GROWINATOR

"DESTROYS YOUR FRESH VEGETABLE BILL!"
–John Connor

"Has your crops saying 'I'll be back' after you harvest!"
–The Terminator

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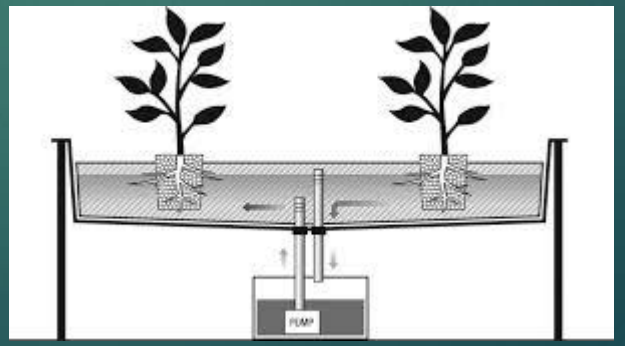
ELT2720

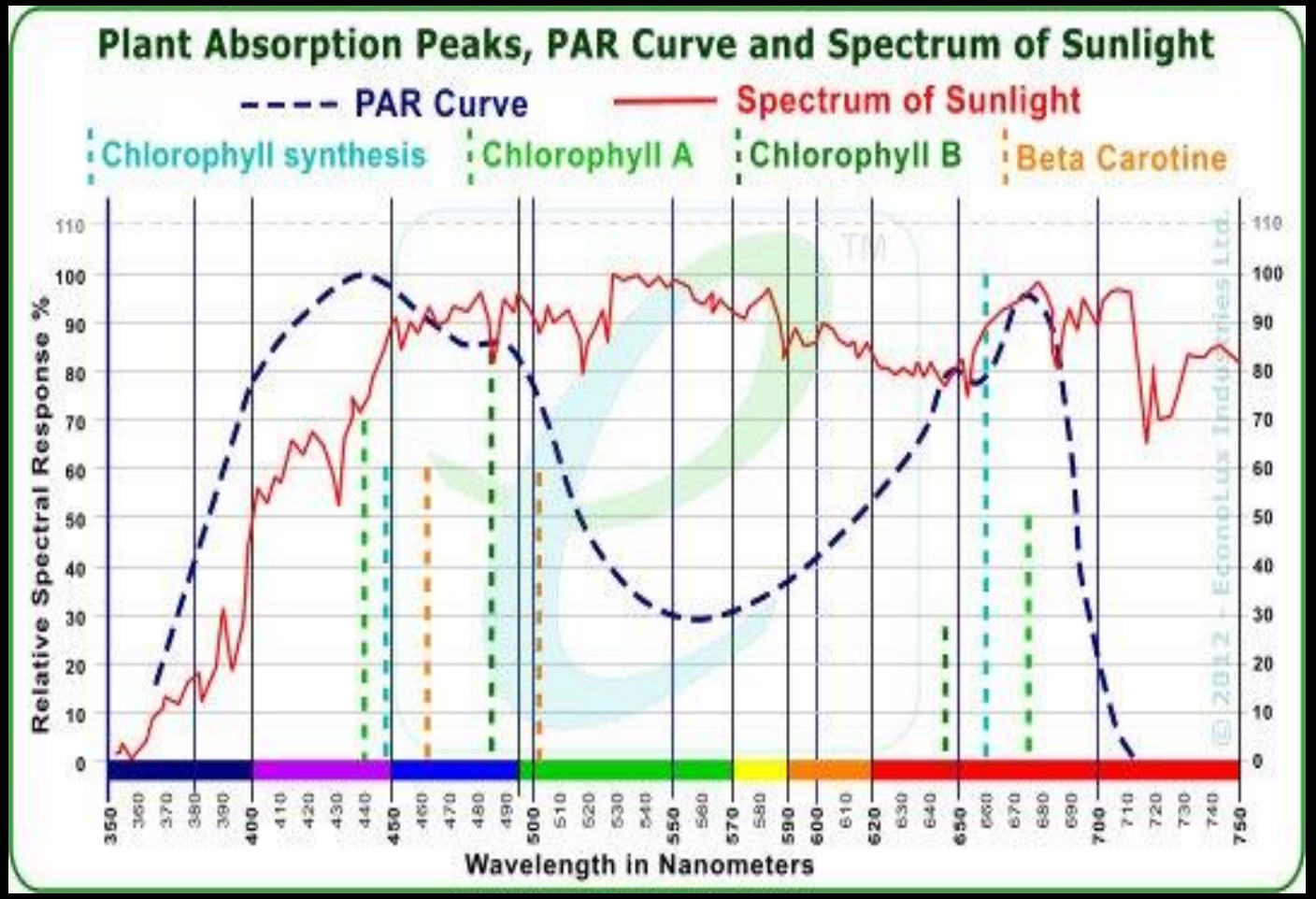
4/20/2016

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 Carotine
  - Reds:
    - Where plants form flowers
    - Necessary for anything that "fruits"

