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Lampiran 1. Alat dan Bahan

1. Rangkaian Panel Surya

2. Turbin Angin

3. Pikohidro

4. *Solar Charger Controller*
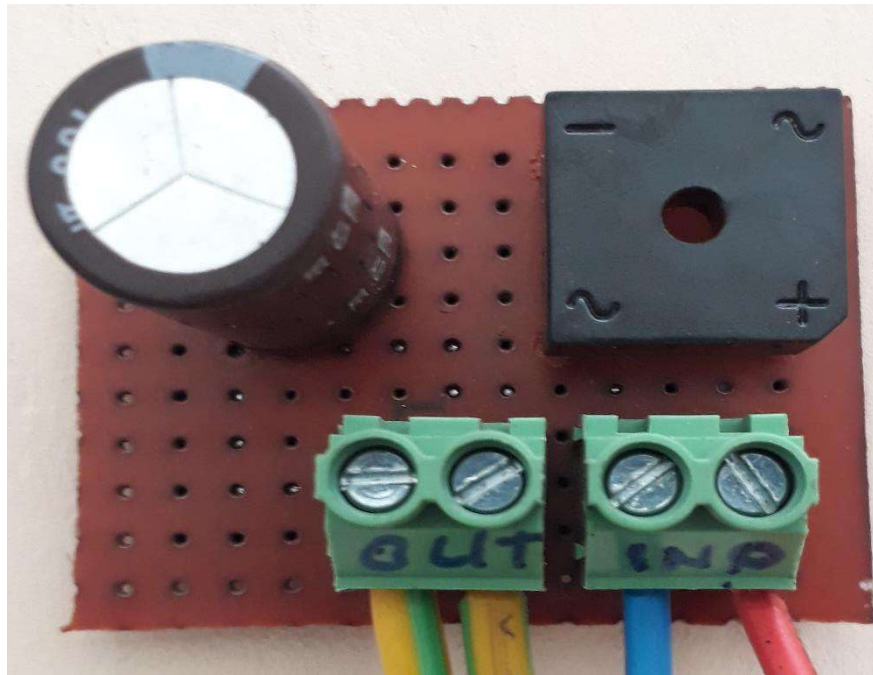
5. Baterai/Aki
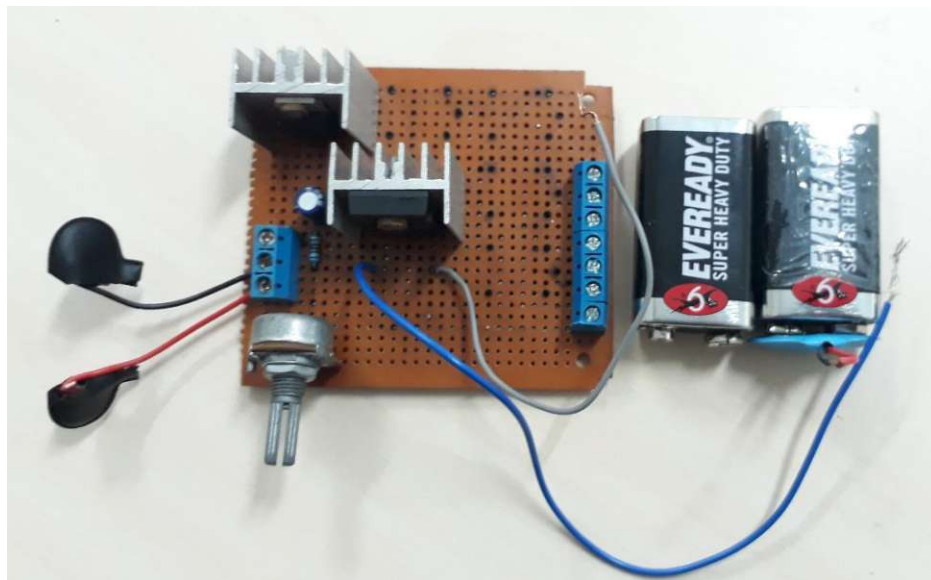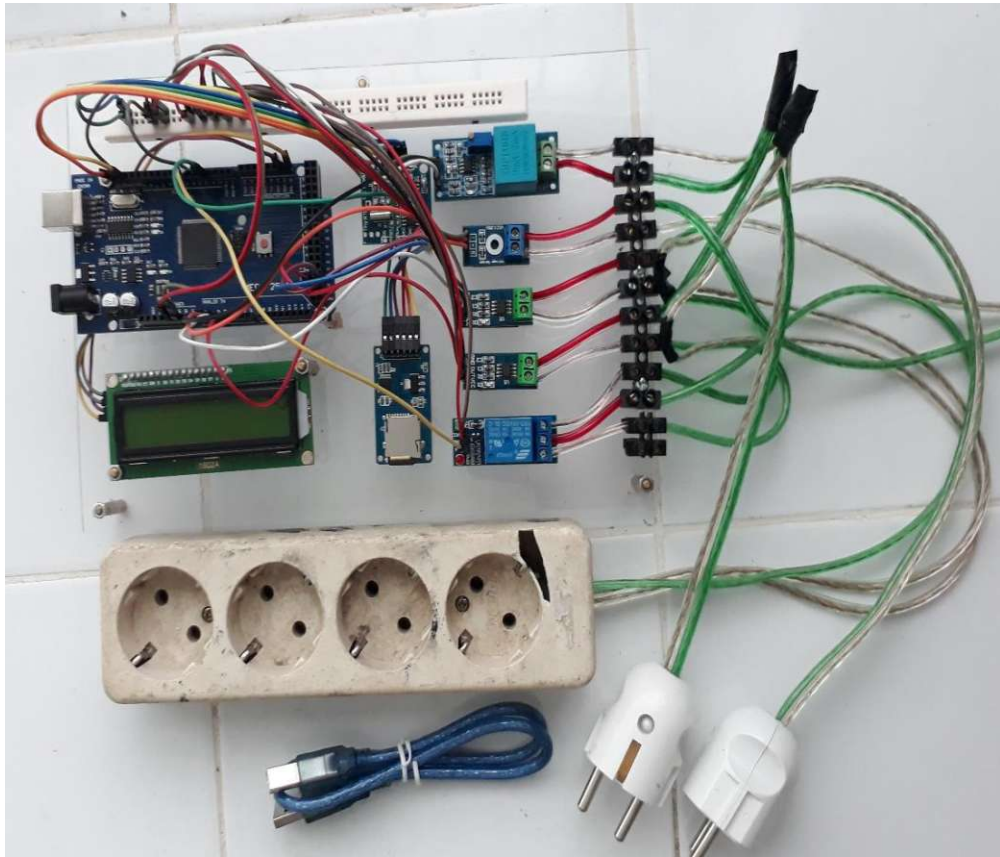

