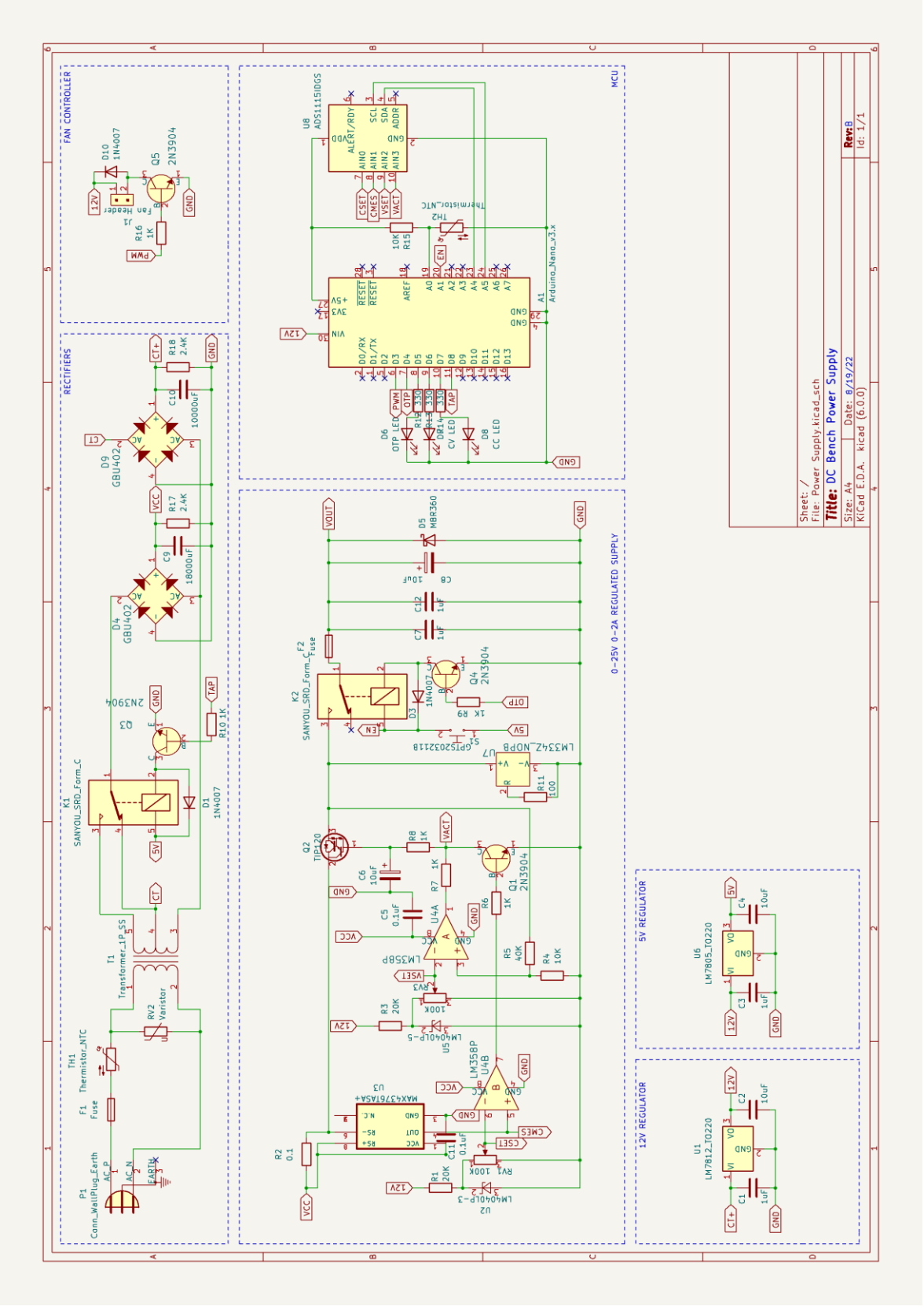
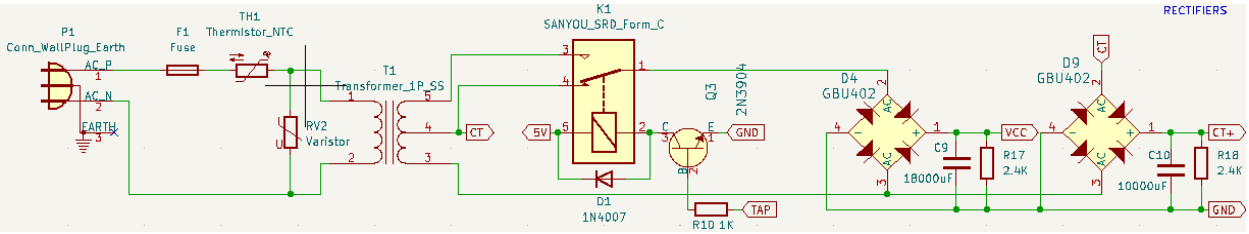
Specification	Range
Input	
Input Voltage	Typical 110-120VAC
Input Frequency	60 Hz
Input Current	Typical 0.25A at 115VAC
Output	
Output Voltage (Res.)	0 to 25V (10mV)
Output Current (Res.)	0 to 2.5A (10mA)
Noise & Ripple	
Protection	
Over Current	Built In
Over Voltage	Built In
General	
Efficiency	
Circuit Topology	Linear (Series Pass)
Transient Response	
Environmental	
Operating Temperature	0°C to +75°C
Storage Temperature	-20°C to +85°C
Cooling	Actively Cooled (12V Fan)

