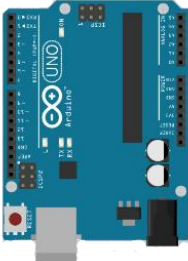
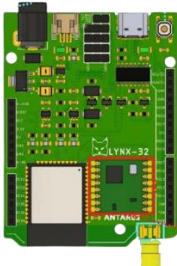
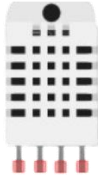



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LAMPIRAN**Lampiran 1. Peralatan Penelitian**

No	Nama Alat	Gambar
1	Arduino Uno	 A blue Arduino Uno microcontroller board with a USB Type-B port, a DC power jack, and a micro-USB port.
2	LoRa (Long Rang)	 A green LoRa module with a white antenna and a yellow SMA connector. The board features a Si4463 chip and is labeled 'ANTARG' and 'LYNX-32'.
3	Sensor DHT 22	 A white, rectangular DHT 22 digital temperature and humidity sensor with four pins (VCC, GND, DATA, and VCC) at the bottom.
4	Sensor Anemometer	 A black anemometer with three hemispherical cups for wind speed measurement and a vertical vane for wind direction measurement, mounted on a black base.

No	Nama Alat	Gambar Alat
5	Sensor ZH03B	 A blue PCB sensor module with a white header and a black component.
6	Sensor MQ-136	 A green PCB sensor module with a circular metal mesh and a blue component.
7	Laptop	 A laptop with a green and black geometric pattern on the screen.
8	<i>Powerbank</i>	 A black, rectangular power bank with a digital display and ports.
9	<i>Kabel Jumper</i>	 A bundle of multi-colored jumper wires with black plastic connectors.

10	<i>Printed Circuit Board (PCB)</i>	
11	Termometer <i>Hygrometer</i> digital	
12	<i>Particle counter</i>	
13	Gas Kalibrasi	

Lampiran 2. Data kalibrasi sensor DHT 22

Suhu

DHT 22 (°C)	Thermo (°C)	Error (%)
17,7	18,2	2,7
19,9	20,1	1,0
21,7	22,5	3,6
27,3	28,2	3,2
31,7	32,4	2,2
38,3	39	1,8
44,5	45,3	1,8
58,6	59	0,7
64,9	65,3	0,6
69,5	70,1	0,9
Rata-rata		1,8
Akurasi		98,2

Kelembapan

DHT22 (%)	Thermo (%)	Error (%)
2,3	25,6	1,2
30,4	31,2	2,6
34,9	35,3	1,1
42,1	43,5	3,2
56,2	57,3	1,9
62,7	63,6	1,4
67,1	69,9	4,0
73,9	74,5	0,8
79,4	80,6	1,5
85,5	85,9	0,5
92,8	93,5	0,7
96,1	97,6	1,5
Rata-rata		1,7
Akurasi		98,3

Lampiran 3. Data kalibrasi sensor ZH03B

ZH03B	Alat ukur ($\mu\text{g}/\text{m}^3$)	Error (%)
7	7	0,0
12	12	0,0
17	17	0,0
20	20	0,0
23	23	0,0
30	32	6,3
57	61	6,6
82	83	1,2
124	132	6,1
158	161	1,9
236	252	6,3
330	344	4,1
390	415	6,0
Rata-rata		3,0
Akurasi		97,0

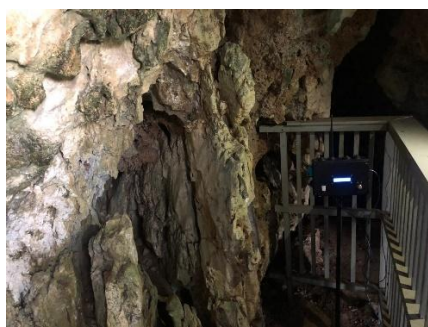
Lampiran 4. Data kalibrasi sensor MQ-136

Gas Kalibrator (ppm)	MQ-136 (ppm)	Error (%)
20	18,4	8,0
40	36,8	8,0
50	47,3	5,4
100	91,5	8,5
500	498,3	0,3
1000	980,5	2,0
Rata-rata		5,4
Akurasi		94,6

