DESIGN PROJECT REPORT

Spring 2019

Project Name	Fully Digital Adjustable Power Supply
Project Team Members (Name – Student ID)	Alişan Aygar – 05140000567 Elif Ege Diken – 05160000053 Emir Kaan Yerli – 05150000734 Fehmi Demirel – 05140000533

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1. INTRODUCTION

1.1 Brief Information About The Project

We have designed, simulated, engineered and tested a power electronics converter in the form of a fully digital adjustable 0-15V/ 2A DC with LCD displayed power supply that is based on a switching converter topology(buck, boost, buck-boost etc.) and is controlled by a microcontroller (PIC, AVR, ARM etc.). All of the DC source needed for the system should be coming from the same DC source (18 V).

1.2 Team Members

Our project team consists of 4 members: Alisan Aygar(3), Elif Ege Diken(3), Emir Kaan Yerli(4) and Fehmi Demirel(4).

Project Team Members (Name)	**Project Team Members (Student IDs)**
Alişan Aygar	05140000567
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Fehmi Demirel	05140000533

1.3 Work Plan

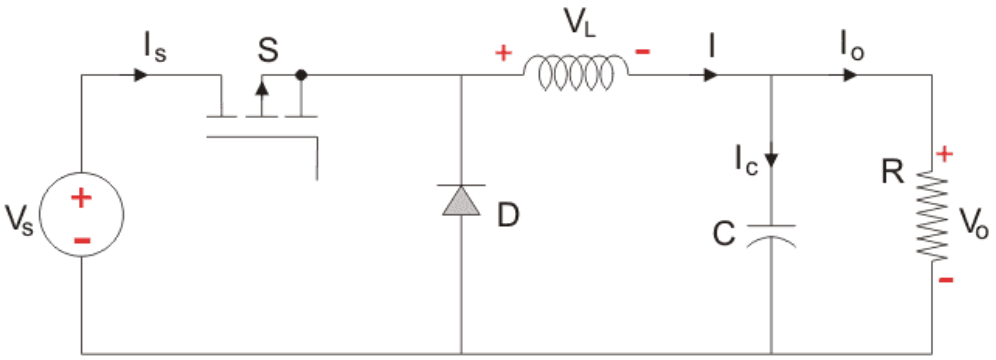
1) Came up with the two converter topology alternatives.
2) Decided to start the project with Buck converter topology.
3) Designed the power circuit and planned the digital circuit's inputs and outputs.
4) Decided the required electronic materials and chose the most suitable ones.
5) Simulated the circuit in the computer environment.
6) Composed the microcontroller's programs to control the circuit fully digital.
7) Designing and making the printed circuit board for the power supply.
8) Combined the whole system together on laboratory.
9) Tested the system and measured the results in the laboratory environment.
10) Prepared the final project report.

2. METHOD

We have considered to design our power supply as in between Flyback and Buck converters. Our reason behind the Flyback converter was to be a safer option since it has an isolated input and output. Also, meanwhile on our research about the best option, the general idea about the Buck converter was it's being unstable. At the very end of our research we have decided to move on with Buck converter anyways because we couldn't have risk the possible troubles with the customized transformers that Flyback converter needs.

2.1 Selected Topology

After deciding the topology, we have made the detailed research about the Buck converter such as how to increase the efficiency, how to decrease ripple etc. In general, the selected topology is shown below.



Example of a Buck converter

2.2 Design Procedure

To achieve the requested adjustable voltage and current, we have to be able to change the Duty Ratio. Thus, we used Pulse Width Modulation PWM) that we generated using Arduino. We decided to change the Duty Ratio with a potentiometer. So that the adjustable Duty Ratio will switch the MOSFET in the circuit. We used a current sensor to track down the current in the circuit and used to output as an input into the Arduino and we wrote it down on the LCD. We printed out a printed circuit board (PCB) at home.