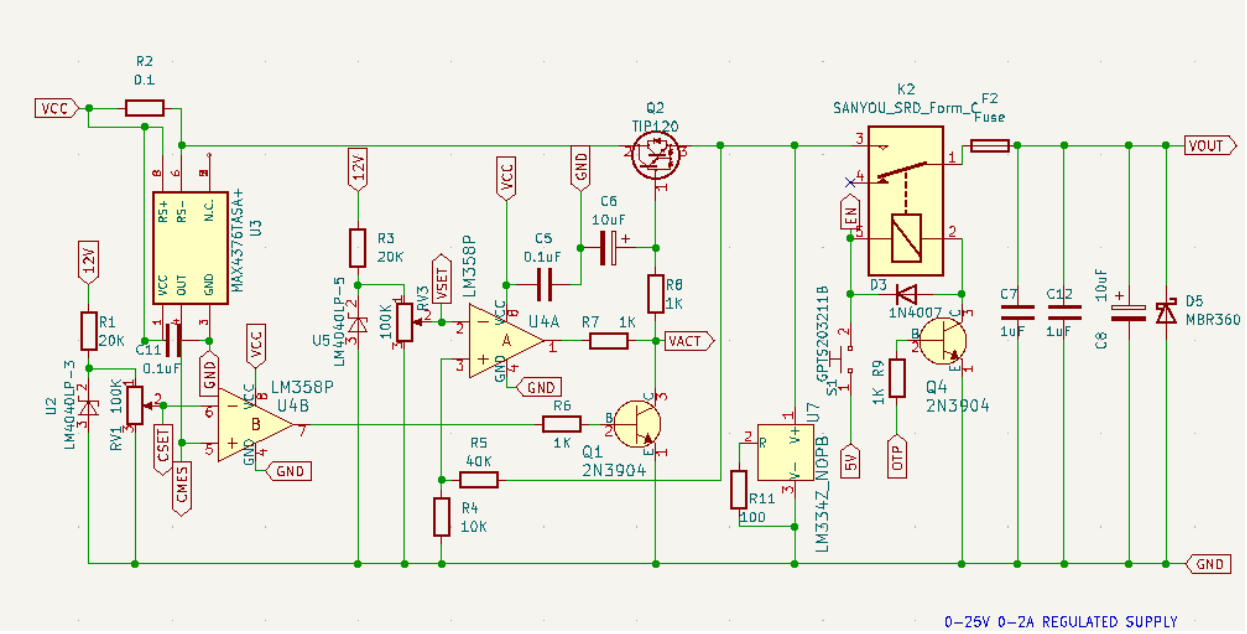
Schematics


FAN CONTROLLER
RECTIFIERS
MCU
0-25V 0-2A REGULATED SUPPLY
5V REGULATOR
12V REGULATOR
Sheet: /
File: Power Supply.kicad_sch
Title: DC Bench Power Supply
Size: A4
Date: 8/19/22
KiCad E.D.A. kicad (6.0.0)
Rev: B
Id: 1/1