6. Inverter DC to AC

7. Beban R dan L

8. Rangkaian Rectifier

9. Rangkaian Regulator DC

10. Rangkaian Sistem *Hybrid* Pembangkit

11. Multimeter

Lampiran 2. Program Sistem *Hybrid* Pembangkit

```
#include <RTClib.h>

//lcd ------------------------------------------------------------

#include <LiquidCrystal_I2C.h>

#include <Wire.h>

LiquidCrystal_I2C lcd(0x27,16,2);  // set the LCD address to 0x27 for a 16 chars
and 2 line display

//sensor tegangan dan arus ------------------------------------------------------------

#include "ZMPT101B.h"

#include "ACS712.h"

ZMPT101B voltageSensor1 (A0); //sensor tegangan dari PLTPH

int voltageSensor2 (A1); //sensor tegangan di Baterai

ACS712 currentSensor1(ACS712_20A, A2);

ACS712 currentSensor2(ACS712_20A, A3);

ZMPT101B voltageSensor3 (A4); //PLTB

int voltageSensor4 (A5); //PLTS

//relay------------------------------------------------------------

int relay1 = 7; //pin D2

//Micro SD ------------------------------------------------------------

#include <SPI.h>

#include <SD.h>

File AllFile;

/* Pin Micro SD Module to Arduino :
 * menggunakan PIN SPI seperti berikut ini :
 ** MOSI - pin 11 ** arduino mega - pin 51
 ** MISO - pin 12 ** arduino mega - pin 50
 ** CLK - pin 13 ** arduino mega - pin 52
           pin 4 (for MKRZero SD: SDCARD_SS_PIN)
```

```cpp
//RTC Library

#include <RTClib.h> //memasukkan Library RTC

RTC_DS1307 rtc;

char namaHari[7][12] = {"Minggu", "Senin", "Selasa", "Rabu", "Kamis", "Jumat", "Sabtu"}; //definisi hari RTC

int hari;

int bulan;

int tahun;

int jam;

int menit;

int detik;

void setup () {

Serial.begin (9600);

//lcd--------------------------------------------------------

 lcd.init();                    // initialize the lcd

  lcd.backlight();

Serial.println("Menkalibrasi, pastikan tidak ada arus dan tegangan mengalir");

 lcd.setCursor(0 ,0);

 lcd.print("Menkalibrasi . . . .");

 delay(250);

 lcd.clear();

 lcd.setCursor(0 ,0);

 lcd.print("Pastikan tidak");

 lcd.setCursor(0 ,1);

 lcd.print("ada arus");

delay(100);

            ensor1.setSensitivity(0.00583); //sensor dari PLTPH (sensitivitas diatur
            a)

            ensor3.setSensitivity(0.00583); //sensor ukur AC untuk PLTB
```

```
//setSentivity adalah how much output voltage value read by adc
voltageSensor1.calibrate();
currentSensor1.calibrate();
currentSensor2.calibrate();
Serial.println("Selesai!");
//relay-------------------------------
pinMode(relay1, OUTPUT);
//// Micro SD Module
Serial.println("Menginiliasisasi SD card...");
 if (!SD.begin(4)) {
   Serial.println("Inisialisasi gagal!");
   Serial.println("Pastikan micro sd sudah diformat");
   Serial.println("Pastikan kabel sudah benar");
   Serial.println("Silahkan klik tombol reset pada arduino");
   lcd.clear();
   lcd.setCursor(0 ,0);
   lcd.print("Tidak Ada");
   lcd.setCursor(0 ,1);
   lcd.print("SD Card");
   while (1);