Lampiran 5. Data kalibrasi sensor anemometer

Alat ukur (m/s)	Sensor (m/s)	Error (%)
5,1	5,20	2,0
4,4	4,30	2,3
2,6	2,64	1,9
2,1	2,15	1,9
1,4	1,43	2,1
1,0	0,98	2,0
0,5	0,48	4,4
0	0,0	0
Rata-Rata		2,4
Akurasi		97,9

Lampiran 6. Dokumentasi pengambilan data di lapangan



Lampiran 7. Data penelitian

No	Timestamp	Waktu/tanggal	Suhu	Kelembapan	Kecepatan Angin	So2	Debu
1	1722245371	7/29/24 17:29	27,8	74,8	0	3,5	0
2	1722245614	7/29/24 17:33	27,8	74,8	0,72	4,48	15
3	1722245977	7/29/24 17:39	27,8	74,8	0	4,48	10
4	1722246216	7/29/24 17:43	27,8	74,8	6,45	565	8
5	1722246458	7/29/24 17:47	27,8	74,8	0	7,04	9
6	1722247040	7/29/24 17:57	27,8	74,8	0	7,04	2
7	1722247282	7/29/24 18:01	27,8	73,7	0	5,65	7
8	1722247841	7/29/24 18:10	27,8	73,7	0	1,11	0
9	1722248084	7/29/24 18:14	27,8	73,7	0	8,69	4
10	1722248205	7/29/24 18:16	27,8	73,7	0	7,04	4
11	1722248419	7/29/24 18:20	27,8	73,7	0	7,04	1
12	1722248686	7/29/24 18:24	27,5	73,7	0,42	5,65	0
13	1722248903	7/29/24 18:28	27,5	73,5	0	5,65	0
14	1722249090	7/29/24 18:31	27,5	73,5	13,1	3,5	1
15	1722249278	7/29/24 18:34	27,5	73,5	1,4	8,69	1
16	1722249465	7/29/24 18:37	27,5	73,5	0	8,69	0
17	1722249652	7/29/24 18:40	27,5	73,5	24,94	8,69	0
18	1722251163	7/29/24 19:06	27,5	73,5	0	8,69	0
19	1722251294	7/29/24 19:08	27,5	71	0	5,65	0
20	1722251320	7/29/24 19:08	27,5	70,9	0	5,65	1
21	1722251508	7/29/24 19:11	27,4	70,7	0	5,65	0
22	1722251695	7/29/24 19:14	27,2	71,4	0	4,48	1
23	1722251882	7/29/24 19:18	27,1	71,7	0	7,04	1
24	1722252069	7/29/24 19:21	26,9	72,4	0	5,65	1
25	1722252256	7/29/24 19:24	26,8	73	0	5,65	1
26	1722252444	7/29/24 19:27	26,7	73,3	16,65	5,65	1
27	1722252631	7/29/24 19:30	26,7	73,2	0	7,04	1
28	1722252818	7/29/24 19:33	26,6	72,7	0	4,48	1
29	1722253005	7/29/24 19:36	26,6	73,3	0	5,65	1
30	1722253192	7/29/24 19:39	26,5	73,6	0	5,65	1
31	1722253380	7/29/24 19:43	26,5	73,8	0	5,65	0
32	1722253567	7/29/24 19:46	26,5	73,5	0	5,65	0
33	1722253754	7/29/24 19:49	26,5	73,3	0	5,65	0
34	1722253941	7/29/24 19:52	26,4	74	0	4,48	1
35	1722254128	7/29/24 19:55	26,4	72,8	0	5,65	1