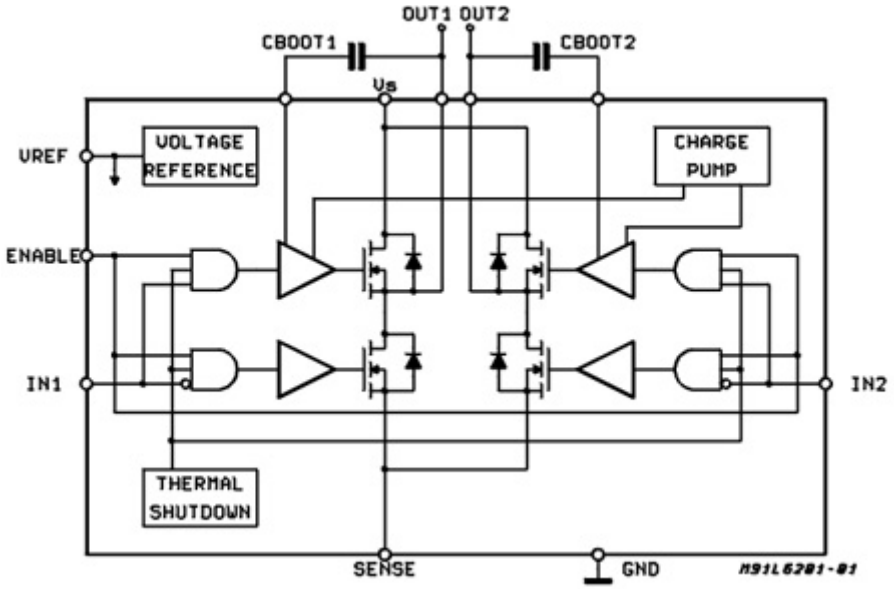
2.3 Component Selection

As in the Buck converter, the components are:

-Capacitor: We have calculated the capacitor value from the formula which is 100µF. $C = \frac{1-D}{8L(\Delta V_o/V_o)f^2}$

-Inductor: We have decided to use toroid inductor to increase the efficiency. However, finding a toroid inductor in any value was hard. So, we estimated the switching frequency and find the minimum and maximum inductor value. And then we selected a reasonable common value so that we can purchase. The value is 60 µH.

-MOSFET: We used an integrated circuit which is L6202 and shown below.



L6202 Integrated Circuit MOSFET

For the rest of the project we used:

-Arduino Uno R3 Clone

-LCD 2X16

-LM7805 Voltage Regulator for Arduino

-1 µF capacitors for LM7805

-Hall Effect Sensor

-HC 06 Bluetooth Module

-Load Resistors

-22k Ω Potentiometers

-Laptop Charger

-Copper Board

-Perhydrol

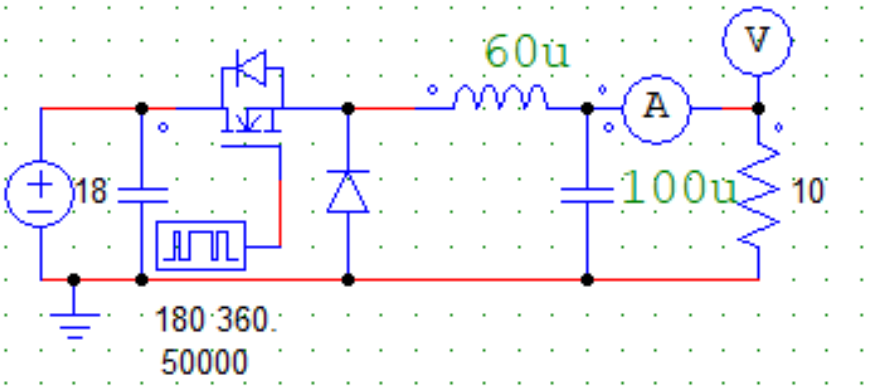
-Hydrochloric Acid

-Cables

-Breadboard

2.4 Circuit Design on PSIM

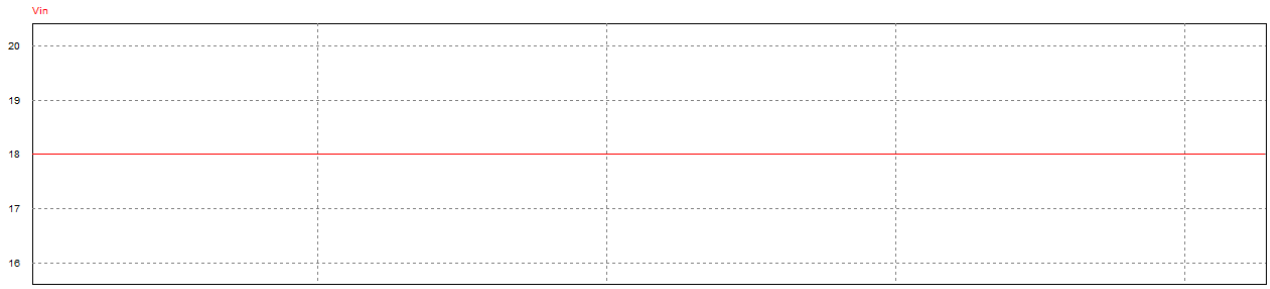
We used PSIM to draw our circuit and to simulate it. The general drawing of the circuit is shown below.