 }
 Serial.println("Inisialisasi selesai.");
 lcd.clear();
 lcd.setCursor(0 ,0);
 lcd.print("selesai");
      50);
      --------------------------------------------------
      (DateTime(F(__DATE__), F(__TIME__)));
```

```cpp
    if (! rtc.isrunning()) {
      Serial.println("RTC is NOT running!");
    }
    if (! rtc.begin()) {
      Serial.println("Couldn't find RTC");
      while (1);
    }
//-------------------------------------------------------
lcd.clear();
//-------------------------------------------------------
  Serial.println("memulai sistem");
  lcd.backlight();
  lcd.setCursor(0 ,0);
  lcd.print("Menyimpan log ");
  delay(250);
  lcd.clear();
  Serial.println("Membaca . . . .");
currentSensor1.setSensitivity(0.1651) ;
currentSensor2.setSensitivity(0.1651) ;
//-------------------------------------------------------
}
void loop () {
AllFile = SD.open("AllFile.txt", FILE_WRITE);
hariRTC();
lcd.backlight();
//----------------------------------------------------------
          LTPH
       tage1  = voltageSensor1.getVoltageAC();
          LTB
```

```
float Voltage3  = voltageSensor3.getVoltageAC();
//sensor arus
float Amp1 = currentSensor1.getCurrentAC();
float Daya1 = Voltage1 * Amp1;
//SENSOR TEGANGAN DI BATERAI
float VoltageDC1  = analogRead(voltageSensor2); //SENSOR DI BATERAI
float Voltage2=((VoltageDC1*0.00489)*5); //rubah angka X (defaultnya
(0.00489)) agar sesuai pengukuran || Voltage2=((VoltageDC*X)*5);
//SENSOR TEGANGAN DI PLTS
float VoltageDC2  = analogRead(voltageSensor4); //SENSOR DI PLTS
float Voltage4=((VoltageDC2*0.00489)*5); //rubah angka X (defaultnya
(0.00489)) agar sesuai pengukuran || Voltage2=((VoltageDC*X)*5);
//SENSOR ARUS
float Amp2 = currentSensor2.getCurrentAC();
float Daya2 = Voltage2 * Amp2;
//------------------------------------------------------------
  AllFile.print(" V1:");
  AllFile.print(" ");
  AllFile.print(Voltage1);
  AllFile.print(" ");
  AllFile.print("A1:");
  AllFile.print(" ");
  AllFile.print(Amp1);
  AllFile.print(" ");
  AllFile.print("V2:");
  AllFile.print(" ");
  AllFile.print(Voltage2);
  print(" ");
  print("A2:");
  print(" ");
```

```
AllFile.print(Amp2);
AllFile.print(" ");
AllFile.print("V3:");
AllFile.print(" ");
AllFile.print(Voltage3);
AllFile.print(" ");
AllFile.print("V4:");
AllFile.print(" ");
AllFile.print(Voltage4);
AllFile.println();
//-----------------------------------------------------------
lcd.setCursor(0 ,0);
lcd.print("V1:"); //TEGANGAN PLTPH
lcd.setCursor(3 ,0);
lcd.print(Voltage1);
lcd.setCursor(0 ,1);
lcd.print("V2:"); //TEGANGAN BATERAI
lcd.setCursor(3 ,1);
lcd.print(Voltage2);
lcd.setCursor(9 ,0);
lcd.print("V3:"); //TEGANGAN PLTB
lcd.setCursor(12 ,0);
lcd.print(Voltage3);
lcd.setCursor(9 ,1);
lcd.print("V4:"); //TEGANGAN PLTS
lcd.setCursor(12 ,1);
lcd.print(Voltage4);
nt(String("Volt1 = ") + Voltage1 + " V ");
nt(String("Amp1 = ") + Amp1 + " A ");
```