No	Timestamp	Waktu/tanggal	Suhu	Kelembapan	Kecepatan Angin	SO2	Debu
36	1722254315	7/29/24 19:58	26,4	73,8	0	5,65	1
37	1722254503	7/29/24 20:01	26,4	73,9	0	5,65	0
38	1722254690	7/29/24 20:04	26,4	74,2	0	5,65	0
39	1722254877	7/29/24 20:07	26,4	74	0	5,65	0
40	1722255064	7/29/24 20:11	26,4	74,3	0	5,65	1
41	1722255251	7/29/24 20:14	26,4	73,4	0	5,65	1
42	1722255439	7/29/24 20:17	26,4	73,4	0	5,65	0
43	1722255626	7/29/24 20:20	26,4	73,7	0	5,65	1
44	1722255813	7/29/24 20:23	26,4	73,7	0	5,65	1
45	1722256000	7/29/24 20:26	26,4	73,5	0	5,65	0
46	1722256187	7/29/24 20:29	26,3	74,5	0	5,65	1
47	1722256375	7/29/24 20:32	26,3	74,3	0	4,48	1
48	1722256562	7/29/24 20:36	26,3	74,5	0	5,65	1
49	1722256749	7/29/24 20:39	26,3	74,7	0	5,65	0
50	1722256936	7/29/24 20:42	26,3	75,2	0	5,65	0
51	1722257123	7/29/24 20:45	26,3	74,8	0	4,48	1
52	1722257311	7/29/24 20:48	26,3	75,1	0	5,65	1
53	1722257498	7/29/24 20:51	26,3	75,4	0	5,65	1
54	1722257685	7/29/24 20:54	26,3	75,7	0	5,65	0
55	1722257872	7/29/24 20:57	26,3	75,7	0	5,65	0
56	1722258059	7/29/24 21:00	26,3	75,9	0	5,65	0
57	1722258247	7/29/24 21:04	26,2	75,9	0	5,65	0
58	1722258434	7/29/24 21:07	26,2	74,9	0	5,65	1
59	1722258621	7/29/24 21:10	26,3	74,9	0	5,65	1
60	1722258808	7/29/24 21:13	26,3	75,2	0	5,65	0
61	1722258995	7/29/24 21:16	26,2	75,4	0	5,65	0
62	1722259183	7/29/24 21:19	26,3	75,2	0	5,65	0
63	1722259370	7/29/24 21:22	26,3	75,3	0	5,65	1
64	1722259557	7/29/24 21:25	26,3	75,5	0	5,65	0
65	1722259744	7/29/24 21:29	26,2	76	0	5,65	0
66	1722259931	7/29/24 21:32	26,2	76	0	4,48	1
67	1722260118	7/29/24 21:35	26,2	76,1	0	5,65	1
68	1722260306	7/29/24 21:38	26,2	76,4	0	5,65	1
69	1722260493	7/29/24 21:41	26,2	76,4	0	5,65	1
70	1722260680	7/29/24 21:44	26,2	76,6	0	5,65	1

Dst...

Lampiran 8. Program

1. Arduino Uno

```

#include <SoftwareSerial.h>
#include <SD_ZH03B.h>

// Pin sensor kecepatan angin
const int WindPin = 2;
unsigned int counterAngin = 0;
unsigned long waktu = 5; // Interval pengukuran dalam detik
unsigned long mil = 1;
float pengukuranAngin = 0;

// Sensor debu ZH03B
#define RX_PIN 10
#define TX_PIN 11
SoftwareSerial ZHSerial(RX_PIN, TX_PIN);
SD_ZH03B ZH03B(ZHSerial, SD_ZH03B::SENSOR_ZH03B);

// Pin analog untuk sensor tambahan
const int analogPin = A0;

void setup() {
  Serial.begin(9600);

  // Setup ZH03B
  ZHSerial.begin(9600);
  ZH03B.setMode(SD_ZH03B::IU_MODE);

  // Setup sensor kecepatan angin
  pinMode(WindPin, INPUT_PULLUP);
  attachInterrupt(digitalPinToInterrupt(WindPin), count, CHANGE);
}

void loop() {
  // Cek apakah ada data yang tersedia di port serial
  if (Serial.available() > 0) {
    char request = Serial.read();
    if (request == 'R') { // 'R' adalah kode permintaan untuk semua data sensor
      // Baca data kecepatan angin
      float windSpeed = readWindSpeedData();
      // Baca data sensor debu
      int dust = readDustSensorData();
      // Baca data SO2
      float so2 = readSO2Data();

      // Kirim semua data sensor secara berurutan tanpa label
      Serial.print(windSpeed);
      Serial.print(",");
      Serial.print(dust);
    }
  }
}

