

GROWINATOR



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ELT2720

4/20/2016

“DESTROYS YOUR FRESH VEGETABLE BILL!”

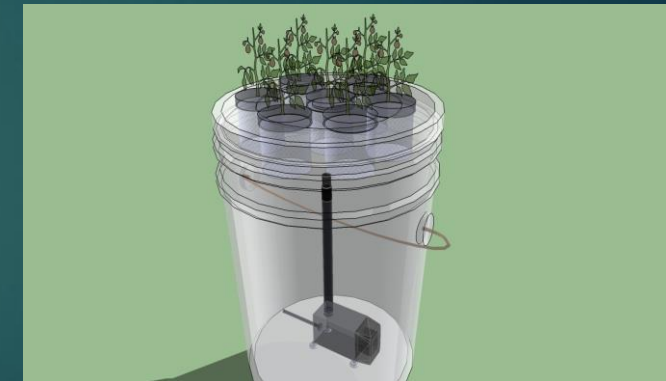
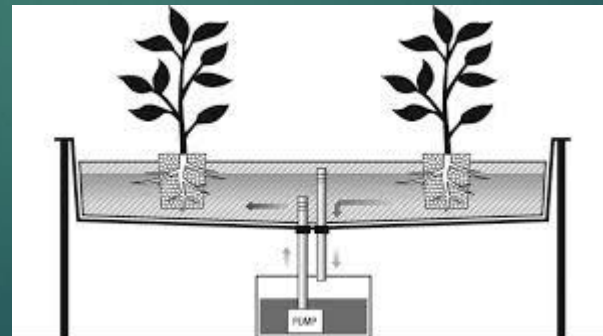
—John Connor

“Has your crops saying ‘I’ll be back’ after you harvest!”

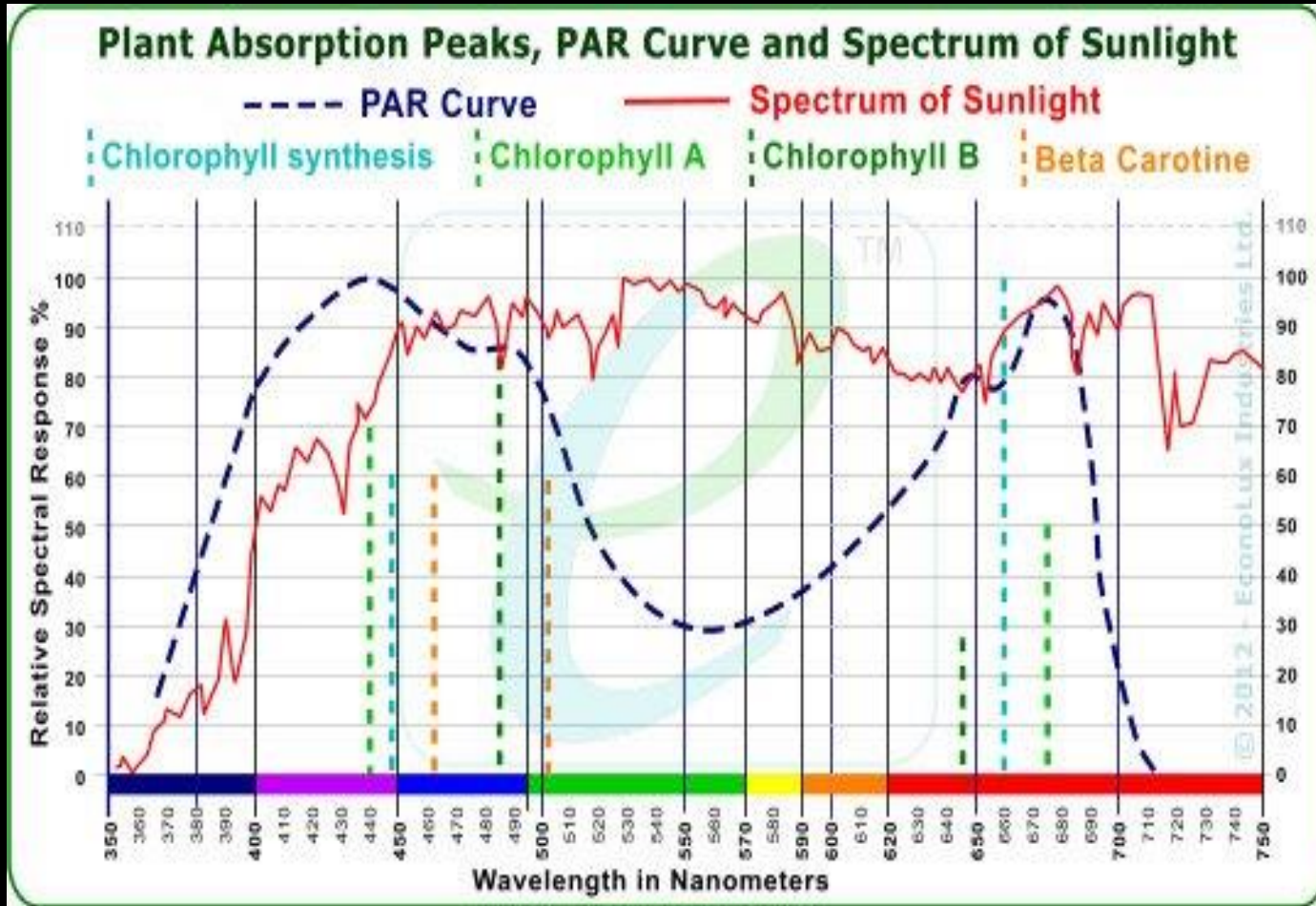
—The Terminator

What is Hydroponics?

- ▶ Soilless growing
 - ▶ Perlite / Vermiculite
 - ▶ Peat or Coir
 - ▶ Expanded clay balls
 - ▶ Rockwool
- ▶ Continuous-Flow Culture
- ▶ Aeroponics
- ▶ Flood and Drain Sub-Irrigation



Light Spectrum and Growing



- Two Wave Bands to focus on:
 - Blues:
 - Critical to plant grow
 - Where Leaves are growing and the majority of upward growth comes from
 - Only place where plants produce Beta Carotene
 - Reds:
 - Where plants form flowers
 - Necessary for anything that “fruits”