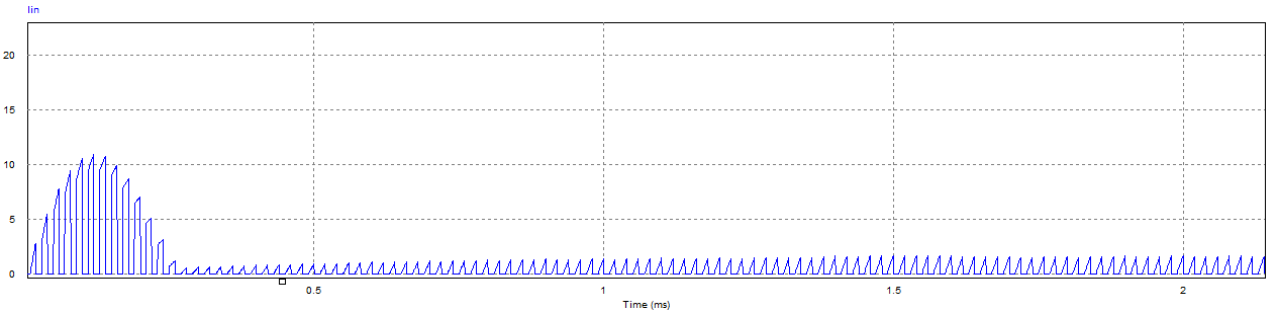
Buck Converter Design

2.4.1 Input Voltage and Input Current Graphs

The input voltage and the input current are shown below. PWM:50%



Input Voltage

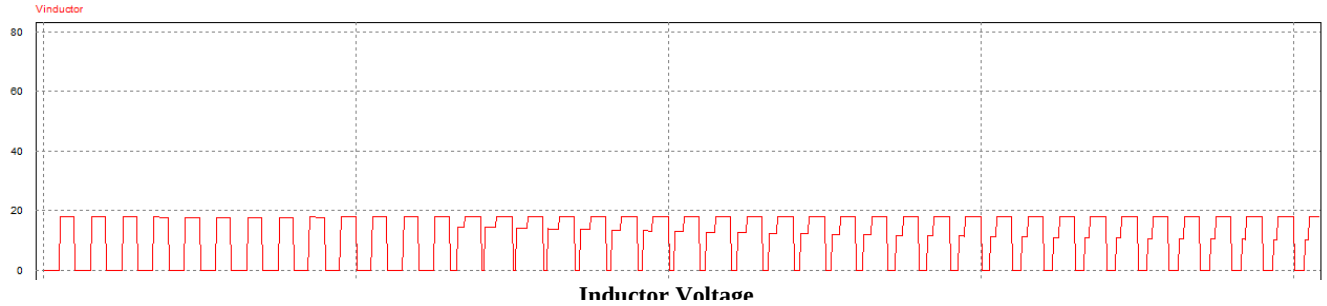


Input Current

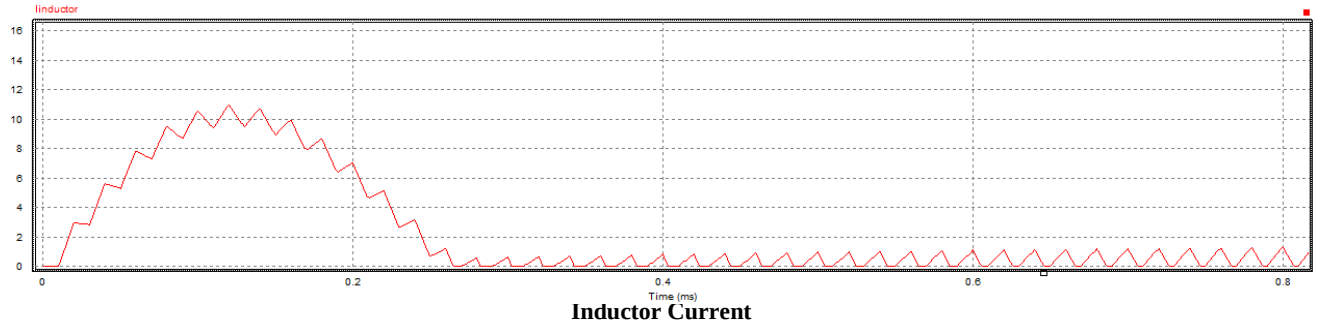