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```
Serial.print(String("Daya1 = ") + Daya1 + " W ");

Serial.print(String(" Volt2 = ") + Voltage2 + " V ");

Serial.print(String("Amp2 = ") + Amp2 + " A ");

Serial.print(String("Daya2 = ") + Daya2 + " W ");

Serial.print(String("Volt3 = ") + Voltage3 + " V ");

Serial.println(String("Volt4 = ") + Voltage4 + " V ");

delay(1000);

lcd.clear();

AllFile.close();

//---------------------------------------------------

if(Voltage2<10){

  digitalWrite(relay1,LOW);

  }

else if(Voltage2>10){

  digitalWrite(relay1,HIGH);

  }

}

void hariRTC(){

  DateTime now = rtc.now();

  hari = now.day(),DEC;

  bulan = now.month(),DEC;

  tahun = now.year(),DEC;

  jam = now.hour(),DEC;

  menit = now.minute(),DEC;

  detik = now.second(),DEC;

  Serial.print(namaHari[now.dayOfTheWeek()]);

          print(namaHari[now.dayOfTheWeek()]);

          int(',');

          print(',');
```

```
Serial.print(hari);
AllFile.print(hari);
Serial.print('/');
AllFile.print('/');
Serial.print(bulan);
AllFile.print(bulan);
Serial.print('/');
AllFile.print('/');
Serial.print(tahun);
AllFile.print(tahun);
Serial.print(' ');
AllFile.print(' ');
Serial.print(jam);
AllFile.print(jam);
Serial.print(':');
AllFile.print(':');
Serial.print(menit);
AllFile.print(menit);
Serial.print(':');
AllFile.print(':');