Nutrients

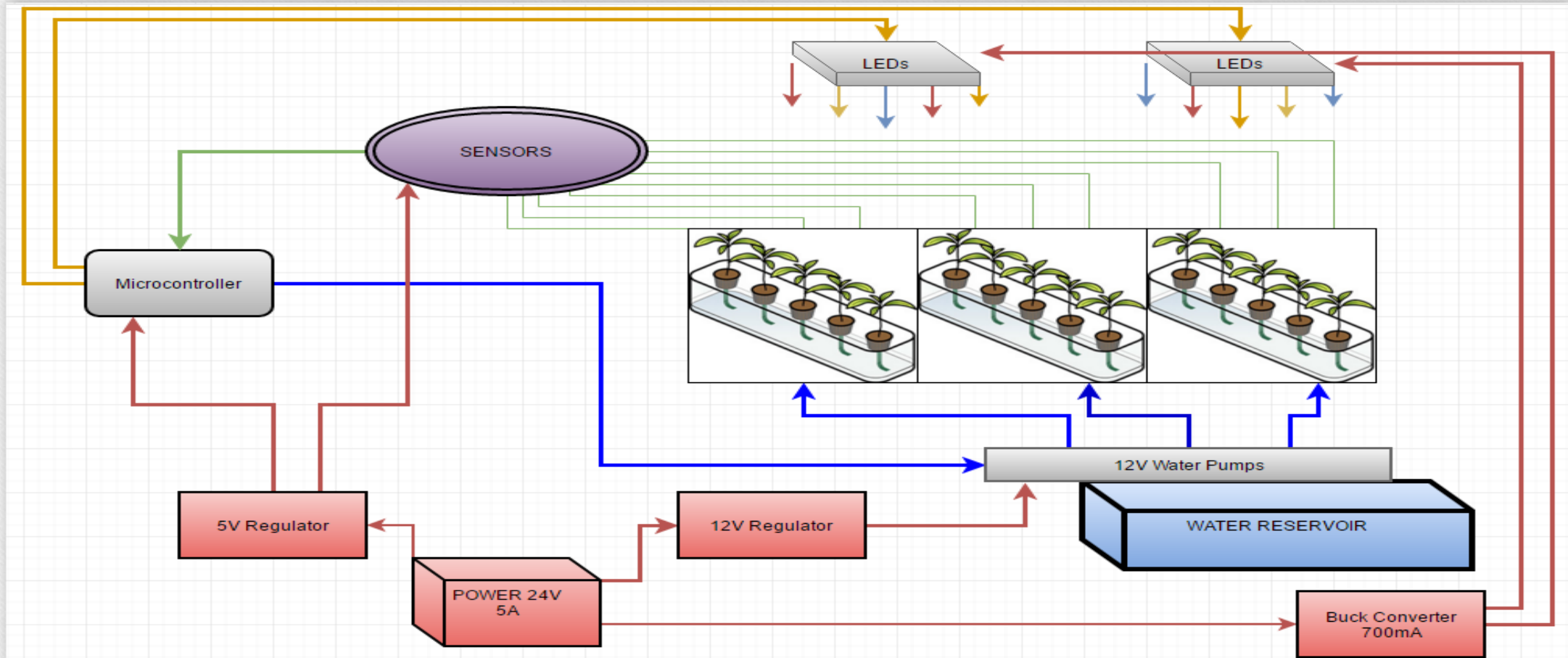
- ▶ Nitrogen
- ▶ Phosphorus
- ▶ Potassium
- ❖ Miscellaneous Minerals
- ❖ PH Level



Problem Statement

- Design a self functioning hydroponic system
- Proper light spectrum
- Self watering when needed
- Sized to function in an indoor environment

The System



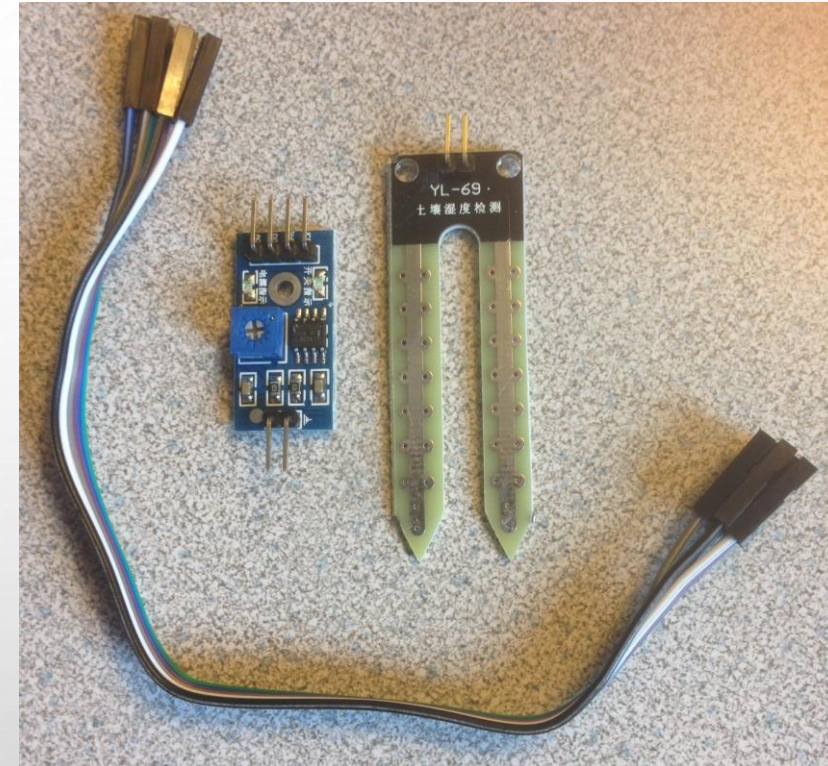
WATER SYSTEM

- LARGE DIAMETER PVC TUBING
- GRAVITY FED
- 10 GALLON RESERVOIR
- PUMPS:
 - SUBMERSIBLE
 - 12V .4A WATER PUMP
 - STATIC LIFT OF 3M
 - 240 LITER/HOUR



MOISTURE SENSORS

- 3.3V~5V IN
- CHOICE OF ANALOG OR DIGITAL OUT
 - DIGITAL:
 - TRIM POT FOR SWITCHING LEVEL
 - LM393 COMPARATOR
 - ANALOG:
 - VOLTAGE OUT OF 0~4.2