Nutrients

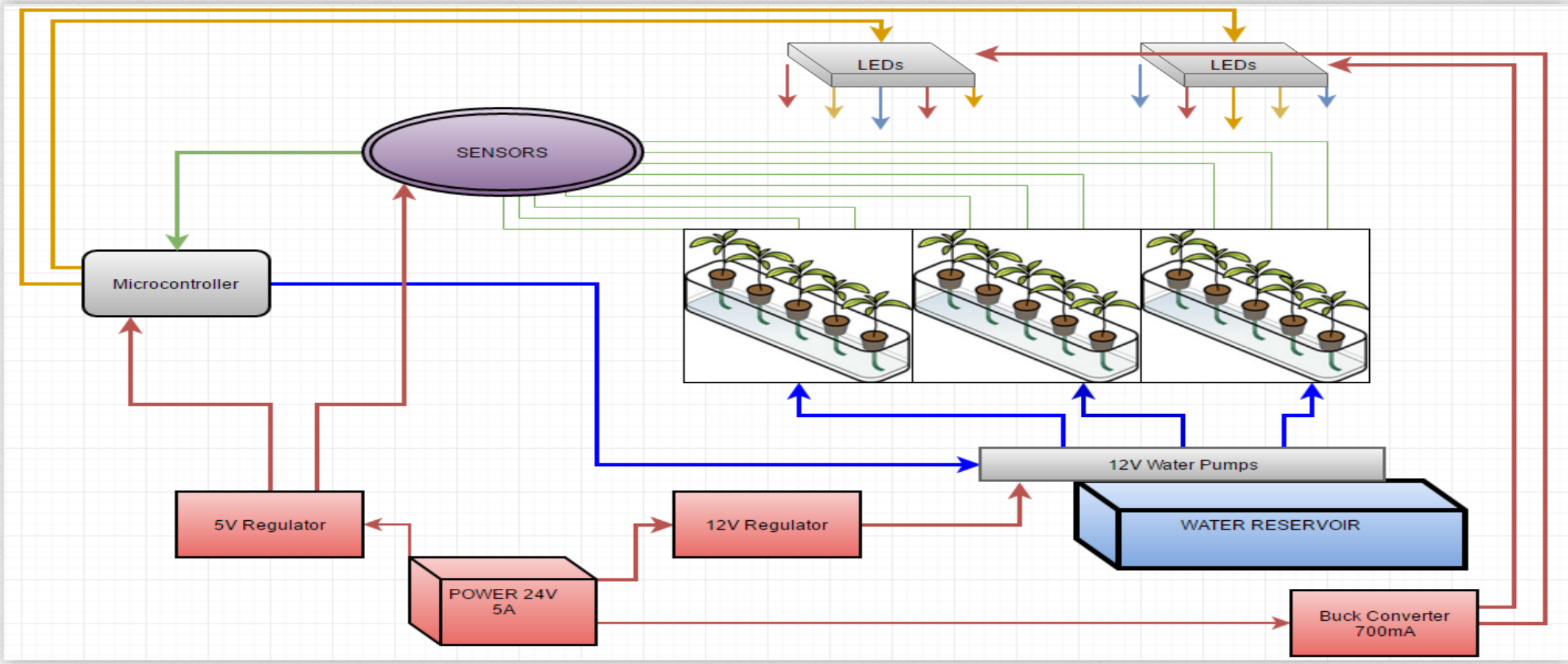
- Nitrogen
- Phosphorus
- Potassium

- 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

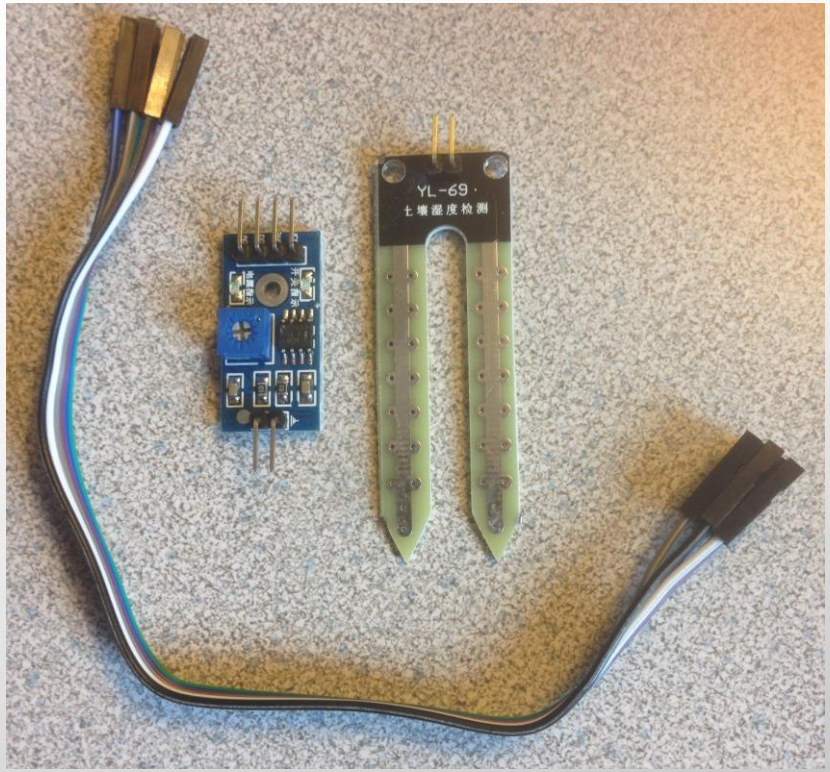

LEDs
LEDs
SENSORS
Microcontroller
12V Water Pumps
WATER RESERVOIR
5V Regulator
12V Regulator
POWER 24V
5A
Buck Converter
700mA