2.4.2 Inductor Voltage and Inductor Current Graphs

Our toroid inductor voltage and current are shown below. PWM:50%

2.4.3 Capacitor Current Graph

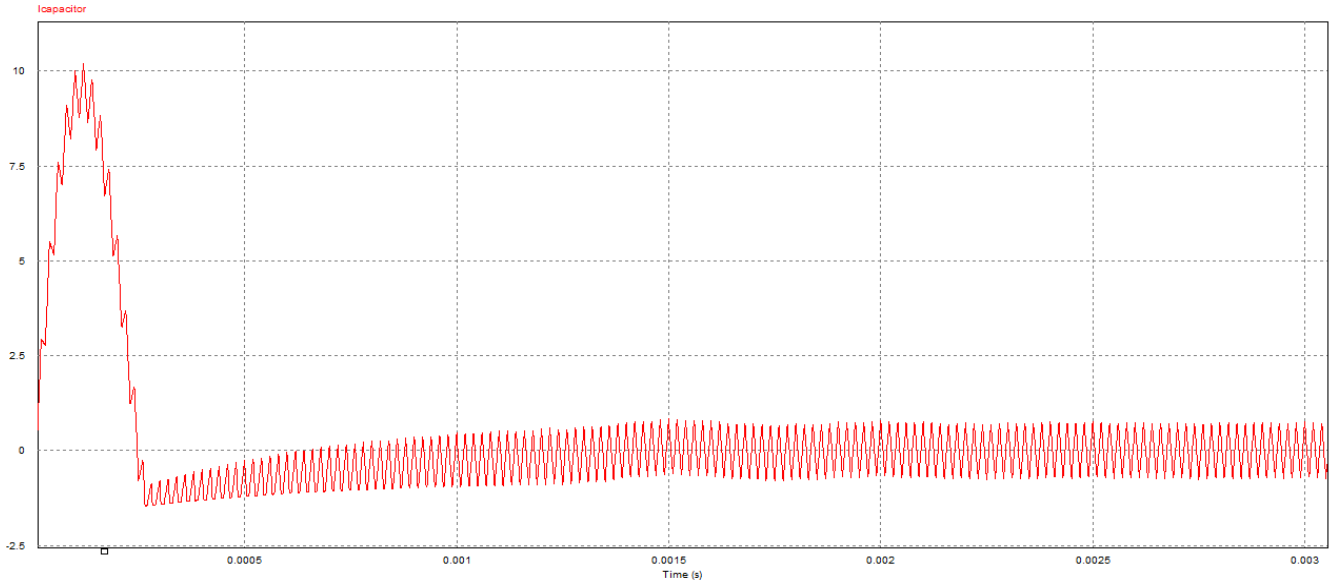


Inductor Voltage



Inductor Current

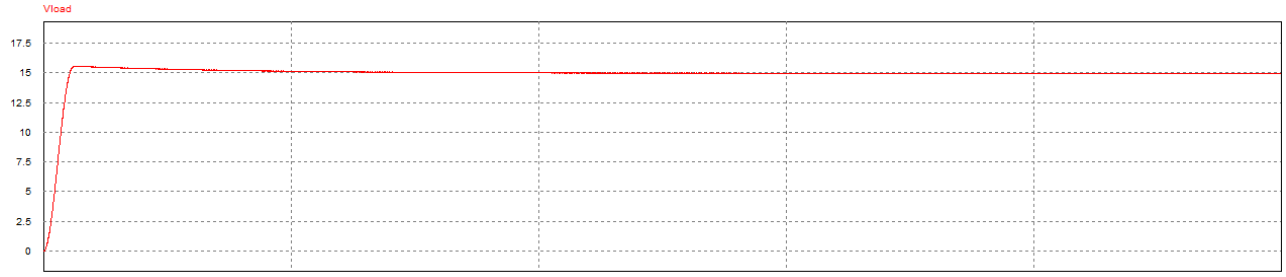
The capacitor current is shown below. PWM:50%



