sensors are hard to find within budget. Many of these specific products are going out of stock from the initial time they are researched.
  - Sponsorships
- Controlling water flow from reservoir to plant tray in different stages
  - Using PWM (pulse width modulation)
- Making cabinet air sealed
  - Use weather stripping on the front panel door and caulking around the corners
- Ensuring plant sensors are not tampered with remotely, security
  - Software related

Questions