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



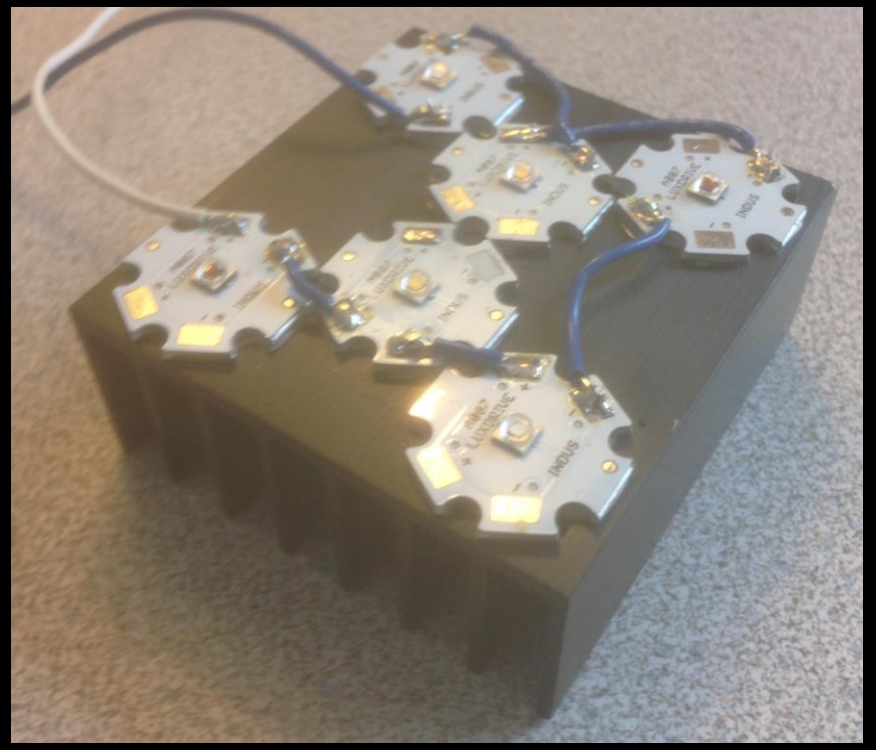
SENSOR TESTS

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

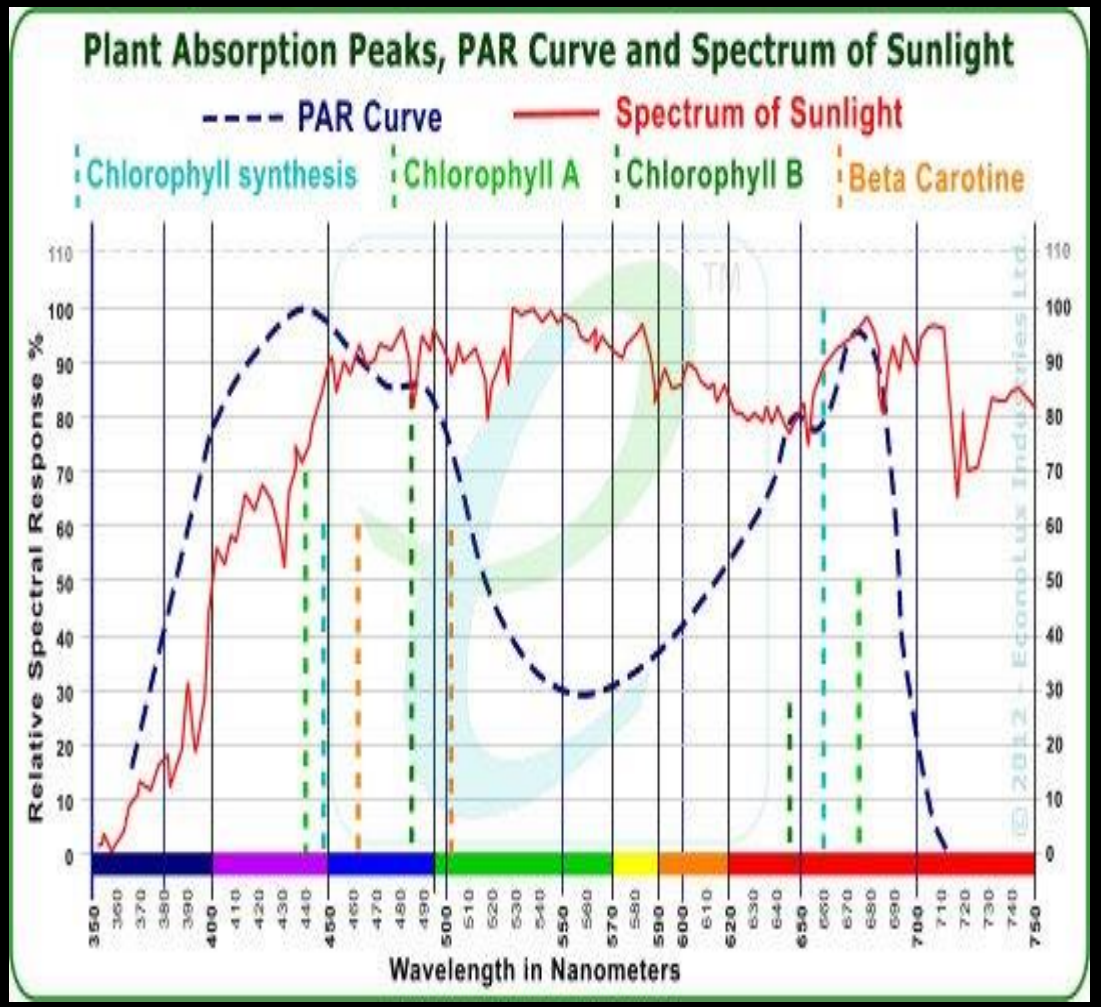
	DRY	MOIST	WATER
SENSOR 12bit Micro output	4095	2730	1692
	4095	3235	2550