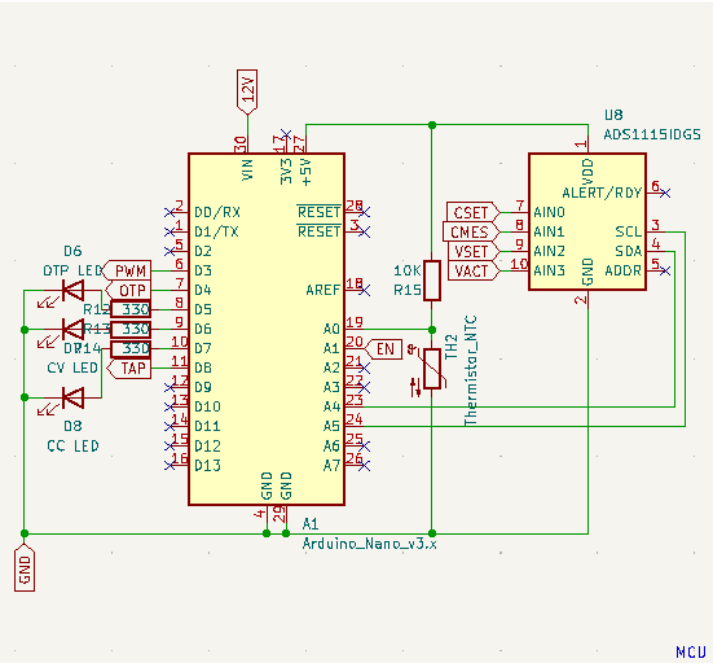
AC Rectifier



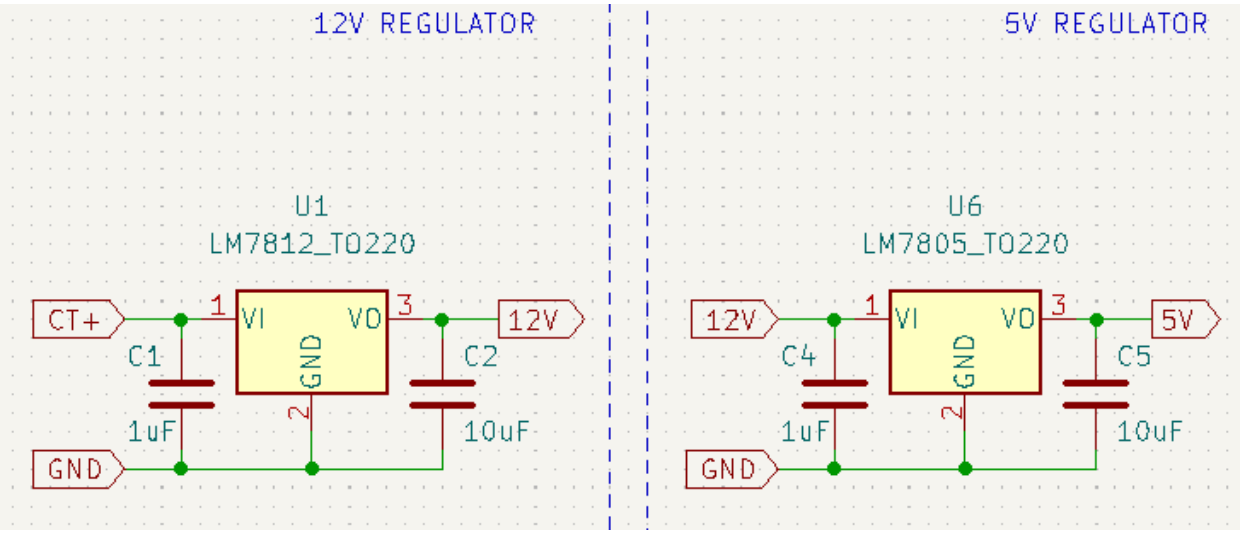
Power Supply Regulation



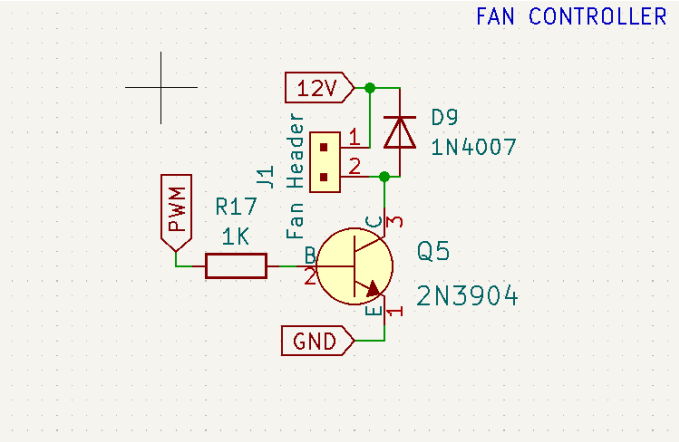
Microcontroller



Regulators



Fan Controller



Part List

Part	Quantity
0.1 µF 10% @ 50V	2
1 µF 10% @ 50V	3
2.2 µF 20% @ 50V	1
10 µF 20% @ 50V	3
47 µF 20% @ 50V	1
10000 µF 20% @ 50V	1
18000 µF 20% @ 50V	1
0.1 Ω 0.25%	1
100 Ω 1%	1
330 Ω 5%	3
1 kΩ 1%	6
2.4 kΩ 5%	2
10 kΩ 0.1%	2
20 kΩ 5%	2
40 kΩ 0.1%	1
20 – 100 kΩ	2
1N4007	3
MBR360	2
LED	3
GBU402	2
2n3904	4
TIP120	1
L7805CV	1
BAJ2DD0T	1
LM358P	1
LM334Z	1
LM4040-3	1
LM4040-5	1
MAX4376TASA+	1
ADS1115	1
SRD 5V Relay	2
1.0A Fuse	1
3.0A Fuse	1
240V Varistor	1
530002B02500G	2
25SH-B-02-TS	6
1217861-1	5
100VA 20V 5A Transformer w/ CT	1
Total	74

Power Board

Reference	Value	Tolerance	Rating
C1	1 µF	10%	50V
C2	10 µF	20%	50V
C3	1 µF	10%	50V
C4	10 µF	20%	50V
C5	0.1 µF	10%	50V
C6	10 µF	20%	50V
C9	18000 µF	20%	50V
C10	10000 µF	20%	50V
C11	0.1 µF	10%	50V
D1	1N4007		1kV @ 1A
D2	MBR360		
D4	GBU402		200V @ 4A
D9	GBU402		200V @ 4A
H1	530002B02500G		
H2	530002B02500G		
J1	J3		25SH-B-02-TS