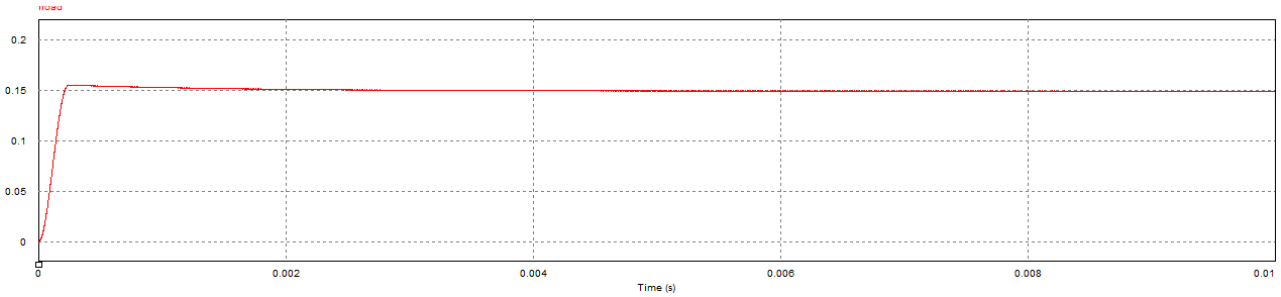
Capacitor Current

2.4.4 Load Voltage and Load Current Graphs

In our Buck converter, the load voltage and the load current graphs are shown below.
Load= 100 ohm. PWM:50%