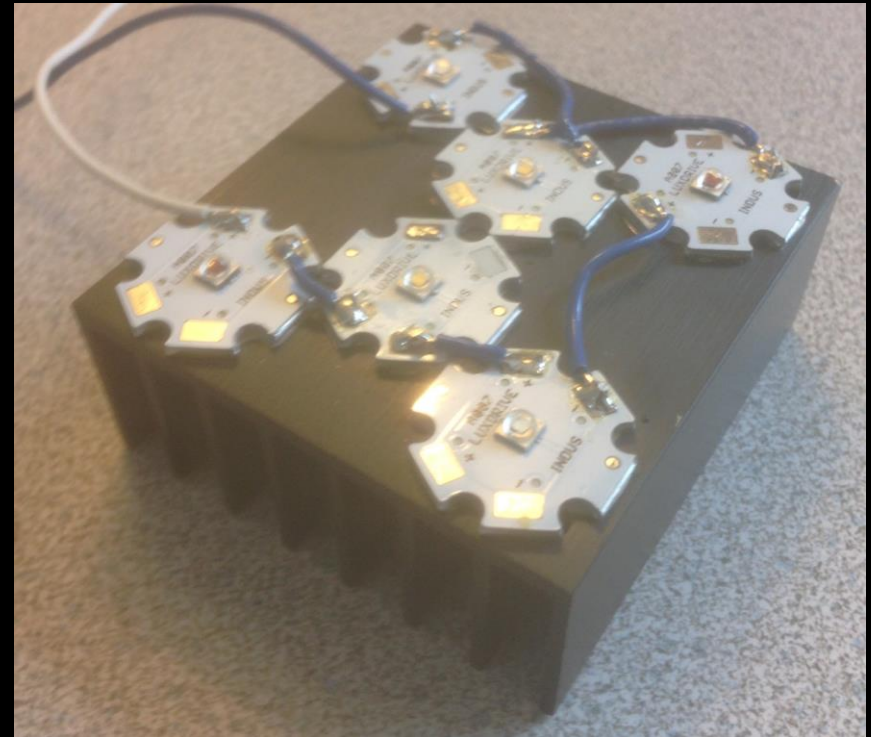
SENSOR TESTS

- USING ANALOG FOR ACCURACY
- WIDE RANGE MEANT IT WAS NOT NECESSARY FOR AN AMPLIFIER

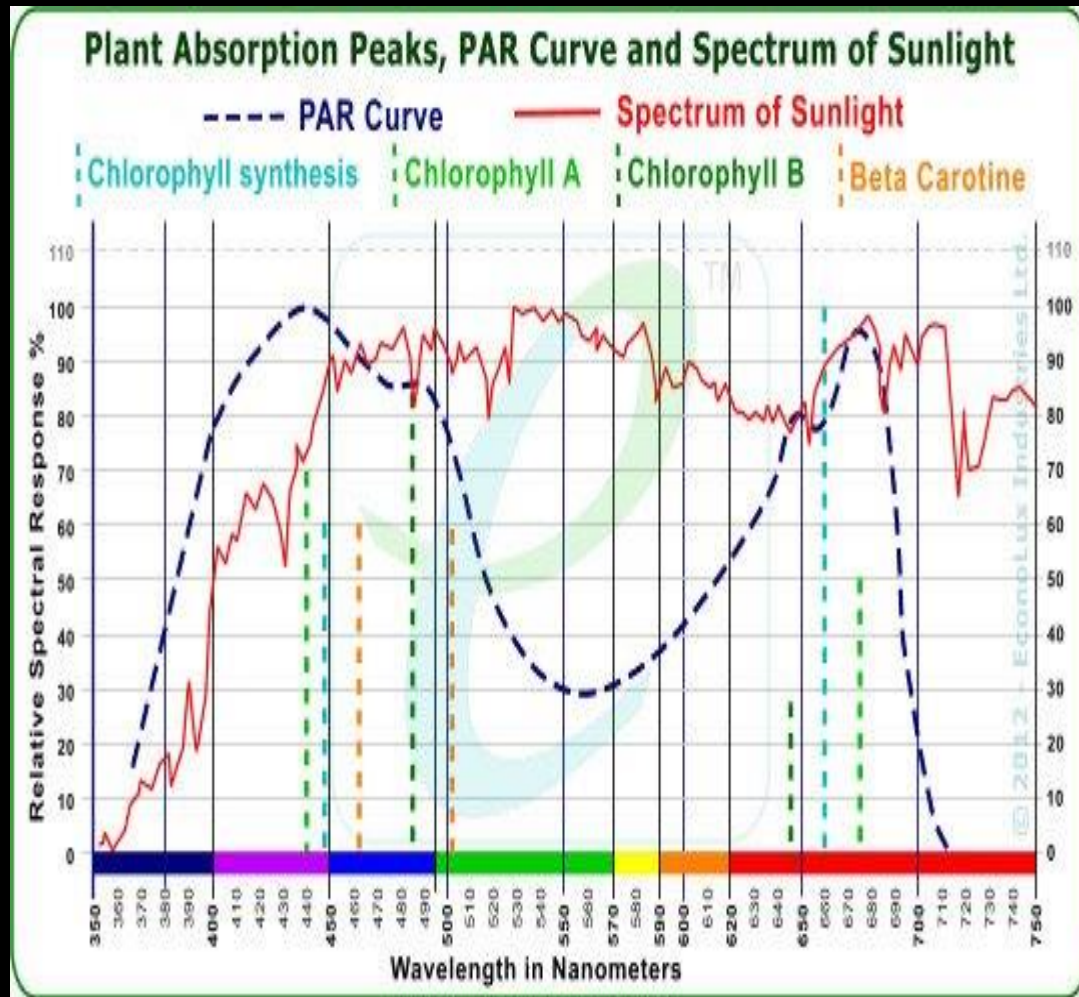
	DRY	MOIST	WATER
SENSOR 12bit Micro output	4095	2730	1692
	4095	3235	2550
	4095	3279	1414
	4095	3166	1695
	4095	3229	1701
Mean	4095	3127	1810

LIGHTING SYSTEM

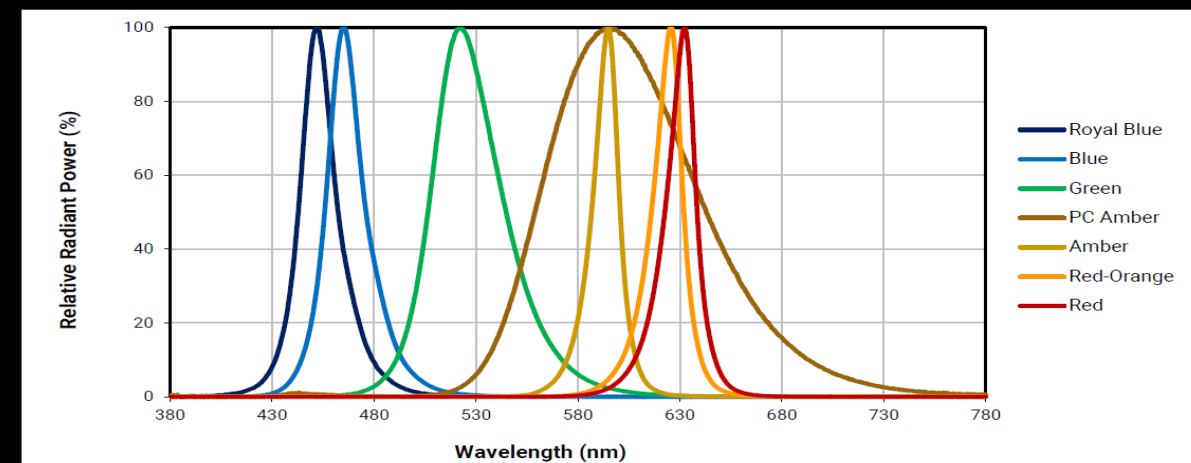
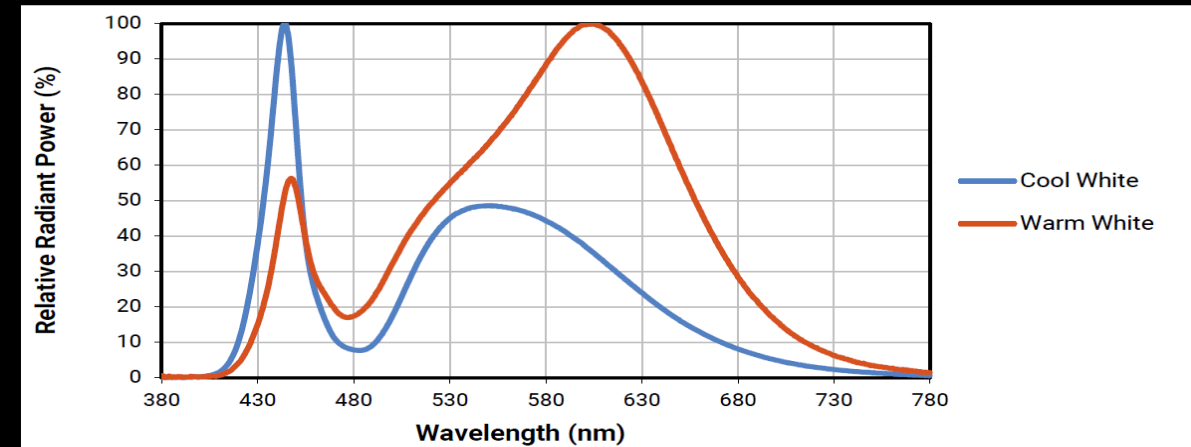
- Cree XP-E 3W LEDs
 - 2 White
 - 2 Red
 - 2 Royal Blue
- Measured Forward Voltage
 - 16.93V
 - 16.86V
- Large Heat Sink
 - Heating concerns for Red LEDs