Serial.print(detik);
Serial.print(", ");
AllFile.print(detik);
}
```
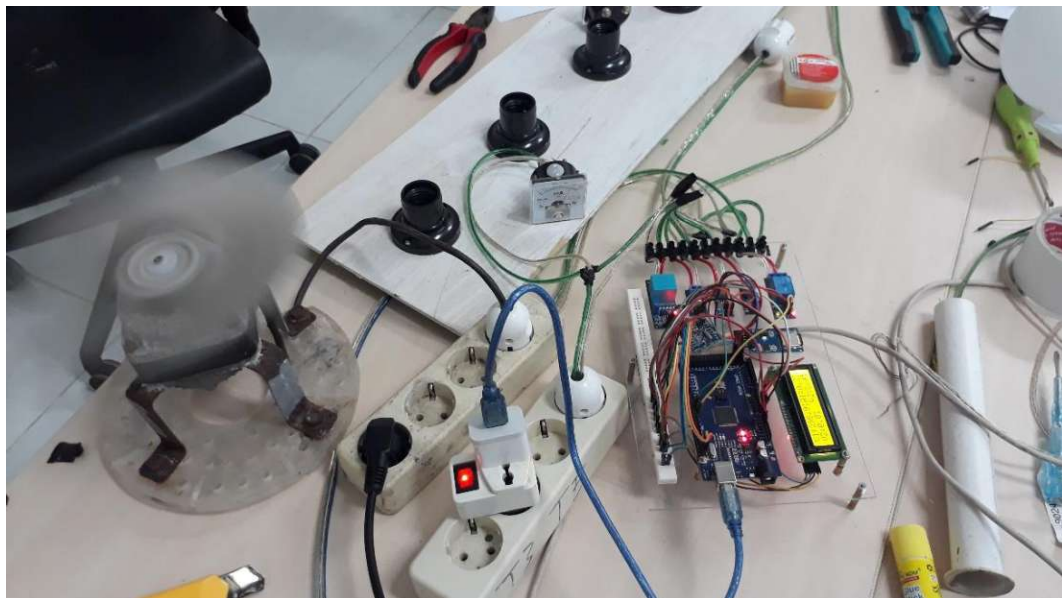
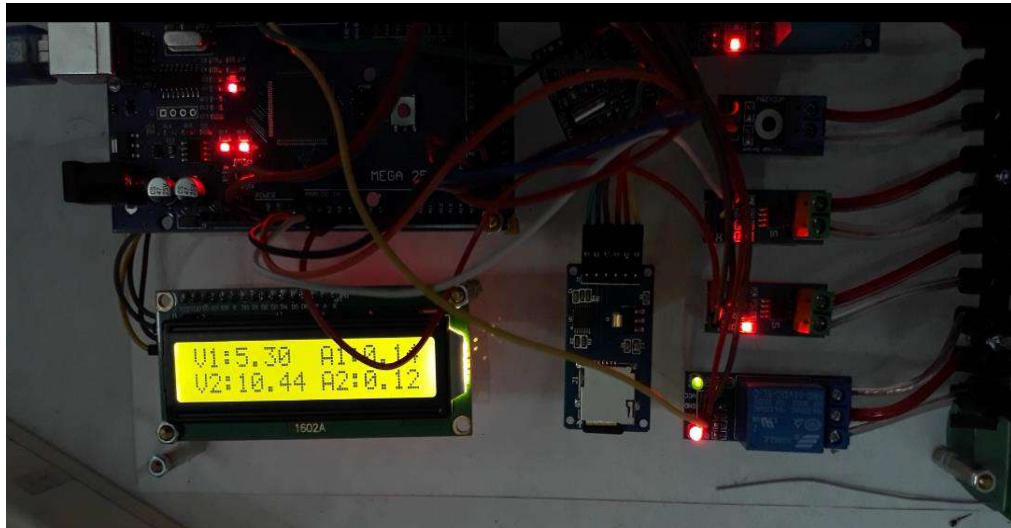**Lampiran 3. Dokumentasi Pengujian Penelitian**

1. Pengujian Sistem *Switching* Pembangkit
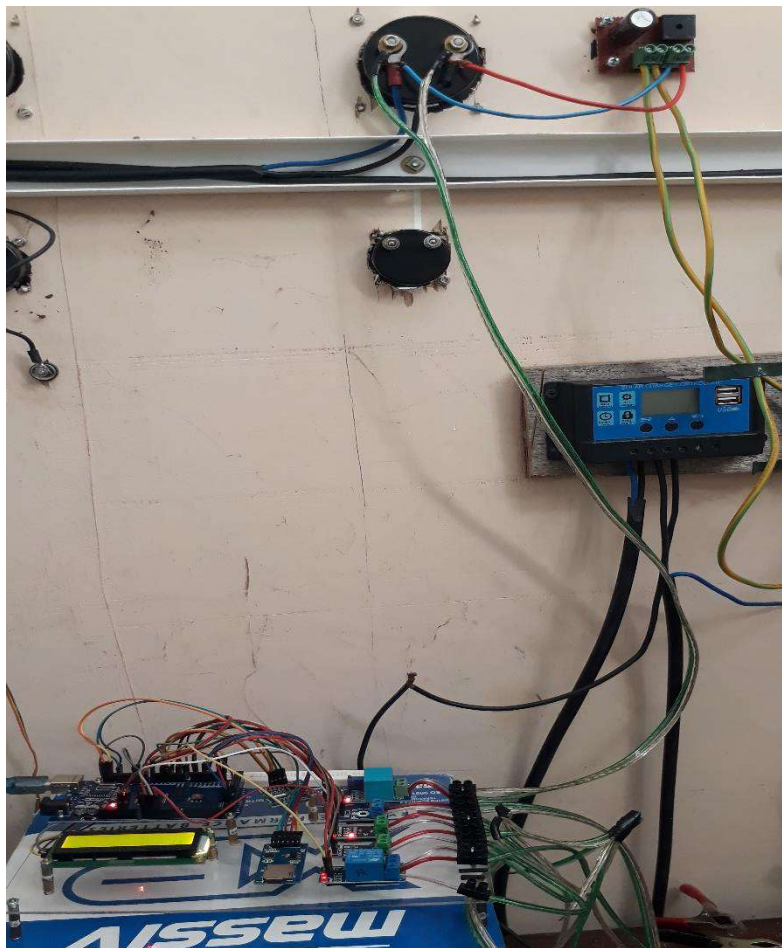

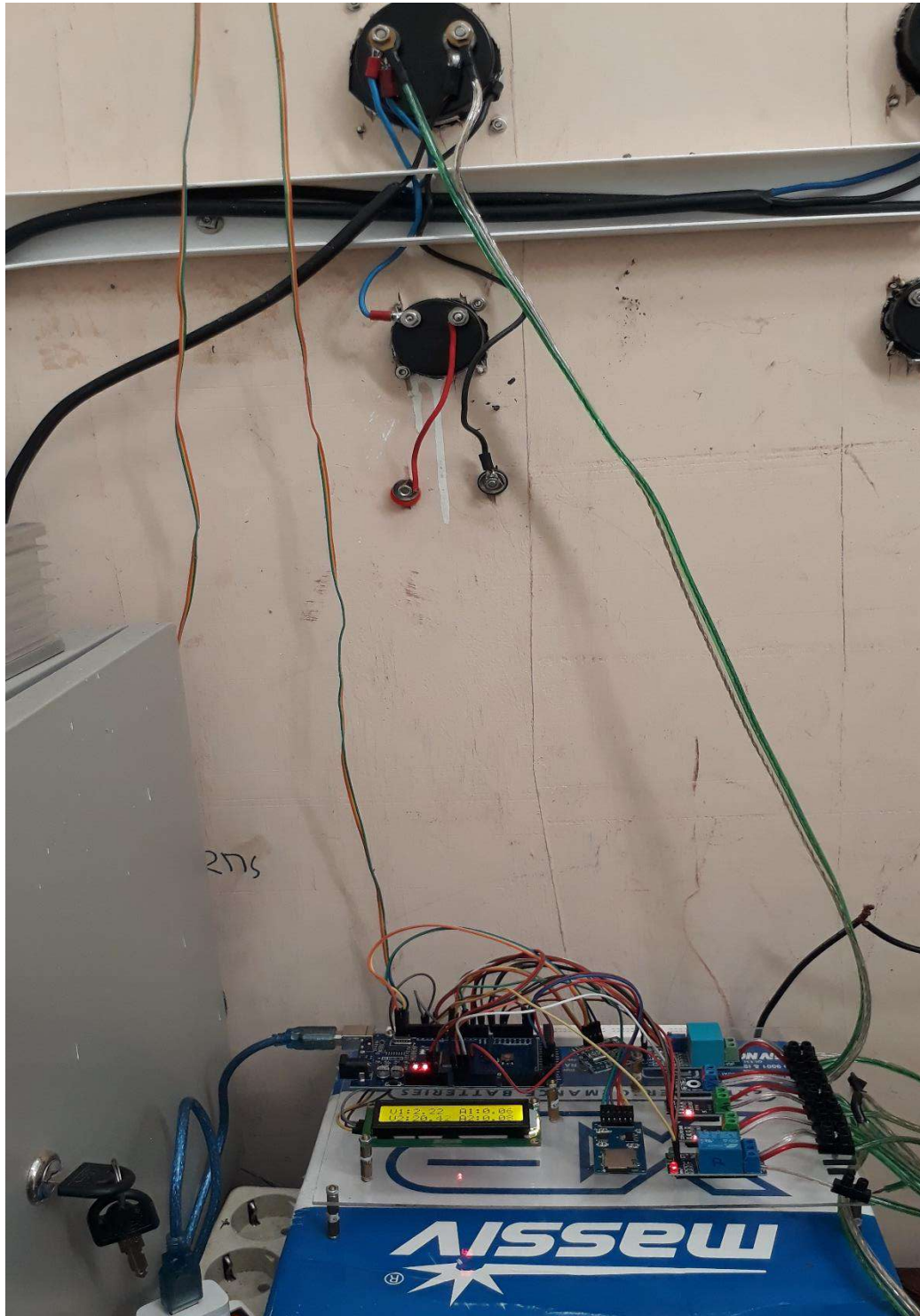2. Pengujian Sensor Arus ACS712

3. Pengujian Modul Relay Switch

4. Pengujian Sensor Tegangan AC

5. Pengujian Sensor Tegangan DC

Lampiran 4. Data Monitoring PLTS

	Waktu (Jam)	Tegangan Rata-rata (V)
Senin, 22 Juni 2020	06.00-07.00	13.61
	07.00-08.00	20.10
	08.00-09.00	20.34
	09.00-10.00	20.05
	10.00-11.00	19.89
	11.00-12.00	19.98
	12.00-13.00	19.91
	13.00-14.00	20.23
	14.00-15.00	20.09
	15.00-16.00	20.15
	16.00-17.00	19.39
	17.00-18.00	18.33
	18.00-19.00	2.20
	19.00-20.00	0.27
Selasa, 23 Juni 2020	06.00-07.00	15.38
	07.00-08.00	20.31
	08.00-09.00	20.31
	09.00-10.00	20.37
	10.00-11.00	19.92
	11.00-12.00	19.88
	12.00-13.00	19.70
	13.00-14.00	20.08
	14.00-15.00	19.94
	15.00-16.00	19.78
	16.00-17.00	19.25
	17.00-18.00	16.76
	18.00-19.00	1.05
	19.00-20.00	0.34
Rabu, 24 Juni 2020	06.00-07.00	15.97
	07.00-08.00	19.31
	08.00-09.00	19.81
	09.00-10.00	20.15
	10.00-11.00	20.05
	11.00-12.00	19.70
	12.00-13.00	19.90
	13.00-14.00	20.15
	14.00-15.00	20.18
	15.00-16.00	19.50
	16.00-17.00	18.35

	17.00-18.00	13.09