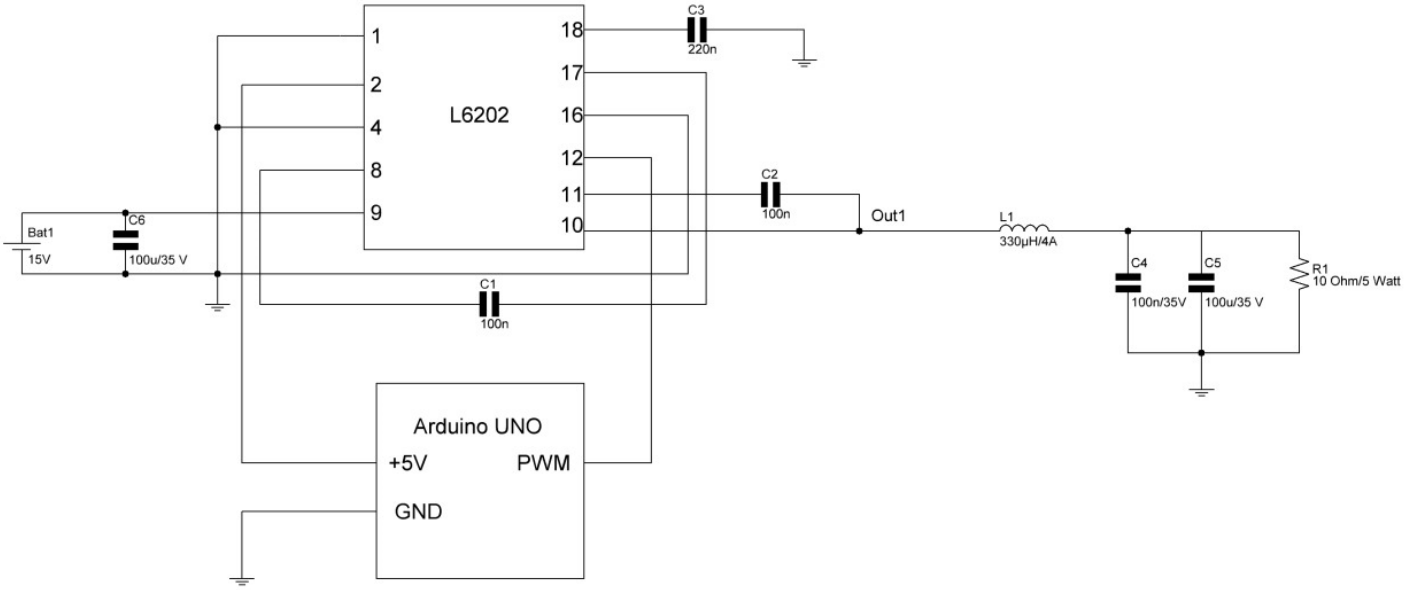
Load Voltage



Load Current

2.5 General Circuit Design

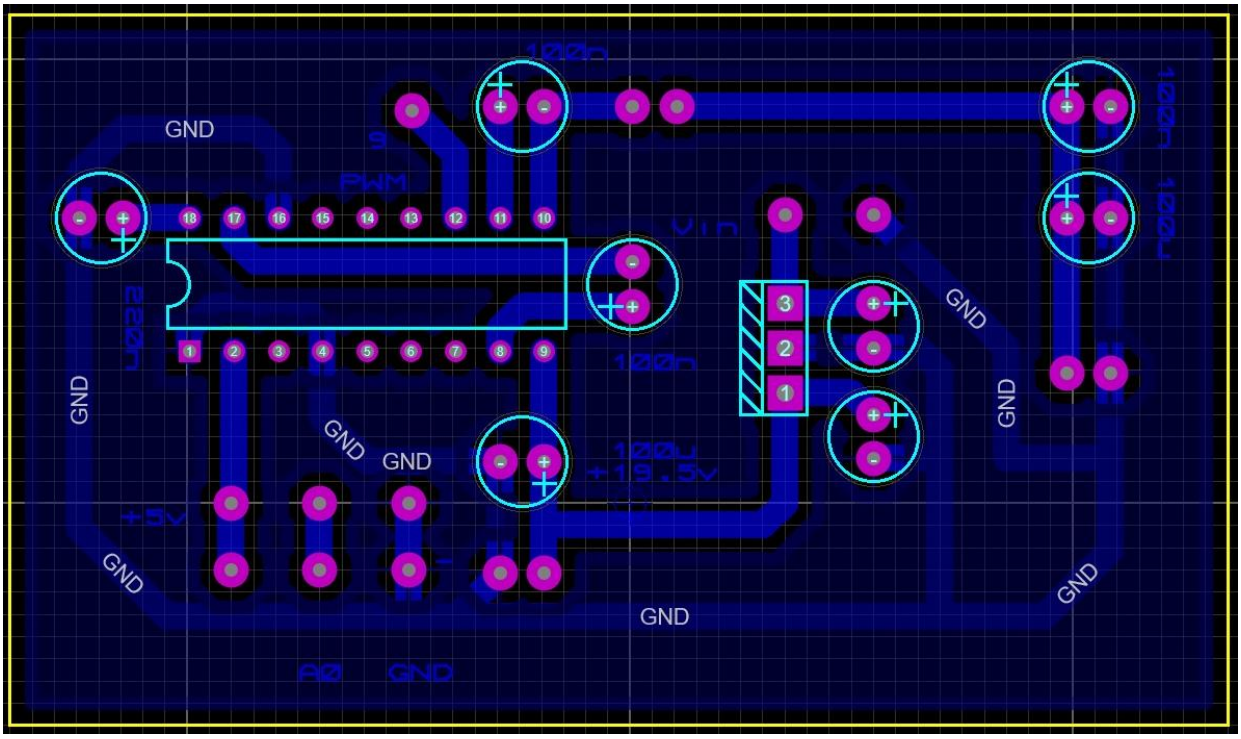
We designed our whole circuit with the idea of this course's laboratory experiment. We used LM 7805 for a constant 5V for Ardunio. We got the PWM from the Arduino and put the output into the L6202. We put the MOSFET output from the L6202 into the Buck converter. The shown inductor value is not what we used. The correct value is 60µH. We got the 18 DC source from a laptop charger.