	4095	3279	1414
	4095	3166	1695
	4095	3229	1701
Mean	4095	3127	1810

LIGHTING SYSTEM

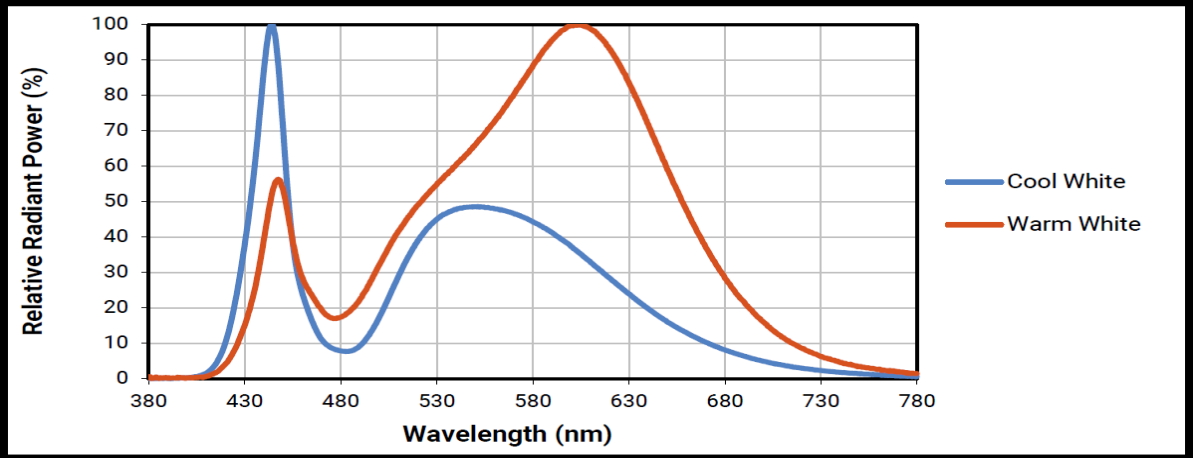
- Cree XP-E 3W LEDs
  - 2 White
  - 2 Red
  - 2 Royal Blue
- Measured Forward Voltage
  - 16.93V
  - 16.86V
- Large Heat Sink
  - Heating concerns for Red LEDs