```

```

        Serial.print(",");
        Serial.println(so2); // Cetak data SO2 di baris baru
    }
}

// Tambahkan delay atau pengaturan lain sesuai kebutuhan
delay(100);
}

void count() {
    counterAngin++;
}

float readWindSpeedData() {
    unsigned long timer = millis() / 1000;

    if (timer >= mil * waktu) {
        // Mengasumsikan counterAngin menghitung jumlah putaran
        // Konversi ke kecepatan angin (modifikasi formula sesuai dengan
        spesifikasi sensor Anda)
        pengukuranAngin = ((2 * 3.14 * 0.089) * (counterAngin / 36.0)) - 1.3; //
        Sesuaikan nilai ini berdasarkan karakteristik sensor
        if (pengukuranAngin < 0) {
            pengukuranAngin = 0;
        }
        mil++;
        counterAngin = 0;
    }

    return pengukuranAngin;
}

int readDustSensorData() {
    const int retryLimit = 5;
    int pm2_5 = -1;

    for (int attempt = 0; attempt < retryLimit; attempt++) {
        if (ZH03B.readData()) {
            pm2_5 = ZH03B.getPM2_5();
            break;
        } else {
            delay(100); // Tunggu sebentar sebelum mencoba membaca lagi
        }
    }

    if (pm2_5 == -1) {
        return 0; // Kembalikan 0 jika tidak dapat membaca data
    } else {
        return pm2_5;
    }
}

```

```

}

float readSO2Data() {
  const int MQ136_SENSOR = A0;
  float RS_gas = 0;
  float ratio = 0;

  int val = analogRead(MQ136_SENSOR);
  RS_gas = (float)(1023 - val) / val;

  // Gunakan kurva kalibrasi baru untuk menghitung konsentrasi SO2
  const float slope = -0.237;
  const float intercept = 0.091;

  ratio = RS_gas / 10; // 1 adalah nilai referensi resistansi dalam udara bersih

  // Hitung ppm menggunakan persamaan kalibrasi yang diperoleh
  float ppmSO2 = pow(10, (log10(ratio) - intercept) / slope);

  // Konversi ppm ke µg/m³
  // Misalnya, faktor konversi 2.62075 (periksa literatur untuk faktor yang tepat)
  float faktorKonversi = 2620.75; // Sesuaikan dengan data yang relevan
  float um_per_m3 = ppmSO2 * faktorKonversi;

  return um_per_m3;
}

```

2. Website

- Indeks.htm

```

• <!DOCTYPE html>
• <html lang="en">
•
• <head>
•
•   <meta charset="utf-8">
•   <meta http-equiv="X-UA-Compatible" content="IE=edge">
•   <meta name="viewport" content="width=device-width,
initial-scale=1, shrink-to-fit=no">
•   <meta name="description" content="">
•   <meta name="author" content="">
•
•   <title>Monitoring Gua</title>
•   <link rel="icon" href="Logo-Resmi-Unhas-1.png"
type="image/png" wide="40px" height="70px" >
•

```

```

• <!-- Custom fonts for this template-->
• <link href="vendor/fontawesome-free/css/all.min.css"
rel="stylesheet" type="text/css">
• <link
•
href="https://fonts.googleapis.com/css?family=Nunito:200,200i
,300,300i,400,400i,600,600i,700,700i,800,800i,900,900i"
• rel="stylesheet">
•
• <!-- Custom styles for this template-->
• <link href="css/sb-admin-2.min.css" rel="stylesheet">
• <script
src="https://www.gstatic.com/firebasejs/9.0.2/firebase-
app.js"></script>
• <script
src="https://www.gstatic.com/firebasejs/9.0.2/firebase-
database.js"></script>
•
•
• <!-- the scripts for products you want to access must be
added-->
•
• <!-- the scripts for products you want to access must be
added-->
•
• <script
src="https://www.gstatic.com/firebasejs/10.4.0/firebase-app-
compat.js"></script>
•
• <script
src="https://www.gstatic.com/firebasejs/10.4.0/firebase-
database-compat.js"></script>
•
• <script type="module">
• // Import the functions you need from the SDKs you need
• import { initializeApp } from
"https://www.gstatic.com/firebasejs/10.12.2/firebase-app.js";
• // TODO: Add SDKs for Firebase products that you want to
use