WAVELENGTH

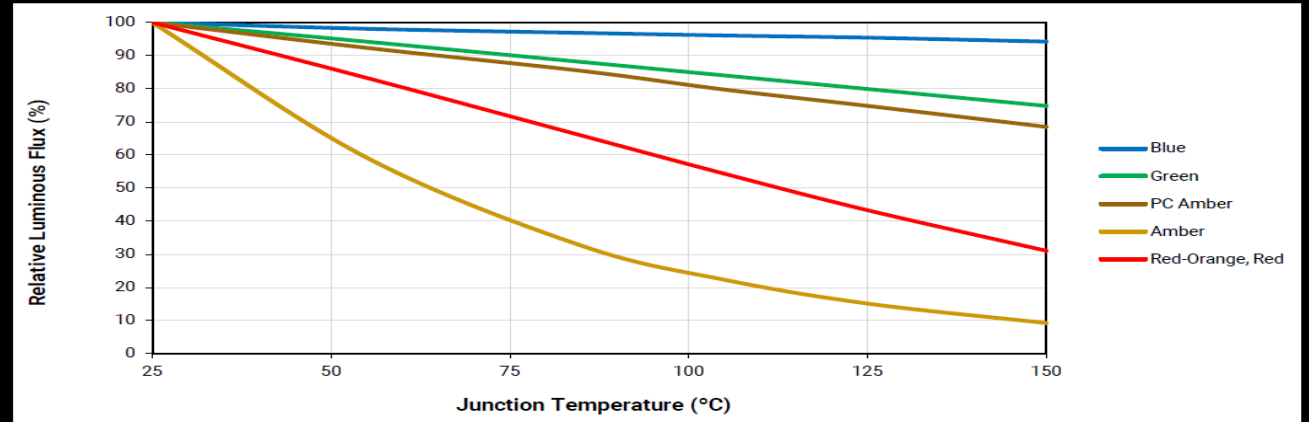


From CREE datasheet:



HEAT CONCERNS AND LIGHT OUTPUT

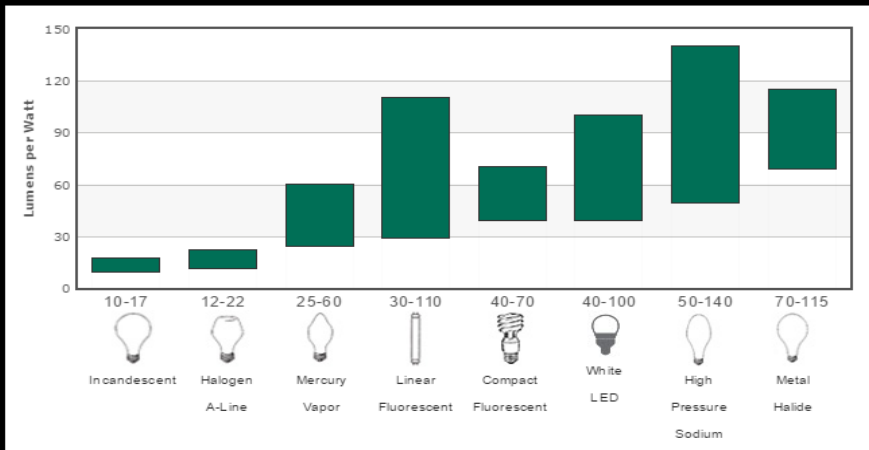
- Red LEDs lose light output fast with heat
- Large heat sink:
 - $4.7^{\circ}\text{C}/\text{W}$
- Industrial light output:
 - 110-140 Lumens/Watt



Temperature	Ambient (°C)	Heat Sink (°C)	Star (°C)	Junction (°C)
Calculated	25	67.836	70.114	86.822
Measured	23	49.8	51.6	n/a

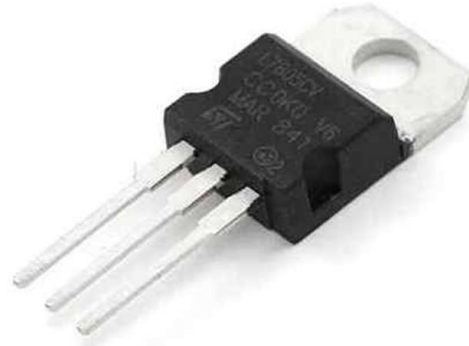
Figure 1. Thermal results from the laboratory

Color	CCT Range		Minimum Luminous Flux (lm) @ 350 mA			Calculated Minimum Luminous Flux (lm)** @ 85 °C		Order Code
	Min.	Max.	Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*	700 mA	1.0 A	
Cool White	5000 K	10,000 K	Q4	100	116	171	218	XPEBWT-L1-0000-00C51
			Q5	107	124	183	233	XPEBWT-L1-0000-00D51
			R2	114	132	195	249	XPEBWT-L1-0000-00E51
			R3	122	142	209	266	XPEBWT-L1-0000-00F51
			R4	130	152	223	284	XPEBWT-L1-0000-00G51



POWER:

- ▶ Main Supply
 - ▶ 24V 5A
- ▶ LM7805
 - ▶ Down to 5V
- ▶ LM7812
 - ▶ Down to 12V
- ▶ Buck Converter
 - ▶ Constant 700mA



