

LAMPIRAN

Lampiran 1. Program Sistem

```
#include <BH1750.h>
#include "DHT.h"
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>
#define DHTPIN 4
#define DHTTYPE DHT22
DHT dht(DHTPIN, DHTTYPE);
BH1750 lightMeter(0x23);
SoftwareSerial esp(2, 3); // RX, TX
// Konstanta untuk LDR
const int ldrPin = A0;
const float Vref = 4.096;
const int resistor = 10000;
int lcdColumns = 20;
int lcdRows = 4;
// Variabel untuk Filter Kalman
float Q = 0.001;
float R = 0.008;
float P = 5.0;
float k = 0.0;
float estimate = 0.0;
// Variabel untuk ThingSpeak
String apiKey = "TE8ZA1WJ77VWWBI3";
String host = "api.thingspeak.com";
// Inisialisasi LCD
LiquidCrystal_I2C lcd(0x27, lcdColumns, lcdRows);
// Fungsi Filter Kalman dari kode pertama
float kalmanFilter(float measurement) {
    P = P + Q;
    k = P / (P + R);
    estimate = estimate + k * (measurement - estimate);
    P = (1.0 - k) * P;
    return estimate;
}
```

```

// Fungsi dari kode kedua
void sendCommand(String cmd, int waitTime = 2000) {
    esp.println(cmd);
    long t = millis();
    while (millis() - t < waitTime) {
        while (esp.available()) {
            char c = esp.read();
            Serial.write(c);
        }
    }
}

void setup() {
    Serial.begin(9600);
    esp.begin(115200);
    // Inisialisasi dari kode pertama
    lcd.init();
    lcd.backlight();
    lcd.setCursor(0, 0);
    lcd.print("Sensor LDR Siap");
    delay(1000);
    lcd.clear();
    dht.begin();
    if (lightMeter.begin(BH1750::CONTINUOUS_HIGH_RES_MODE)) {
        Serial.println(F("BH1750 Advanced begin"));
    } else {
        Serial.println(F("Error initialising BH1750"));
    }
    // Inisialisasi dari kode kedua
    Serial.println("Menghubungkan ke WiFi...");
    sendCommand("AT", 1000);
    sendCommand("AT+CWMODE=1", 1000);
    sendCommand("AT+CWJAP=\"FST-WMS-UNJA\", \"fst.2023\", 8000);
    sendCommand("AT+CIFSR", 1000);
    Serial.println("Koneksi WiFi selesai.");
}

void loop() {

```

```

// Bagian dari kode pertama
int ldrValue = analogRead(ldrPin);
float voltage = (ldrValue / 1023.0) * Vref;
float resistance = (Vref * resistor / voltage) - resistor;
float luxLDR = 500 / (resistance / 1000);
float h = dht.readHumidity();
float t = dht.readTemperature();
float filteredLux = kalmanFilter(luxLDR);
float resistansi, calibratedLux;
if (filteredLux > 0) {
    resistansi = 500000.0 / filteredLux;
    calibratedLux = pow(resistansi / 97538.26, 1.0 / -0.6422);
} else {
    resistansi = 0;
    calibratedLux = 0;
}

// Bagian dari kode kedua
if (lightMeter.measurementReady()) {
    float luxBH1750 = lightMeter.readLightLevel();
    // Tampilkan di LCD
    lcd.setCursor(0, 0);
    lcd.print("FKal: ");
    lcd.print(filteredLux);
    lcd.print(" lux");

    lcd.setCursor(0, 1);
    lcd.print("Cal: ");
    lcd.print(calibratedLux);
    lcd.print(" lux");

    lcd.setCursor(0, 2);
    lcd.print("stdr: ");
    lcd.print(luxBH1750);
    lcd.print(" lux");

    lcd.setCursor(0,3);
    lcd.print("RH:");
    lcd.print(h);