J2	J5		25SH-B-02-TS
J4	J7		25SH-B-02-TS
J7	CENTER TAP		1217861-1
J8	NEUTRAL		1217861-1
J9	LINE		1217861-1
TAP	TAP		
K1	SRD 5V Relay		
Q1	2n3904		
Q2	TIP120		
Q3	2n3904		
R2	0.1 Ω	0.25%	1/2W
R4	10 kΩ	0.1%	1/4W
R5	40 kΩ	0.1%	1/2W
R6	1 kΩ	1%	1/4W
R7	1 kΩ	1%	1/4W
R8	1 kΩ	1%	1/4W
R10	1 kΩ	1%	1/4W
R11	100 Ω	1%	3/5W
R17	2.4 kΩ	5%	1W
R18	2.4 kΩ	5%	1W
U1	BAJ2DD0T		
U3	MAX4376TASA+		
U4	LM358P		
U6	L7805CV		
U7	LM334Z		

Control Board

Reference	Value	Tolerance	Rating
A1	Arduino Nano		
C7	1 µF	10%	50V
C8	47 µF	20%	50V
C12	2.2 µF	20%	50V
D3	1N4007		
D5	MBR360		
D6	LED		
D7	LED		
D8	LED		
D10	1N4007		
F2	3.0A		125V
J1	FAN		
J3	J1		25SH-B-02-TS
J5	J2		25SH-B-02-TS
J6	I2C LCD		
J7	J4		25SH-B-02-TS
TAP	TAP		
K2	SRD 5V Relay		
Q4	2n3904		
Q5	2n3904		
R1	20 kΩ	5%	1/8W
R3	20 kΩ	5%	1/8W
R9	1 kΩ	1%	1/4W
R12	330 Ω	5%	1/4W
R13	330 Ω	5%	1/4W
R14	330 Ω	5%	1/4W
R15	10 kΩ	0.1%	1/4W
R16	1 kΩ	1%	1/4W
RV1	20 – 100 kΩ		
RV3	20 – 100 kΩ		
S1			
TH2	10 kΩ	1%	
U2	LM4040-3		
U5	LM4040-5		
U8	ADS1115		

Mains Board

Reference	Value	Tolerance	Rating
F1	1A		250VAC
J10	NEUTRAL		1217861-1
J11	LINE		1217861-1
TH1			
RV2	240V Varistor		6kA