	18.00-19.00	0.42
	19.00-20.00	0.37
Kamis, 24 Juni 2020	06.00-07.00	18.52
	07.00-08.00	20.22
	08.00-09.00	20.11
	09.00-10.00	20.04
	10.00-11.00	20.12
	11.00-12.00	20.02
	12.00-13.00	19.96
	13.00-14.00	19.95
	14.00-15.00	19.21
	15.00-16.00	19.16
	16.00-17.00	18.77
	17.00-18.00	12.61
	18.00-19.00	1.09
	19.00-20.00	1.00
Jumat, 26 Juni 2020	06.00-07.00	17.99
	07.00-08.00	20.41
	08.00-09.00	20.94
	09.00-10.00	20.72
	10.00-11.00	20.89
	11.00-12.00	20.92
	12.00-13.00	20.52
	13.00-14.00	20.15
	14.00-15.00	20.18
	15.00-16.00	19.48
	16.00-17.00	18.35
	17.00-18.00	12.90
	18.00-19.00	0.41
	19.00-20.00	0.37

Lampiran 5. Data Monitoring PLTB

	Waktu	Tegangan Rata-rata
	10.00-11.00	17.75
	11.00-12.00	20.21
Senin, 22 Juni 2020	12.00-13.00	17.67
	13.00-14.00	17.46
	14.00-15.00	19.28
	15.00-16.00	19.68
	Waktu	Tegangan Rata-rata
	10.00-11.00	17.55
	11.00-12.00	20.25
Selasa, 23 Juni 2020	12.00-13.00	20.19
	13.00-14.00	20.22
	14.00-15.00	19.58
	15.00-16.00	17.65
	Waktu	Tegangan Rata-rata
	10.00-11.00	16.83
	11.00-12.00	19.48
Rabu, 24 Juni 2020	12.00-13.00	20.33
	13.00-14.00	20.19
	14.00-15.00	19.27
	15.00-16.00	17.12
	Waktu	Tegangan Rata-rata
	10.00-11.00	17.72
	11.00-12.00	20.25
Kamis, 25 Juni 2020	12.00-13.00	17.68
	13.00-14.00	17.44
	14.00-15.00	19.28
	15.00-16.00	18.08
	Waktu	Tegangan Rata-rata
	10.00-11.00	16.52
	11.00-12.00	17.25