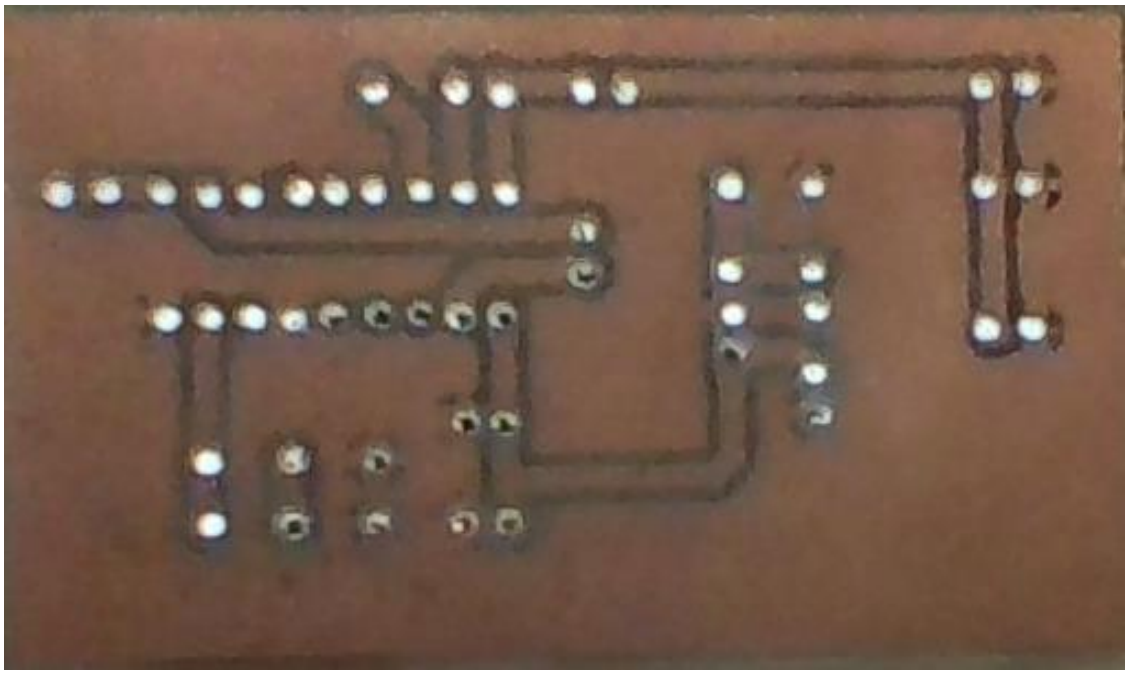
General Circuit Design

2.6 PCB Design

We designed a printed circuit board for our general circuit. We printed the circuit at home with perhydrol and hydrochloric acid. The drawn circuit and the printed circuit shown are shown below.



Drawn Circuit on Proteus



Printed Circuit

2.7 Arduino Code

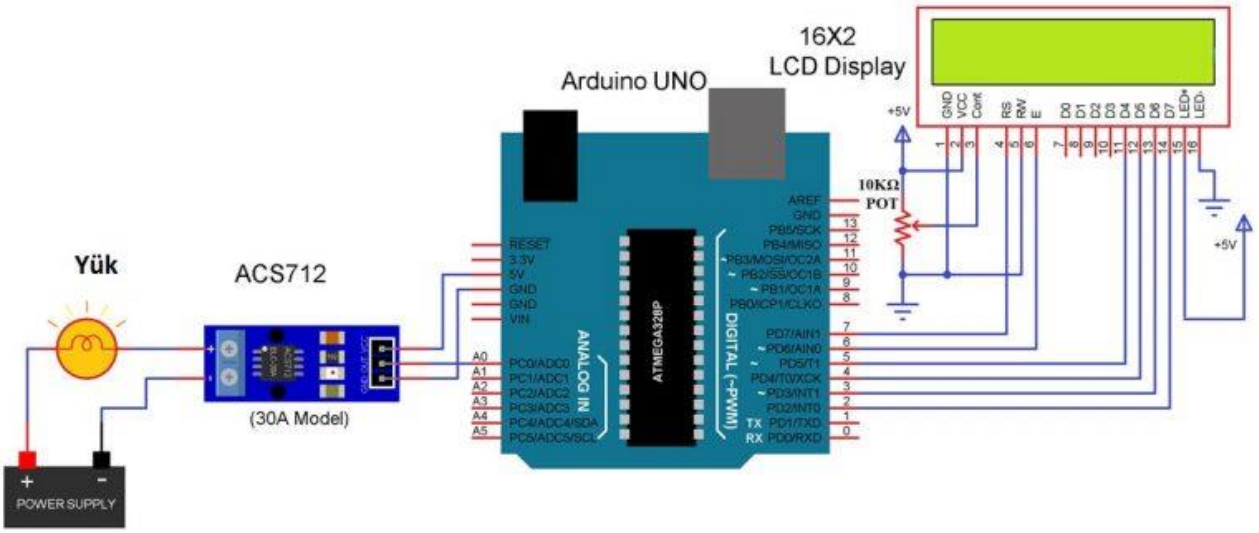
We coded the Arduino for the PWM output and the LCD placements. The Code is given below:

```
#include <LiquidCrystal.h>
#include <PWM.h>

LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
const int analogIn = 1;
 mVperAmp = 185;
int RawValue = 0;
int ACSoffset = 2500;
double Voltage = 0;
double Amps = 0;
double Power = 0;
int led_pin = 9;
int pot_pin = A0;
int output;
int led_value;
```

```
void setup()
{

  pinMode(led_pin, OUTPUT);

 TCCR1B = TCCR1B & B11111000 | B00000001;

 lcd.begin(16, 2);

}
void loop() {

 output = analogRead(pot_pin);

 led_value = map(output, 0, 1023, 0, 200);

 analogWrite(led_pin, led_value);

delay(1);

RawValue = analogRead(analogIn);

Voltage = (RawValue / 1024.0) * 5000;

Amps = ((Voltage - ACSoffset) / mVperAmp);

lcd.display();

lcd.setCursor(0, 0);

lcd.print("A= ");

lcd.setCursor(2, 0);

lcd.print(Amps, 2);

delay(100);

lcd.setCursor(0, 1);

lcd.print("V= ");

lcd.setCursor(2, 1);

lcd.print(Amps*10, 2);

delay(100);

}
```