POWER REASONING:

total capacity

$$\begin{aligned} \times 2 \text{ LED Arrays} &= (.7\text{A}) \times 2 = 1.4\text{A} \\ \times 3 \text{ Water pumps} &= (.4\text{A}) \times 3 = 1.2\text{A} \\ \text{Microcontroller} &= .06\text{A} \\ \times 9 \text{ moisture sensors} &= (.03) \times 9 = 0.270\text{A} \\ \text{lm7805s} &= (0.006) \times 2 = 0.012\text{A} \\ &= 2.942\text{A} \\ +20\% &= 3.53\text{A} \end{aligned}$$

Power supply modified to 24V
5A should be able to
handle everything

- 24V 5A standard supply
 - Cost effective
 - Allows Expansion of system
- LM78XX
 - Easy onboard fix
- BUCKPUCK
 - Allows for LEDs up to 32V forward voltage

Absolute Maximum Ratings

Input Voltage, DC Model	32V _{DC}
Input Voltage, AC Model	24V _{RMS}
Output Voltage	32V _{DC}
Control Pin Voltage	10V
Reference regulator current (5V _{DC}) Output	20mA

LM7812

3-Terminal 1A Positive Voltage Regulator

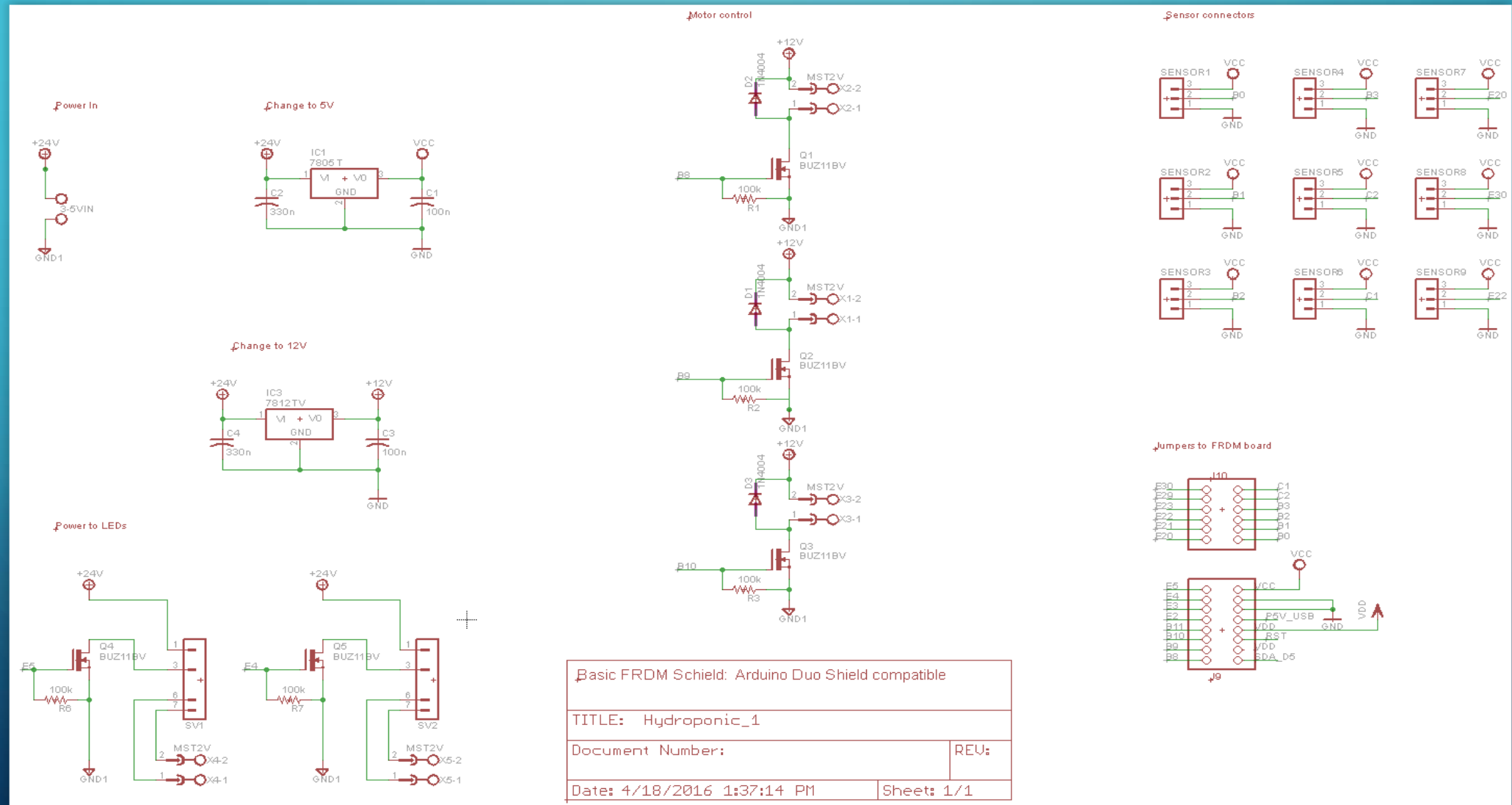
The LM78XX series of three terminal positive regulators are available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