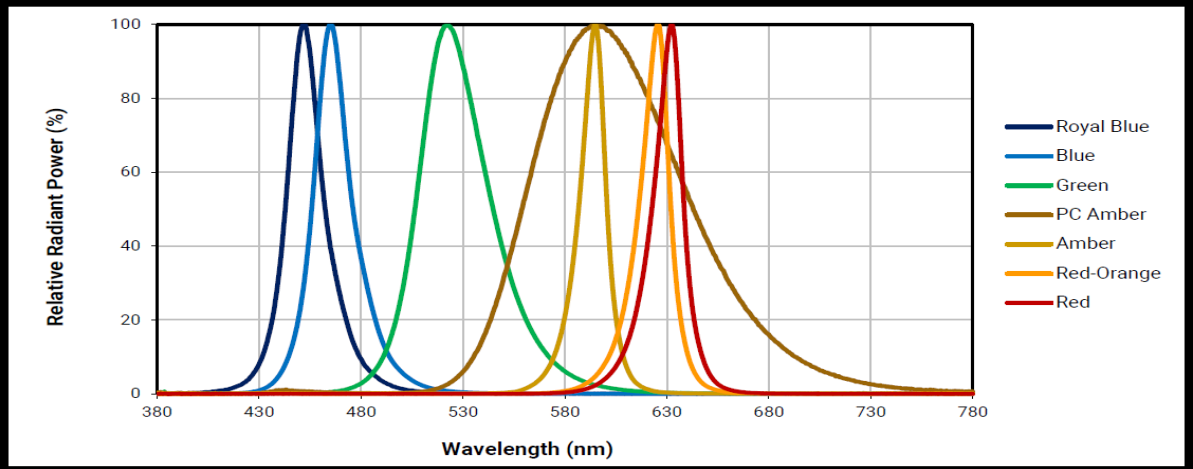


WAVELENGTH



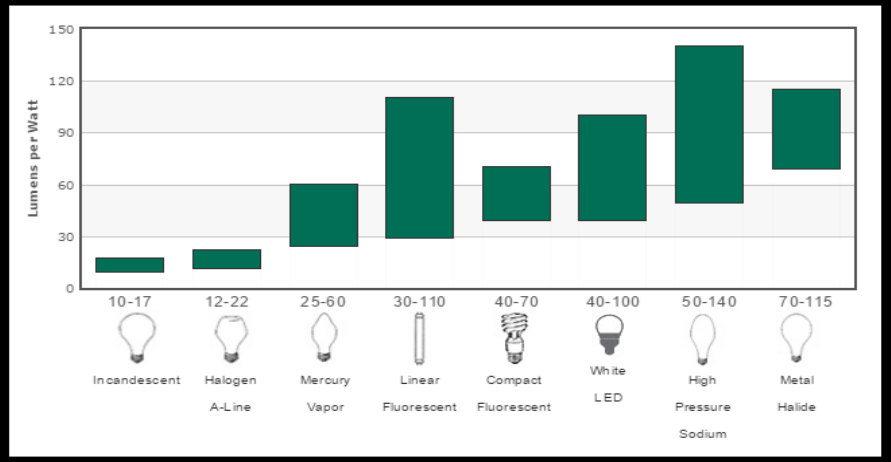
From CREE datasheet:

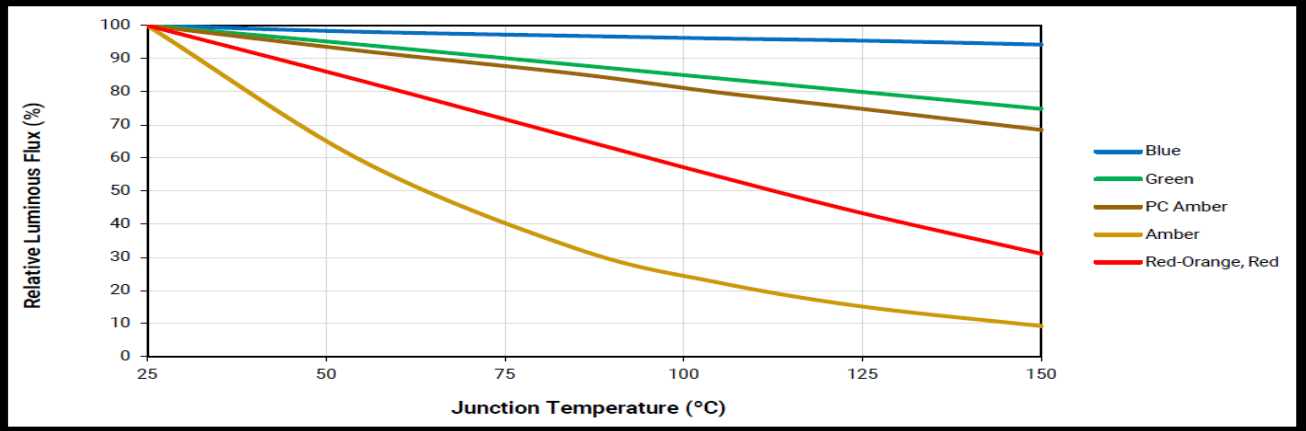




HEAT CONCERNS AND LIGHT OUTPUT

- Red LEDs lose light output fast with heat
- Large heat sink:
  - 4.7°C/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