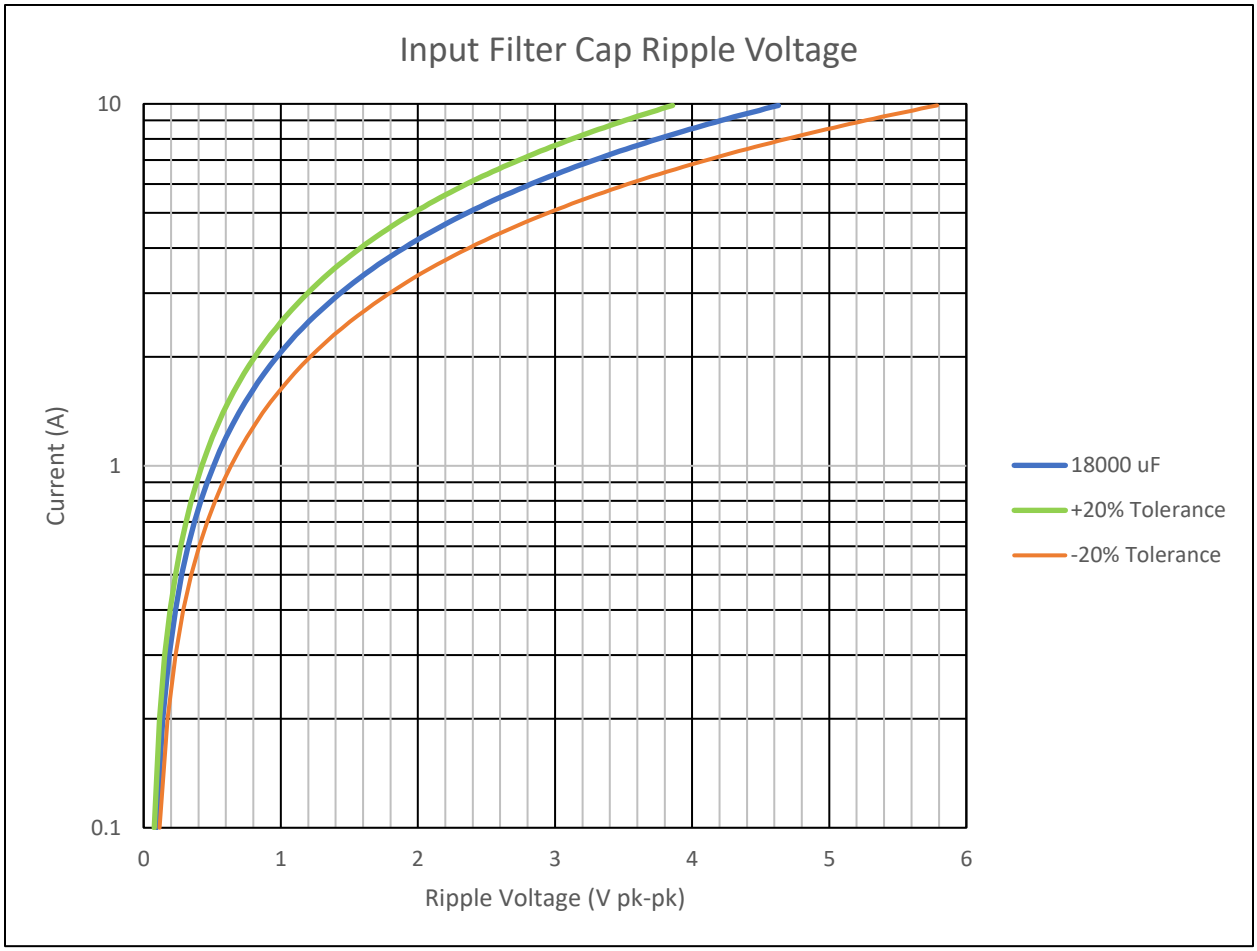
Microcontroller Code

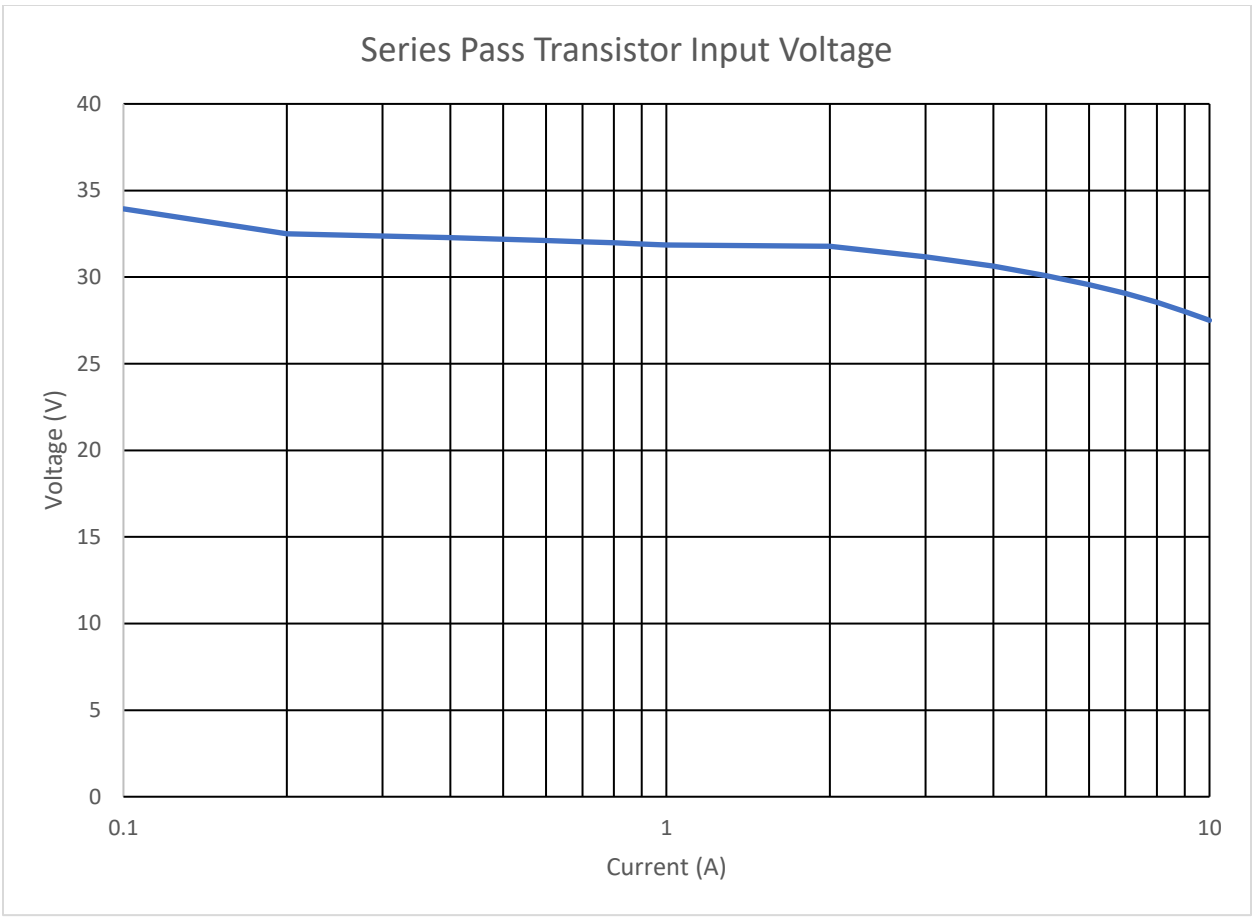
```
//Libraries
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Adafruit_ADS1015.h>

//i2c Addresses
#define DISPLAYADDRESS 0x27;
Adafruit_ADS1115 ads(0x48);
LiquidCrystal_I2C lcd(0x27, 16, 2); //Address, columns, rows

//16 bit adc to voltage
const float multiplier = 0.0001875;

//PWM Fan Control (Trigger Temps)
#define TWENTYPERCENT 51 //20C
#define FOURTYPERCENT 102 //30C
#define SIXTYPERCENT 153 //45C
#define EIGHTYPERCENT 204 //55C
#define HUNDREDPERCENT 255 //65C

//Temp Calcs
#define SERIESRESISTOR 10000 //Resistor
#define BETA 3425 //Thermistor Beta
#define AMBIENT 25 //Temperature Reference Point
#define AMBIENTRESISTANCE 10000 //Thermistor Resistance
float resistance;
float temp;
float measured_temp;

//PINS
#define FANPIN 3 // PWM Data pin 3