```

```
• // https://firebase.google.com/docs/web/setup#available-  
libraries  
•  
• // Your web app's Firebase configuration here (Do not  
use the existing configuration)  
• const firebaseConfig = {  
•   apiKey: "AIzaSyC2kc1tevYCUdMkGoEdFntwJLyl_x0wb74",  
•   authDomain: "monitoring-gua-iot.firebaseio.com",  
•   databaseURL: "https://monitoring-gua-iot-default-  
rtbd.asia-southeast1.firebaseio.com",  
•   projectId: "monitoring-gua-iot",  
•   storageBucket: "monitoring-gua-iot.appspot.com",  
•   messagingSenderId: "625337493735",  
•   appId:  
"1:625337493735:web:476fb73f75e5af471a9a42",  
•   measurementId: "G-W71N4DVCNE"  
• };  
•  
•  
• // Inisialisasi Firebase  
• firebase.initializeApp(firebaseConfig);  
•  
• // Mendapatkan referensi ke database  
• var database = firebase.database();  
•  
• // Mendapatkan referensi ke simpul loraData  
• var loraDataRef = database.ref('loraData');  
•  
• // Mendengarkan event child_added untuk mendapatkan data baru  
yang masuk  
• loraDataRef.on('child_added', function(snapshot) {  
•   // snapshot.val() akan berisi data dari simpul yang baru  
ditambahkan  
•   var newData = snapshot.val();  
•  
•   // Mendapatkan nilai dari setiap properti dalam data baru  
•   var suhu = newData.suhu;  
•   var kelembapan = newData.kelembapan;  
•   var kecepatanAngin = newData.kecepatanAngin;  
•   var SO2 = newData.SO2;
```



```

•     var PM2_5 = newData.PM2_5;
•
•     // Memperbarui elemen HTML dengan data yang didapatkan
•     document.getElementById('suhu').innerHTML = suhu +
"    &#8451;";
•     document.getElementById('kelembapan').innerHTML =
kelembapan + "%";
•     document.getElementById('Angin').innerHTML =
kecepatanAngin + "m/s";
•     document.getElementById('so2').innerHTML = SO2 + "ug/m3";
•     document.getElementById('debu').innerHTML = PM2_5 +
"ug/m3";
• });
• </script>
• </script>
•
• </head>
•
• <body id="page-top">
•
•     <!-- Page Wrapper -->
•     <div id="wrapper">
•
•         <!-- Sidebar -->
•         <ul class="navbar-nav bg-gradient-primary sidebar
sidebar-dark accordion" id="accordionSidebar">
•
•             <!-- Sidebar - Brand -->
•             <a class="sidebar-brand d-flex align-items-
center justify-content-center">
•                 <div class="wrapper">
•                     </i>
•                 </div>
•             </a>
•
•             <!-- Divider -->
•             <hr class="sidebar-divider my-0">
•
•             <!-- Nav Item - Dashboard -->

```

```

•     <li class="nav-item active">
•         <a class="nav-link" href="index.html">
•             <i class="fas fa-fw fa-tachometer-
alt"></i>
•
•             <span>Dashboard</span></a>
•
•         </li>
•
•         <!-- Divider -->
•         <hr class="sidebar-divider d-none d-md-block">
•
•         <!-- Nav Item - Charts -->
•         <li class="nav-item">
•             <a class="nav-link" href="charts.html">
•                 <i class="fas fa-fw fa-chart-area"></i>
•
•                 <span>Grafik</span></a>
•
•             </li>
•
•             <!-- Divider -->
•             <hr class="sidebar-divider d-none d-md-block">
•
•
•             <!-- Nav Item - Tables -->
•             <li class="nav-item">
•                 <a class="nav-link" href="tables.html">
•                     <i class="fas fa-fw fa-table"></i>
•
•                     <span>Tabel</span></a>
•
•                 </li>
•
•                 <!-- Divider -->
•                 <hr class="sidebar-divider d-none d-md-
block">
•
•             </body>
•
• </html>

```