```

```

lcd.print("%");
lcd.setCursor(10,3);
lcd.print("Temp:");
lcd.print(t);
lcd.print("C");
delay(250);
// Kirim ke ThingSpeak
String getData = "GET /update?api_key=" + apiKey +
    "&field1=" + String(luxLDR) +
    "&field2=" + String(filteredLux) +
    "&field3=" + String(calibratedLux) +
    "&field4=" + String(luxBH1750);
sendCommand("AT+CIPSTART=\"TCP\", \"" + host + "\",80", 3000);
sendCommand("AT+CIPSEND=" + String(getData.length() + 4), 2000);
esp.println(getData);
esp.println();

Serial.println("Data terkirim ke ThingSpeak.");
Serial.print("LDR: "); Serial.print(ldrValue);
Serial.print("Fkal: "); Serial.print(filteredLux);
Serial.print("Std: "); Serial.println(luxBH1750);
Serial.print("Cal: "); Serial.println(calibratedLux);

delay(250);
}
}

```

Lampiran 2. Data Hasil Pengukuran Optisense Di Ruang Uji Setelah Penerapan Filter Kalman.

No.	Tanggal/Bulan/Tahun	Waktu	Tanpa Kalman (Lux)	Dengan Kalman (Lux)	Alat Pembanding (Lux)
1	10/6/2025	12:30:07	315.36	308.97	400
2	10/6/2025	12:30:07	302.76	307.13	402.5
3	10/6/2025	12:30:07	312.77	308.8	400.83
4	10/6/2025	12:30:08	302.76	307.01	402.5
5	10/6/2025	12:30:08	312.77	308.72	400.83
6	10/6/2025	12:30:08	302.76	306.95	401.67
7	10/6/2025	12:30:09	300.34	304.99	399.17
8	10/6/2025	12:30:09	315.36	308.06	400.83
9	10/6/2025	12:30:09	300.34	305.77	400
10	10/6/2025	12:30:10	315.36	308.62	401.67
11	10/6/2025	12:30:10	300.34	306.16	400
12	10/6/2025	12:30:10	312.77	308.12	400.83
13	10/6/2025	12:30:11	312.77	309.5	400
14	10/6/2025	12:30:11	300.34	306.78	400
15	10/6/2025	12:30:11	312.77	308.56	400
16	10/6/2025	12:30:12	300.34	306.12	399.17
17	10/6/2025	12:30:12	315.36	308.86	400
18	10/6/2025	12:30:13	300.34	306.33	400.83
19	10/6/2025	12:30:13	302.76	305.27	400.83
20	10/6/2025	12:30:13	312.77	307.5	399.17
21	10/6/2025	12:30:14	302.76	306.09	401.67
22	10/6/2025	12:30:14	312.77	308.07	400.83
23	10/6/2025	12:30:14	302.76	306.5	401.67
24	10/6/2025	12:30:15	312.77	308.35	400.83
25	10/6/2025	12:30:15	310.21	308.91	402.5
26	10/6/2025	12:30:15	305.21	307.81	400.83
27	10/6/2025	12:30:16	310.21	308.52	402.5
28	10/6/2025	12:30:16	302.76	306.81	398.33
29	10/6/2025	12:30:16	310.21	307.82	401.67
30	10/6/2025	12:30:17	302.76	306.32	400
31	10/6/2025	12:30:17	307.69	306.73	401.67
32	10/6/2025	12:30:17	307.69	307.01	400
33	10/6/2025	12:30:18	307.69	307.21	405.83
34	10/6/2025	12:30:18	310.21	308.1	405
35	10/6/2025	12:30:18	307.69	307.98	405.83

Lampiran 3. Data Hasil Pengukuran Optisense Di Ruang Uji Setelah Penerapan Filter Kalman dan Kalibrasi.