#define THERMALPIN 4 //THERMAL Protection
#define THERMALLED 5 //THERMAL Led
#define VOLTAGEMODE 6 //CV Led
#define CURRENTMODE 7 //CC Led
#define SECONDARYTAP 8 //Transformer Taps

//Analog Inputs
#define THERMISTORPIN A0 //Thermistor Voltage From Heatsink
#define POWERSWITCH A1 //Load output status

void setup() {
 //Set pin types as outputs
 pinMode(FANPIN, OUTPUT); //Pin 3
 pinMode(THERMALPIN, OUTPUT); //Pin 4
 pinMode(THERMALLED, OUTPUT); //Pin 5
 pinMode(VOLTAGEMODE, OUTPUT); //Pin 6
 pinMode(CURRENTMODE, OUTPUT); //Pin 7
 pinMode(SECONDARYTAP, OUTPUT); //Pin 8

 Serial.begin(9600);
 setPwmFrequency(3, 1); //Increase Timer2 PWM Frequency

 //LCD initiation
 lcd.init();
 lcd.backlight();
 lcd.clear();
 lcd.setCursor(0,0);

 //Set default digital pin status
 digitalWrite(THERMALPIN, HIGH);
 digitalWrite(THERMALLED, LOW);
 digitalWrite(SECONDARYTAP, LOW);
```