Jumat, 26 Juni 2020	12.00-13.00	20.19
	13.00-14.00	20.22
	14.00-15.00	18.58
	15.00-16.00	17.65

Lampiran 6. Perhitungan Teori Tegangan DC Pada Rectifier

Rumus: Teg. DC = Teg. AC x √2

- Teg. DC = 25,8 x √2 = 36,4V

- Teg. DC = 17,6 x √2 = 24,8V

- Teg. DC = 32 x √2 = 45,2V

- Teg. DC = 22,3 x √2 = 31,5V

- Teg. DC = 16,6 x √2 = 23,4V

Lampiran 7. Perhitungan Waktu Pengosongan Baterai

Beban yang digunakan:

- Lampu (L) = 30 W

- Kipas (K) = 16 W

Maka, dapat dihitung

- $S_L = P_L$

    = 30 W

- $S_K = V \times I$

    = 220 x 0,43

    = 94,6 VA

- $S_K = P_K + jQ_K$

  94,6 = 16 + jQ_K

  [Q] = $\sqrt{94,6^2} - \sqrt{16^2}$

    = 93,24 Var

- $S_{total} = S_L + S_K$

    = 30W + 16W + j93,24VAr

    = 46 + j93,24Var

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$$[S_{total}] = \sqrt{46^2} + \sqrt{93,24^2}$$

$$= 103,96$$

- $I_{total} = S_{total} / V$

$$= 103,96 / 220$$

$$= 0,47A$$

- $P_{in} = P_{out}$

$V \times I = 103,96$

$12 \times I = 103,96$

$I = 103,96/12$

$I = 8,6A$

- Waktu operasi baterai

t = kapasitas baterai (Ah) / arus output baterai

$$= 120Ah / 8,6A$$

$$= 13,95h$$

$$= 14h$$

Lampiran 8. Perhitungan Waktu Pengisian Baterai

Kapasitas Baterai : 60 Ah

Arus Pengisian : 3 A

t = Kapasitas Baterai / Arus Pengisian

t = 60Ah / 3A

t = 20 h

Lampiran 9. Wiring Diagram Pengendalian Pembangkit Listrik *Hybrid*