Features

Output Current up to 1A

Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24

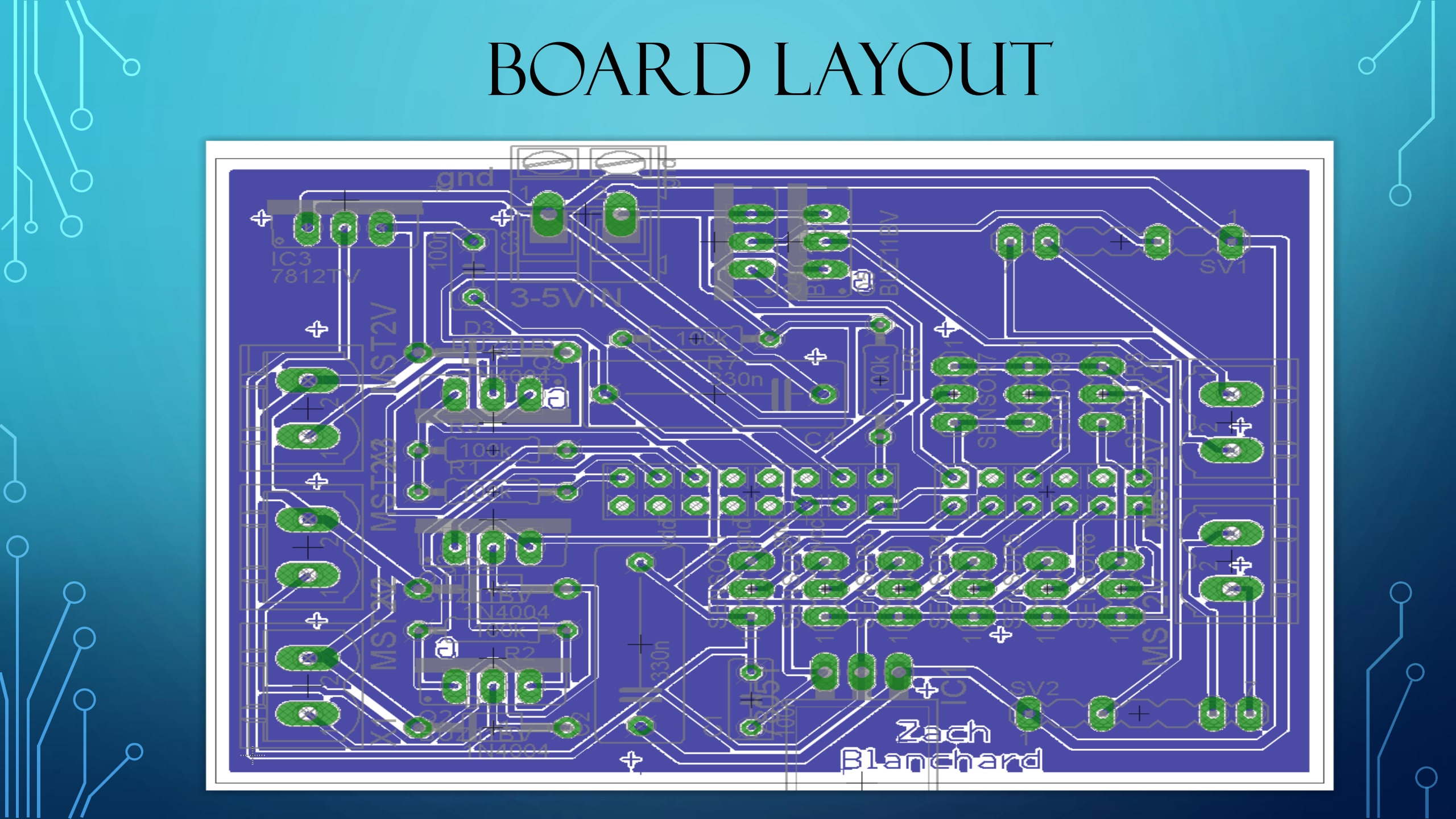
SCHEMATIC



BOARD LAYOUT

The image displays a complex PCB layout on a blue background. The layout includes numerous components and their connections, labeled with text and symbols. Key components and labels include:

- IC3 7812TV**: A voltage regulator at the top left.
- 3-5VIN**: A power input label near the top center.
- BLZ11EV**: A component label near the top right.
- SV1**: A signal or power output label on the right side.
- MS2V**: A label for a multi-pin connector on the right.
- MS2V2**: A label for another multi-pin connector on the right.
- MS2V3**: A label for a third multi-pin connector on the right.
- MS2V4**: A label for a fourth multi-pin connector on the right.
- MS2V5**: A label for a fifth multi-pin connector on the right.
- MS2V6**: A label for a sixth multi-pin connector on the right.
- MS2V7**: A label for a seventh multi-pin connector on the right.
- MS2V8**: A label for an eighth multi-pin connector on the right.
- MS2V9**: A label for a ninth multi-pin connector on the right.
- MS2V10**: A label for a tenth multi-pin connector on the right.
- MS2V11**: A label for an eleventh multi-pin connector on the right.
- MS2V12**: A label for a twelfth multi-pin connector on the right.
- MS2V13**: A label for a thirteenth multi-pin connector on the right.
- MS2V14**: A label for a fourteenth multi-pin connector on the right.
- MS2V15**: A label for a fifteenth multi-pin connector on the right.
- MS2V16**: A label for a sixteenth multi-pin connector on the right.
- MS2V17**: A label for a seventeenth multi-pin connector on the right.
- MS2V18**: A label for an eighteenth multi-pin connector on the right.
- MS2V19**: A label for a nineteenth multi-pin connector on the right.
- MS2V20**: A label for a twentieth multi-pin connector on the right.
- MS2V21**: A label for a twenty-first multi-pin connector on the right.
- MS2V22**: A label for a twenty-second multi-pin connector on the right.
- MS2V23**: A label for a twenty-third multi-pin connector on the right.
- MS2V24**: A label for a twenty-fourth multi-pin connector on the right.
- MS2V25**: A label for a twenty-fifth multi-pin connector on the right.
- MS2V26**: A label for a twenty-sixth multi-pin connector on the right.
- MS2V27**: A label for a twenty-seventh multi-pin connector on the right.
- MS2V28**: A label for a twenty-eighth multi-pin connector on the right.
- MS2V29**: A label for a twenty-ninth multi-pin connector on the right.
- MS2V30**: A label for a thirtieth multi-pin connector on the right.
- MS2V31**: A label for a thirty-first multi-pin connector on the right.
- MS2V32**: A label for a thirty-second multi-pin connector on the right.
- MS2V33**: A label for a thirty-third multi-pin connector on the right.
- MS2V34**: A label for a thirty-fourth multi-pin connector on the right.
- MS2V35**: A label for a thirty-fifth multi-pin connector on the right.
- MS2V36**: A label for a thirty-sixth multi-pin connector on the right.
- MS2V37**: A label for a thirty-seventh multi-pin connector on the right.
- MS2V38**: A label for a thirty-eighth multi-pin connector on the right.
- MS2V39**: A label for a thirty-ninth multi-pin connector on the right.
- MS2V40**: A label for a fortieth multi-pin connector on the right.
- MS2V41**: A label for a forty-first multi-pin connector on the right.
- MS2V42**: A label for a forty-second multi-pin connector on the right.
- MS2V43**: A label for a forty-third multi-pin connector on the right.
- MS2V44**: A label for a forty-fourth multi-pin connector on the right.
- MS2V45**: A label for a forty-fifth multi-pin connector on the right.
- MS2V46**: A label for a forty-sixth multi-pin connector on the right.
- MS2V47**: A label for a forty-seventh multi-pin connector on the right.
- MS2V48**: A label for a forty-eighth multi-pin connector on the right.
- MS2V49**: A label for a forty-ninth multi-pin connector on the right.
- MS2V50**: A label for a fiftieth multi-pin connector on the right.
- MS2V51**: A label for a fifty-first multi-pin connector on the right.
- MS2V52**: A label for a fifty-second multi-pin connector on the right.
- MS2V53**: A label for a fifty-third multi-pin connector on the right.
- MS2V54**: A label for a fifty-fourth multi-pin connector on the right.
- MS2V55**: A label for a fifty-fifth multi-pin connector on the right.
- MS2V56**: A label for a fifty-sixth multi-pin connector on the right.
- MS2V57**: A label for a fifty-seventh multi-pin connector on the right.
- MS2V58**: A label for a fifty-eighth multi-pin connector on the right.
- MS2V59**: A label for a fifty-ninth multi-pin connector on the right.
- MS2V60**: A label for a sixtieth multi-pin connector on the right.
- MS2V61**: A label for a sixty-first multi-pin connector on the right.
- MS2V62**: A label for a sixty-second multi-pin connector on the right.
- MS2V63**: A label for a sixty-third multi-pin connector on the right.
- MS2V64**: A label for a sixty-fourth multi-pin connector on the right.
- MS2V65**: A label for a sixty-fifth multi-pin connector on the right.
- MS2V66**: A label for a sixty-sixth multi-pin connector on the right.
- MS2V67**: A label for a sixty-seventh multi-pin connector on the right.
- MS2V68**: A label for a sixty-eighth multi-pin connector on the right.
- MS2V69**: A label for a sixty-ninth multi-pin connector on the right.
- MS2V70**: A label for a seventieth multi-pin connector on the right.
- MS2V71**: A label for a seventy-first multi-pin connector on the right.
- MS2V72**: A label for a seventy-second multi-pin connector on the right.
- MS2V73**: A label for a seventy-third multi-pin connector on the right.
- MS2V74**: A label for a seventy-fourth multi-pin connector on the right.
- MS2V75**: A label for a seventy-fifth multi-pin connector on the right.
- MS2V76**: A label for a seventy-sixth multi-pin connector on the right.
- MS2V77**: A label for a seventy-seventh multi-pin connector on the right.
- MS2V78**: A label for a seventy-eighth multi-pin connector on the right.
- MS2V79**: A label for a seventy-ninth multi-pin connector on the right.
- MS2V80**: A label for an eightieth multi-pin connector on the right.
- MS2V81**: A label for an eighty-first multi-pin connector on the right.
- MS2V82**: A label for an eighty-second multi-pin connector on the right.
- MS2V83**: A label for an eighty-third multi-pin connector on the right.
- MS2V84**: A label for an eighty-fourth multi-pin connector on the right.
- MS2V85**: A label for an eighty-fifth multi-pin connector on the right.
- MS2V86**: A label for an eighty-sixth multi-pin connector on the right.
- MS2V87**: A label for an eighty-seventh multi-pin connector on the right.
- MS2V88**: A label for an eighty-eighth multi-pin connector on the right.
- MS2V89**: A label for an eighty-ninth multi-pin connector on the right.
- MS2V90**: A label for a ninetieth multi-pin connector on the right.
- MS2V91**: A label for a ninety-first multi-pin connector on the right.
- MS2V92**: A label for a ninety-second multi-pin connector on the right.
- MS2V93**: A label for a ninety-third multi-pin connector on the right.
- MS2V94**: A label for a ninety-fourth multi-pin connector on the right.
- MS2V95**: A label for a ninety-fifth multi-pin connector on the right.
- MS2V96**: A label for a ninety-sixth multi-pin connector on the right.
- MS2V97**: A label for a ninety-seventh multi-pin connector on the right.
- MS2V98**: A label for a ninety-eighth multi-pin connector on the right.
- MS2V99**: A label for a ninety-ninth multi-pin connector on the right.
- MS2V100**: A label for a hundredth multi-pin connector on the right.
- MS2V101**: A label for a hundred-first multi-pin connector on the right.
- MS2V102**: A label for a hundred-second multi-pin connector on the right.
- MS2V103**: A label for a hundred-third multi-pin connector on the right.
- MS2V104**: A label for a hundred-fourth multi-pin connector on the right.
- MS2V105**: A label for a hundred-fifth multi-pin connector on the right.
- MS2V106**: A label for a hundred-sixth multi-pin connector on the right.
- MS2V107**: A label for a hundred-seventh multi-pin connector on the right.
- MS2V108**: A label for a hundred-eighth multi-pin connector on the right.
- MS2V109**: A label for a hundred-ninth multi-pin connector on the right.
- MS2V110**: A label for a hundred-tenth multi-pin connector on the right.
- MS2V111**: A label for a hundred-eleventh multi-pin connector on the right.
- MS2V112**: A label for a hundred-twelfth multi-pin connector on the right.
- MS2V113**: A label for a hundred-thirteenth multi-pin connector on the right.
- MS2V114**: A label for a hundred-fourteenth multi-pin connector on the right.
- MS2V115**: A label for a hundred-fifteenth multi-pin connector on the right.
- MS2V116**: A label for a hundred-sixteenth multi-pin connector on the right.
- MS2V117**: A label for a hundred-seventeenth multi-pin connector on the right.
- MS2V118**: A label for a hundred-eighteenth multi-pin connector on the right.
- MS2V119**: A label for a hundred-nineteenth multi-pin connector on the right.
- MS2V120**: A label for a hundred-twentieth multi-pin connector on the right.
- MS2V121**: A label for a hundred-twenty-first multi-pin connector on the right.
- MS2V122**: A label for a hundred-twenty-second multi-pin connector on the right.
- MS2V123**: A label for a hundred-twenty-third multi-pin connector on the right.
- MS2V124**: A label for a hundred-twenty-fourth multi-pin connector on the right.
- MS2V125**: A label for a hundred-twenty-fifth multi-pin connector on the right.
- MS2V126**: A label for a hundred-twenty-sixth multi-pin connector on the right.
- MS2V127**: A label for a hundred-twenty-seventh multi-pin connector on the right.
- MS2V128**: A label for a hundred-twenty-eighth multi-pin connector on the right.
- MS2V129**: A label for a hundred-twenty-ninth multi-pin connector on the right.
- MS2V130**: A label for a hundred-thirtieth multi-pin connector on the right.
- MS2V131**: A label for a hundred-thirty-first multi-pin connector on the right.
- MS2V132**: A label for a hundred-thirty-second multi-pin connector on the right.
- MS2V133**: A label for a hundred-thirty-third multi-pin connector on the right.
- MS2V134**: A label for a hundred-thirty-fourth multi-pin connector on the right.
- MS2V135**: A label for a hundred-thirty-fifth multi-pin connector on the right.
- MS2V136**: A label for a hundred-thirty-sixth multi-pin connector on the right.
- MS2V137**: A label for a hundred-thirty-seventh multi-pin connector on the right.
- MS2V138**: A label for a hundred-thirty-eighth multi-pin connector on the right.
- MS2V139**: A label for a hundred-thirty-ninth multi-pin connector on the right.
- MS2V140**: A label for a hundred-fortieth multi



PIN ASSIGNMENTS AND SWITCH CHOICES

- Need 9 Analog to Digital Converters
- 2 GPIO pins for the LED arrays
- 3 GPIO pins for the water pumps

- Need a 5 switches for the arrays and pumps
- N-channel MOSFET
 - On voltage well within the 3.3V output from the micro
- Fairchild FQP30N06L
 - 60V 32A Max
 - 1~2.5V On gate voltage

```

/*****ADC0 channel select*****/

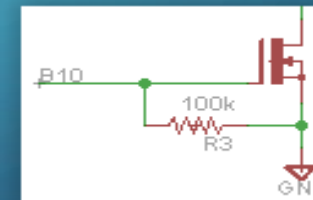
/* adc0_value returns a 12 bit value proportional to the analog value at the pin selected.
   The partial list is:

ADC0_23  PTE30  | | | PTC1  ADC0_15
4B      E29   | | | C2      11
7A      E23   | | | B3      13
3        E22   | | | B2      12
4A      E21   | | | B1       9
0        E20   | | | B0       8
-----

For example, if you want to use the PTB2 pin as an atod

adc0_init();

x=adc0_value(12); will return the analog value.
    
```