2.8 LCD Placement with Current Sensor

We used 2x16 LCD for the output of the circuit's current and voltage. We connected a 10k potentiometer for the contrast and finished the connections with the Arduino as given below.



LCD Placement

We used ACS712 for the current sensor. ACS712 current sensor is based on the Hall Effect. There is a copper strip that internally connects the IP + and IP - pins. While some current flows through this copper conductor, a magnetic field sensed by the Hall Effect sensor is generated. The Hall Effect sensor then converts this magnetic field to the appropriate voltage. In this method, the input and output are completely isolated. We had some trouble with using this sensor. We mentioned it in the conclusion part.

3. RESULTS

3.1 Finished Circuit and Test Results versus Calculations

Tests	Results
Test step #1: Voltage regulation	No-load 0-15 V adjustable circuit designed by potentiometer.
Test step #2: No-load input power	Input current measured 98 mA with turn off the LCD backlight.
Test step #3: Load regulation =(Vnl-Vfl)/Vfl*100	The output voltage measured 13 V at load(No-load 15 V). Voltage regulation:%13.3
Test step #4: Power limit trip	We did not design the power limit because of the useless current sensor.
Test step #5: Current limit trip	We did not design the current limit because of the useless current sensor.
Test step #6: Output voltage ripple	The output voltage ripple measured 300 mV.
Test step #7: Remote control	We did not designed.
Test step #8: Pcb	We showed the pcb design in the report.
Test step #9: Early finish	We did not show the project earlier.

4. CONCLUSION

4.1 General Review of The Project

In general, the idea of the project was helpful for our current studies and exams. Also, the idea of using different components such as microcontrollers, LCDs, sensors, wireless control and Android application making were beneficial for us as students. We have learnt that the working area of the Power Electronics is wider than we thought before.

The planning step of the project was easy, and the calculations were not strange to us since we had the course this year. The simulation part was also easy and effective using PSIM. However, the reliability of the electronic devices had put us down on our planned schedule. Because of the difficulties from our current sensor, we have burnt the Arduino for once. Then we got a new one and tried to use the current sensor better that time. However, the Hall Effect sensor has continuously got distracted by the magnetic field surrounding it. So, we couldn't use our printed circuit board to eliminate any unexpected burning again. Also, because of we couldn't get exact measurements from the sensor, we weren't able to set current and voltage limit to our circuit. We left our circuit on breadboard. At the end, the capacitive and inductive elements effected our circuit's performance.

5. REFERENCES

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https://sites.google.com/site/mutluboztepe/ee328