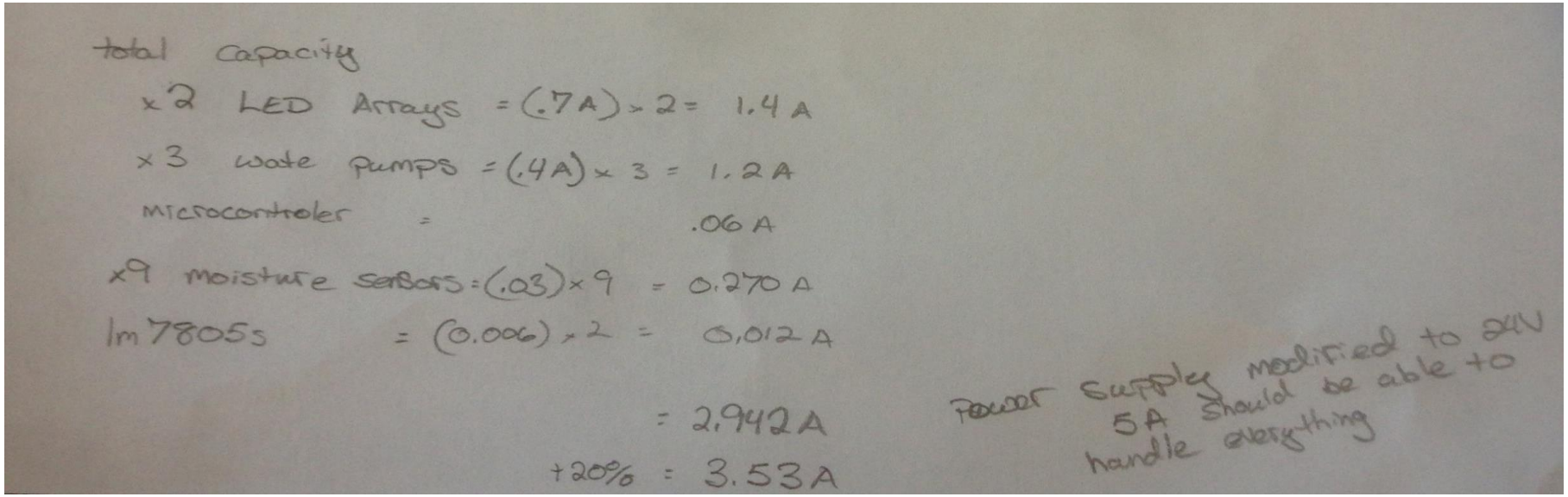
Figure 1. Thermal results from the laboratory

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:



- 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

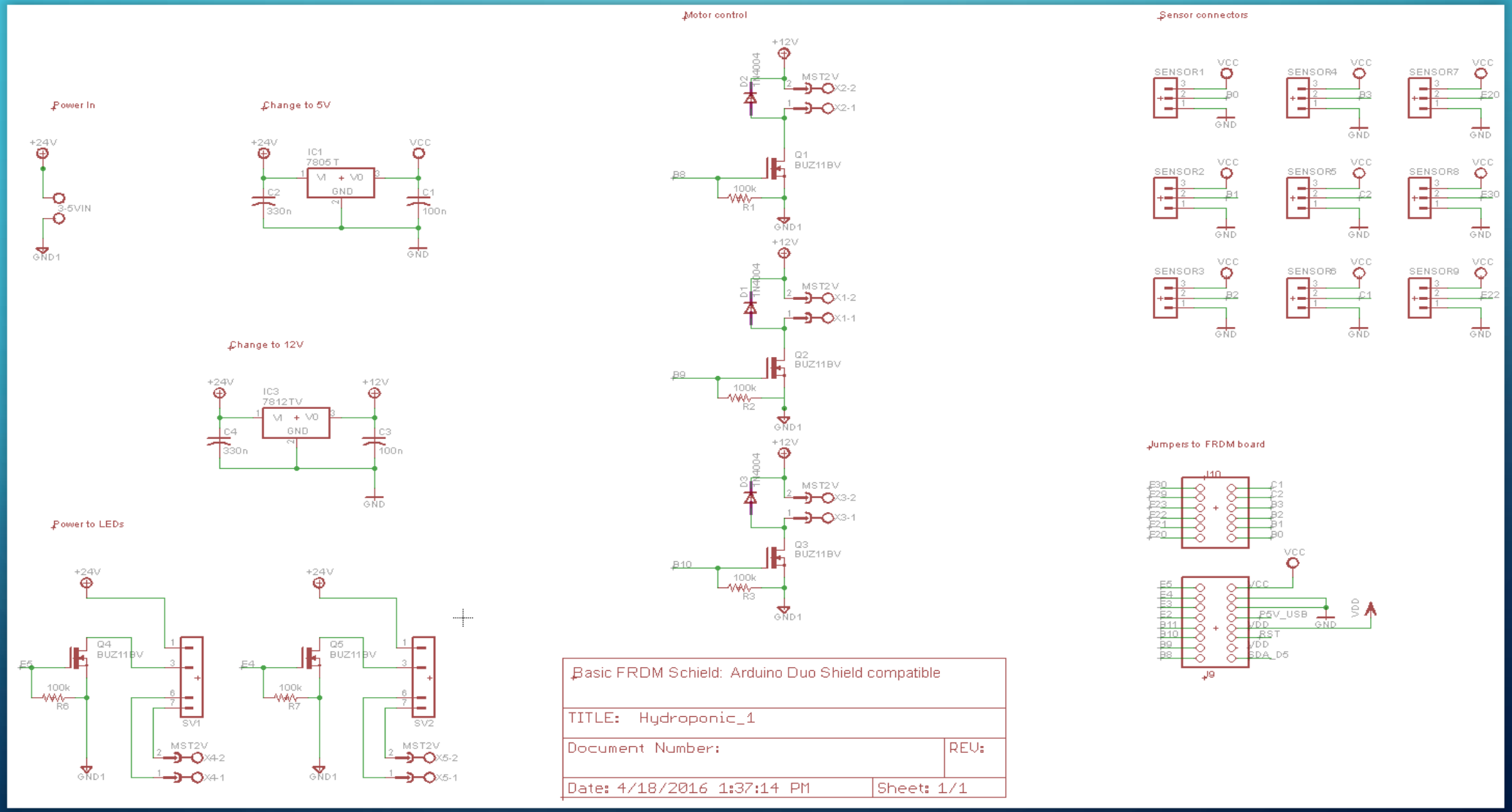
3-Terminal 1A Positive Voltage Regulator