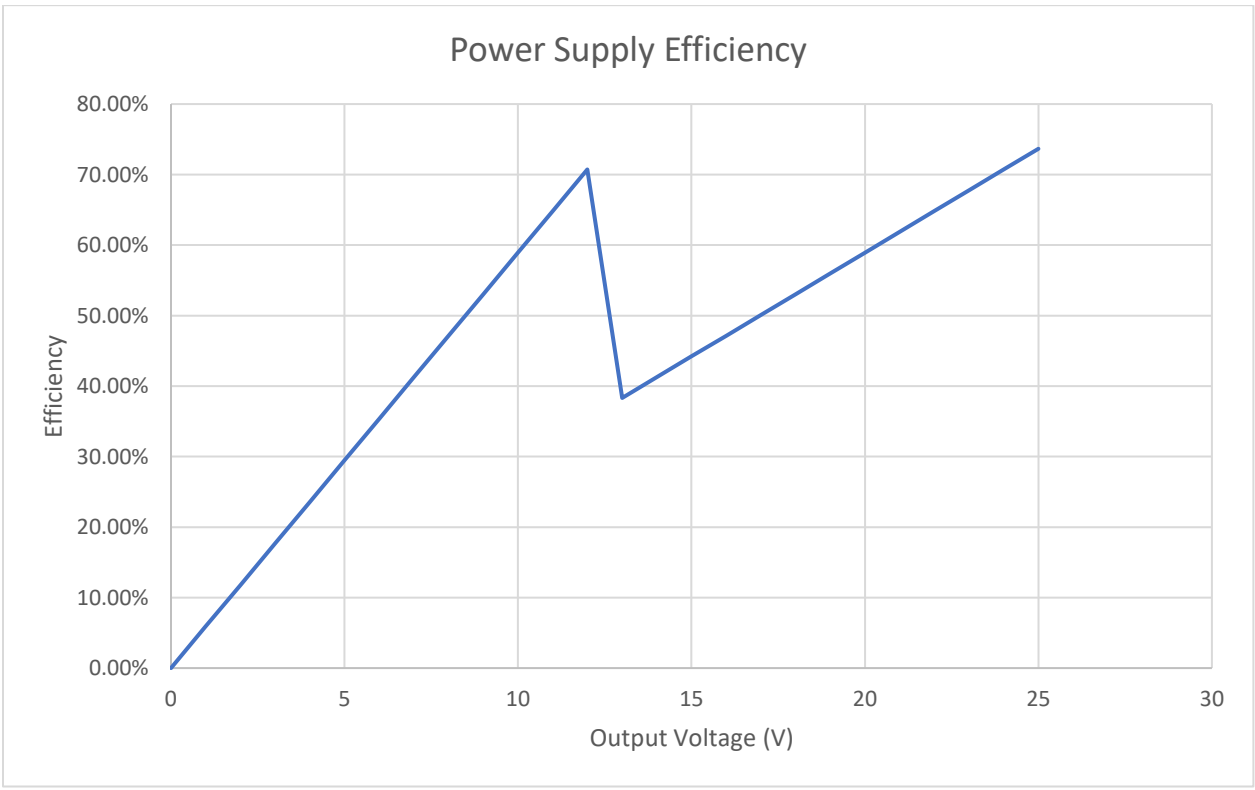
```
  //Start ADC conversion
  ads.begin();
  delay(10);
}
void loop() {
  tempControl();
  adcDisplay();
  delay(100);
}

void adcDisplay() {

  int outputStatus = 0;
  int outputADC = 0;
  float voltage_set, current_set, voltage_act, current_act;
  voltage_set = ads.readADC_SingleEnded(0); //Read voltages for current and voltage
  voltage_act = ads.readADC_SingleEnded(1);
  current_set = ads.readADC_SingleEnded(2);
  current_act = ads.readADC_SingleEnded(3);

  voltage_set = ((voltage_set * multiplier) * 4); //PSU has feedback gain of 4
  voltage_act = ((voltage_act * multiplier) * 4);
  current_set = (current_set * multiplier); //MAX4376 has gain of 20 with 0.1R
  current_act = (current_act * multiplier);

  if(voltage_set < 0){
    voltage_set = 0;
  }
  if(voltage_act < 0){
    voltage_act = 0;
  }
  if(current_set < 0){
    current_set = 0;
  }
  if(current_act < 0){
    current_act = 0;
  }

  outputADC = analogRead(POWERSWITCH);
  if (outputADC >= 512){
    outputStatus = 1;
  }
  else {
    outputStatus = 0;
  }

  lcd.setCursor(0,0);
  lcd.print("Voltage: ");
  lcd.print(voltage_act, 2);
  lcd.print(" V");
  lcd.setCursor(0,1);

  if (outputStatus == 1){
    lcd.print("Current: ");
    lcd.print(current_act, 2);
    lcd.print(" A");
  }
  else {
    lcd.print("Current: ");
    lcd.print(current_set, 2);
    lcd.print(" A");
  }

  if (voltage_act <= (voltage_set - (voltage_set * 0.05))){
    digitalWrite(VOLTAGEMODE, LOW);
    digitalWrite(CURRENTMODE, HIGH);
```

```
  }
  else {
    digitalWrite(VOLTAGEMODE, HIGH);
    digitalWrite(CURRENTMODE, LOW);
  }
  if (voltage_set <= (5/2)){
    digitalWrite(SECONDARYTAP, HIGH);
  }
  else {
    digitalWrite(SECONDARYTAP, LOW);
  }
}

void tempControl(){
  float thresh = 72.5;
  float margin = 5.0;
  measured_temp = thermistorRead();
  Serial.println(measured_temp);
  //fanSpeed(measured_temp);
  if (measured_temp >= (thresh + margin)){
    digitalWrite(THERMALPIN, LOW);
    digitalWrite(THERMALLED, HIGH);
  }
  if (measured_temp <= (thresh - margin)){
    digitalWrite(THERMALPIN, HIGH);
    digitalWrite(THERMALLED, LOW);
  }
}