No	Tanggal/Bulan/Tahun	Waktu	Optisense (Lux)	Alat Pembanding (Lux)
1	14/8/2025	12:40:33	380.94	380.83
2	14/8/2025	12:40:33	380.73	379.17
3	14/8/2025	12:40:34	383.27	380
4	14/8/2025	12:40:34	382.37	381.67
5	14/8/2025	12:40:34	381.74	380
6	14/8/2025	12:40:35	382.63	380.83
7	14/8/2025	12:40:35	388.79	380
8	14/8/2025	12:40:35	393.15	379.17
9	14/8/2025	12:40:36	392.01	380.83
10	14/8/2025	12:40:36	392.59	379.17
11	14/8/2025	12:40:37	395.83	377.5
12	14/8/2025	12:40:37	395.28	379.17
13	14/8/2025	12:40:37	389.47	377.5
14	14/8/2025	12:40:38	385.41	377.5
15	14/8/2025	12:40:38	383.87	375
16	14/8/2025	12:40:38	384.13	379.17
17	14/8/2025	12:40:39	381.66	377.5
18	14/8/2025	12:40:39	379.92	375.83
19	14/8/2025	12:40:40	385.46	378.33
20	14/8/2025	12:40:40	389.38	378.33
21	14/8/2025	12:40:40	388	375.83
22	14/8/2025	12:40:41	389.77	378.33
23	14/8/2025	12:40:41	392.42	377.5
24	14/8/2025	12:40:41	391.5	378.33
25	14/8/2025	12:40:42	388.15	380.83
26	14/8/2025	12:40:42	385.8	381.67
27	14/8/2025	12:40:42	388.22	380
28	14/8/2025	12:40:43	387.18	380.83
29	14/8/2025	12:40:43	385.12	380
30	14/8/2025	12:40:44	387.74	380.83
31	14/8/2025	12:40:44	393.85	383.33
32	14/8/2025	12:40:44	395.29	379.17
33	14/8/2025	12:40:45	390.81	379.17
34	14/8/2025	12:40:45	394.57	380.83
35	14/8/2025	12:40:45	395.8	380

Lampiran 4. Data Hasil Pengukuran Optisense Di Laboratorium

No	Tanggal/Bulan/Tahun	Waktu	Optisense (Lux)	Alat Pembanding (Lux)
1	31/8/2025	07:37:15	191.01	190.83
2	31/8/2025	07:37:36	190.72	190
3	31/8/2025	07:37:58	190.52	190
4	31/8/2025	07:38:20	190.38	190
5	31/8/2025	07:38:41	190.28	190
6	31/8/2025	07:39:03	190.21	189.17
7	31/8/2025	07:39:24	190.16	189.17
8	31/8/2025	07:39:46	189.67	189.17
9	31/8/2025	07:40:07	189.32	189.17
10	31/8/2025	07:40:29	189.08	189.17
11	31/8/2025	07:40:51	188.91	189.17
12	31/8/2025	07:41:12	188.79	189.17
13	31/8/2025	07:41:34	188.71	189.17
14	31/8/2025	07:41:55	188.65	189.17
15	31/8/2025	07:42:17	188.61	189.17
16	31/8/2025	07:42:38	188.58	189.17
17	31/8/2025	07:43:00	188.56	189.17
18	31/8/2025	07:43:22	188.54	189.17
19	31/8/2025	07:43:43	188.53	188.33
20	31/8/2025	07:44:05	188.52	188.33
21	31/8/2025	07:44:26	188.52	188.33
22	31/8/2025	07:44:48	188.52	188.33
23	31/8/2025	07:45:10	188.51	188.33
24	31/8/2025	07:45:31	188.51	188.33
25	31/8/2025	07:45:53	188.51	188.33
26	31/8/2025	07:46:14	188.51	188.33
27	31/8/2025	07:46:36	188.51	188.33
28	31/8/2025	07:46:57	188.51	189.17
29	31/8/2025	07:47:19	188.51	188.33
30	31/8/2025	07:47:41	188.51	188.33
31	31/8/2025	07:48:02	188.51	188.33
32	31/8/2025	07:48:24	188.51	188.33
33	31/8/2025	07:48:45	188.51	188.33
34	31/8/2025	07:49:07	188.51	188.33
35	31/8/2025	07:49:29	188.51	188.33