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


Power In
+24V
3-5VIN
GND1
Change to 5V
+24V
IC1
7805 T
VI + VO
GND
VCC
C2
330n
C1
100n
GND
Change to 12V
+24V
IC3
7812TV
VI + VO
GND
+12V
C4
330n
C3
100n
GND
Power to LEDs
+24V
Q4
BUZ11BV
E5
100k
R6
SV1
MST2V
X4-2
X4-1
GND1
+24V
Q5
BUZ11BV
E4
100k
R7
SV2
MST2V
X5-2
X5-1
GND1
Motor control
+12V
D2
1N4004
MST2V
X2-2
X2-1
Q1
BUZ11BV
B8
100k
R1
GND1
+12V
D1
1N4004
MST2V
X1-2
X1-1
Q2
BUZ11BV
B9
100k
R2
GND1
+12V
D3
1N4004
MST2V
X3-2
X3-1
Q3
BUZ11BV
B10
100k
R3
GND1
Sensor connectors
SENSOR1
VCC
B0
GND
SENSOR4
VCC
B3
GND
SENSOR7
VCC
E20
GND
SENSOR2
VCC
B1
GND
SENSOR5
VCC
C2
GND
SENSOR8
VCC
E30
GND
SENSOR3
VCC
B2
GND
SENSOR6
VCC
C1
GND
SENSOR9
VCC
E22
GND
Jumpers to FRDM board
J10
E30
E29
E23
E22
E21
E20
C1
C2
B3
B2
B1
B0
VCC
E5
E4
E3
E2
B11
B10
B9
B8
VCC
P5V_USB
VDD
RST
VDD
SDA_D5
GND
VDD
J9
Basic FRDM Schield: Arduino Duo Shield compatible
TITLE: Hydroponic_1
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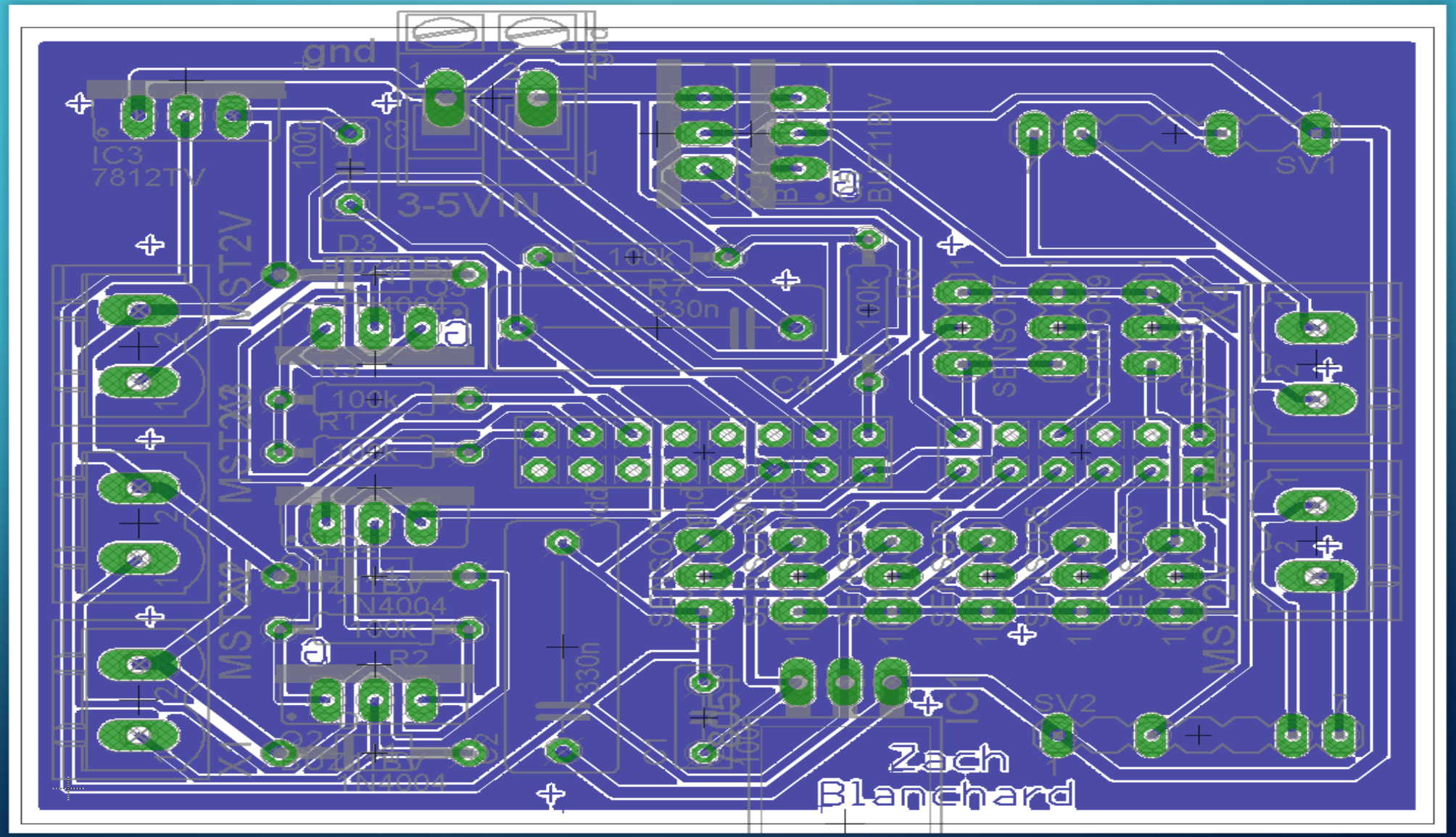
BOARD LAYOUT