float thermistorRead(){
  temp = 0;

  //Thermistor resistance calculation
  resistance = analogRead(THERMISTORPIN);
  resistance = 1023 / resistance - 1;
  resistance = SERIESRESISTOR / resistance;

  //Temperature approximation calculation
  temp = resistance / AMBIENTRESISTANCE; // (R/Ro)
  temp = log(temp); // ln(R/Ro)
  temp /= BETA; // 1/B * ln(R/Ro)
  temp += 1.0 / (AMBIENT + 273.15); // + (1/To)
  temp = 1.0 / temp; // Invert
  temp -= 273.15; // Convert K -> C

  return temp;
}

void fanSpeed(float temperature){
  if (temperature >= 30 && temperature < 45){
    analogWrite(FANPIN, FOURTYPERCENT);
  }
  else if (temperature >= 45 && temperature < 55){
    analogWrite(FANPIN, SIXTYPERCENT);
  }
  else if (temperature >= 55 && temperature < 65){
    analogWrite(FANPIN, EIGHTYPERCENT);
  }
  else if (temperature >= 65){
    analogWrite(FANPIN, HUNDREDPERCENT);
  }
  else {
    analogWrite(FANPIN, TWENTYPERCENT);
  }
}
```

```
void setPwmFrequency(int pin, int divisor) {
  byte mode;
  if(pin == 5 || pin == 6 || pin == 9 || pin == 10) {
    switch(divisor) {
      case 1: mode = 0x01; break;
      case 8: mode = 0x02; break;
      case 64: mode = 0x03; break;
      case 256: mode = 0x04; break;
      case 1024: mode = 0x05; break;
      default: return;
    }
    if(pin == 5 || pin == 6) {
      TCCR0B = TCCR0B & 0b11111000 | mode;
    } else {
      TCCR1B = TCCR1B & 0b11111000 | mode;
    }
  } else if(pin == 3 || pin == 11) {
    switch(divisor) {
      case 1: mode = 0x01; break;
      case 8: mode = 0x02; break;
      case 32: mode = 0x03; break;
      case 64: mode = 0x04; break;
      case 128: mode = 0x05; break;
      case 256: mode = 0x06; break;
      case 1024: mode = 0x07; break;
      default: return;
    }
    TCCR2B = TCCR2B & 0b11111000 | mode;
  }
}
```


Input Filter Cap Ripple Voltage
10
1
0.1
Current (A)
0
1
2
3
4
5
6
Ripple Voltage (V pk-pk)
18000 uF
+20% Tolerance
-20% Tolerance


Series Pass Transistor Input Voltage
40
35
30
25
20
15
10
5
0
Voltage (V)
0.1
1
10
Current (A)


Power Supply Efficiency
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Efficiency
0
5
10
15
20
25
30
Output Voltage (V)