Lampiran 5. Perhitungan Akurasi dan Presisi

- Perhitungan Akurasi dan Presisi Lampiran 2

$$\text{akurasi} = (1 - \text{error}) \times 100$$

$$= (1 - 0.227) \times 100$$

$$= 77.3\%$$

$$\text{error} = \frac{\text{nilai sebenarnya} - \text{nilai pengukuran}}{\text{nilai sebenarnya}}$$

$$= \frac{400 - 308.97}{400}$$

$$= 0.227$$

$$SD = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1}}$$

$$\begin{aligned} \sum_{i=1}^N (x_i - \bar{x})^2 &= (308.97 - 307.5)^2 + (307.13 - 307.5)^2 + (308.8 - 307.5)^2 \\ &\quad + (307.01 - 307.5)^2 + (308.72 - 307.5)^2 \\ &\quad + (306.95 - 307.5)^2 + (304.99 - 307.5)^2 + (308.06 - 307.5)^2 \\ &\quad + (305.77 - 307.5)^2 + (308.62 - 307.5)^2 = 16.876 \end{aligned}$$

$$SD = \sqrt{\frac{16.876}{10 - 1}}$$

$$SD = 1.36$$

$$\text{Presisi} = \left(1 - \frac{SD}{\bar{x}}\right) \times 100$$

$$= \left(1 - \frac{1.36}{307.5}\right) \times 100$$

$$= 99.6\%$$

- Perhitungan Akurasi dan Presisi Lampiran 3

$$\text{akurasi} = (1 - \text{error}) \times 100$$

$$= (1 - 0.0003) \times 100$$

$$= 99.97\%$$

$$\text{error} = \frac{\text{nilai sebenarnya} - \text{nilai pengukuran}}{\text{nilai sebenarnya}}$$

$$= \frac{380.83 - 380.94}{380.83}$$

$$= 0.0003$$

$$SD = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1}}$$

$$\begin{aligned} \sum_{i=1}^N (x_i - \bar{x})^2 &= (380.94 - 385.82)^2 + (380.73 - 385.82)^2 + (383.27 - 385.82)^2 \\ &\quad + (382.37 - 385.82)^2 + (381.74 - 385.82)^2 + (382.63 - 385.82)^2 \\ &\quad + (388.79 - 385.82)^2 + (393.15 - 385.82)^2 + (392.01 - 385.82)^2 \\ &\quad + (392.59 - 385.82)^2 = 241.67 \end{aligned}$$

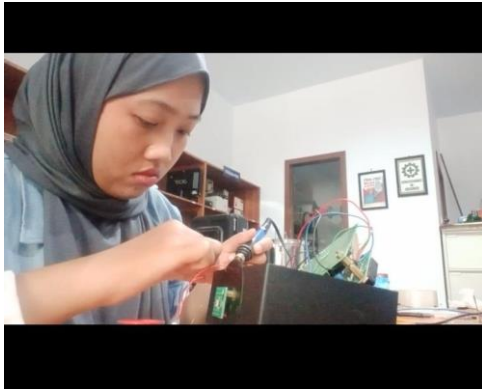
$$SD = \sqrt{\frac{241.67}{10 - 1}}$$

$$SD = 5.18$$

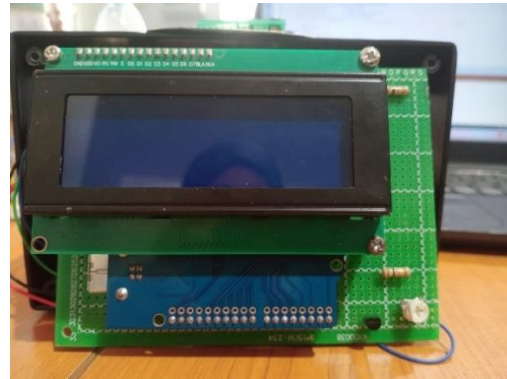
$$\begin{aligned} \text{Presisi} &= \left(1 - \frac{SD}{\bar{x}}\right) \times 100 \\ &= \left(1 - \frac{5.18}{385.82}\right) \times 100 \\ &= 98.6\% \end{aligned}$$

$$\begin{aligned} \text{akurasi} &= (1 - \text{error}) \times 100 \\ &= (1 - 0.0003) \times 100 \\ &= 99.97\% \end{aligned}$$

$$\begin{aligned} \text{error} &= \frac{\text{nilai sebenarnya} - \text{nilai pengukuran}}{\text{nilai sebenarnya}} \\ &= \frac{380.83 - 380.94}{380.83} \\ &= 0.0003 \end{aligned}$$

Lampiran 6. Dokumentasi

1. Proses Perakitan Alat



2. Tampilan Dalam Sistem



3. Proses pengambilan data di ruang uji



4. Proses pengambilan data di laboratorium