On Characteristics

$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 250 \mu A$	1.0	--	2.5	V
$R_{DS(on)}$	Static Drain-Source On-Resistance	$V_{GS} = 10 V, I_D = 16 A$ $V_{GS} = 5 V, I_D = 16 A$	--	0.027 0.035	0.035 0.045	Ω
g_{fs}	Forward Transconductance	$V_{DS} = 25 V, I_D = 16 A$	--	24	--	S

PROGRAMMING

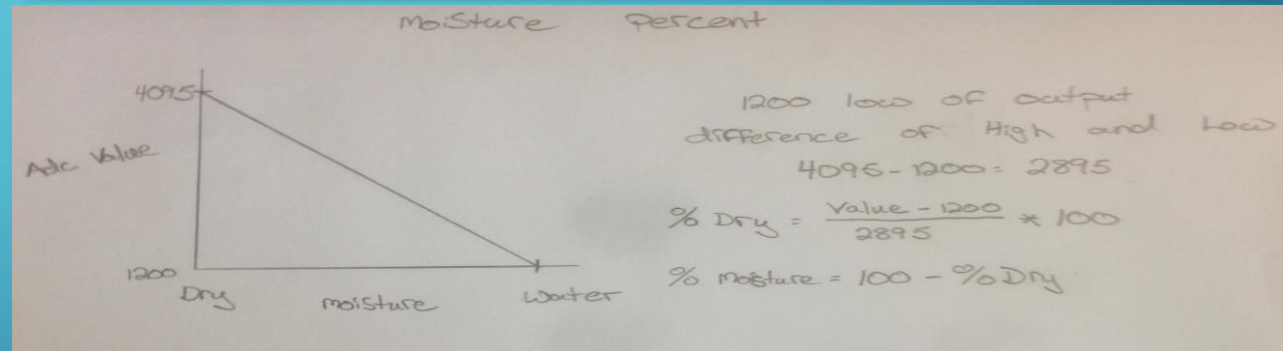
- Delay functions for timing
- Assurance that only one pump is on at a time due to constraints of the LM7812
- Define length of time LED arrays are on for
- Checking sensors and checking them against a defined percentage
- Maintain a moisture content

```
53 for(;;) {
54     if(Hour_Timer<=17){ // Turns LED arrays on for 18 hours.
55         TURN_ON_LED_ARRAY1;
56         TURN_ON_LED_ARRAY2;
57     }
58     if(Hour_Timer>17){ // Turns LED arrays off for 6 hours.
59         TURN_OFF_LED_ARRAY1;
60         TURN_OFF_LED_ARRAY2;
61     }
62     if(Hour_Timer>=23){Hour_Timer=0;} // Resets the time for a day.
63
64     Moisture_Row1=adc0_value(8); // Check row 1 in three different places along the row.
65     Moisture_Row1=adc0_value(9); // Ideally each row will be similar plants so that an imbalance in watering does not occur.
66     Moisture_Row1=adc0_value(12); // Individual calibration may be needed on each sensor.
67
68     Moisture_Row2=adc0_value(13); // Check row 2 in three different places along the row.
69     Moisture_Row2=adc0_value(11); // Ideally each row will be similar plants so that an imbalance in watering does not occur.
70     Moisture_Row2=adc0_value(15); // Individual calibration may be needed on each sensor.
71
72     Moisture_Row3=adc0_value(0); // Check row 3 in three different places along the row.
73     Moisture_Row3=adc0_value(3); // Ideally each row will be similar plants so that an imbalance in watering does not occur.
74     Moisture_Row3=adc0_value(23); // Individual calibration may be needed on each sensor.
75
76     if(Moisture_Row1<70){ // Check moisture percentage. If lower then defined set point turn one pump on for defined amount of time.
77         TURN_ON_PUMP1;
78         WAIT_MINUTE(5);
79         TURN_OFF_PUMP1;
80         WAIT_SECOND(10); // Assurance that only one pump on at time. Due to Max output of LM7812
81     }
82     if(Moisture_Row2<70){ // Check moisture percentage. If lower then defined set point turn one pump on for defined amount of time.
83         TURN_ON_PUMP2;
84         WAIT_MINUTE(5);
85         TURN_OFF_PUMP2;
86         WAIT_SECOND(10); // Assurance that only one pump on at time. Due to Max output of LM7812
87     }
88     if(Moisture_Row3<70){ // Check moisture percentage. If lower then defined set point turn one pump on for defined amount of time.
89         TURN_ON_PUMP3;
90         WAIT_MINUTE(5);
91         TURN_OFF_PUMP3;
92         WAIT_SECOND(10); // Assurance that only one pump on at time. Due to Max output of LM7812
93     }
94
95
96
97     while(sys_ticks<3600000); // One hour delay
98     sys_ticks=0;
99 }
100
101 return 0;
102 }
103 }
```

PROGRAMMING CONTINUED

- Set up ADC as a 12 bit converter
- Find a way to determine moisture percentage in the planting medium
- Set up a function to determine this

```
223 /***** ADC0 initialization *****/
224 //Initialize PTC1 as ADC15 A to D
225 void adc0_init(void){
226
227     // Turn on the clock for ADC0
228     SIM_SCGC6 |= SIM_SCGC6_ADC0_MASK;
229
230
231     ADC0_SC1A=0x0;    //start of with no channel selected
232     ADC0_SC2=0;
233
234     ADC0_CFG1=0x4;    // 12 bit conversion, single ended, full speed bus clock normal operation
235     ADC0_CFG2=0;
236 }
```



```
105 int MOISTURE_PERCENT (int adc0_value){
106     int Percent;
107     x=adc0_value();
108     Percent=(100-(((x-1200)/(2895))*100));
109     return(Percent);
110 }
```



Ethical Concerns:

❖ Low Power

- ❖ Use of Two 12 Watt LED arrays opposed to 400~1000 Watt traditional high insanity grow bulbs.
- ❖ Less On-Time with pumps since they are only turning on when moisture gets to low. Opposed to continuous flow that is traditionally always on.

❖ Knowing what you are putting into the plants

- ❖ You will know and can decide on pesticides that may or may not need to be used. Opposed to just guessing with grocery store vegetables.
- ❖ You will decide upon the nutrients used and can decide whether or not to grow fully organic.

❖ Price/Satisfaction/Health

- ❖ Organic vegetables are expensive!
- ❖ Producing your own food is satisfying to many people!
- ❖ Having plants in your house naturally cleans the air!

THANK YOU FOR YOUR TIME

QUESTIONS?