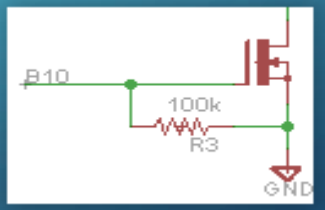


PIN ASSIGNMENTS AND SWITCH CHOICES

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

```
/*****************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.
```

- 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



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

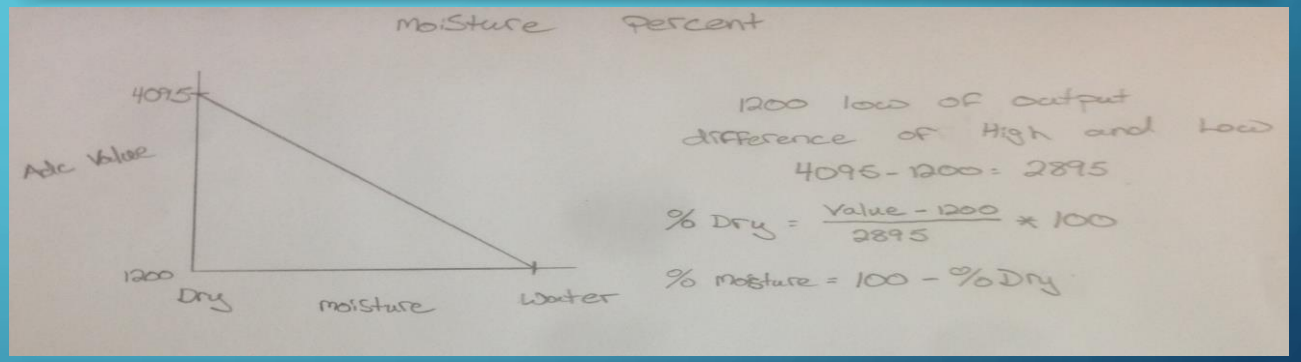
- Delay functions for timing
- Assurance that only one pump is on at a time due to constraints of the LM7812
- Define length of time LED arrays are on for
- Checking sensors and checking them against a defined percentage
- Maintain a moisture content

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