LAMPIRAN

Lampiran 1. Koding Program Arduino IDE

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <MPU6050_tockn.h>

// Inisialisasi sensor MPU6050
MPU6050 mpu(Wire);

// Inisialisasi LCD (alamat biasanya 0x27 atau 0x3F)
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Pin buzzer
const int buzzerPin = 8;

// Faktor kalibrasi (offset)
float pitchOffset = +2.0;   // Koreksi Pitch
float rollOffset  = -1.0;   // Koreksi Roll

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

  // Inisialisasi LCD
  lcd.init();
  lcd.backlight();

  // Inisialisasi buzzer
```

```
  pinMode(buzzerPin, OUTPUT);

  // Jalankan animasi loading screen + bunyi
  showLoadingScreen();

  // Jalankan kalibrasi sensor
  kalibrasiSensor();

  // Tampilkan header
  showHeader();
}

void loop() {
  mpu.update(); // Update data dari MPU6050

  // Baca sudut dari sensor dan terapkan koreksi
  float pitch = mpu.getAccAngleX() + pitchOffset;
  float roll  = mpu.getAccAngleY() + rollOffset;

  // Bersihkan layar
  lcd.clear();

  // Jika hampir datar
  if (abs(pitch) < 1 && abs(roll) < 1) {
    lcd.setCursor(0, 0);
    lcd.print("Posisi Stabil!");

    lcd.setCursor(0, 1);
```

```
      lcd.print("Pitch: 0 Roll: 0");

      // Bunyi dua kali pendek jika stabil
      playStableBeep();
    } else {
      // Petunjuk arah pitch
      char dirPitch[2];
      if (pitch > 1) strcpy(dirPitch, "^");
      else if (pitch < -1) strcpy(dirPitch, "v");
      else strcpy(dirPitch, "-");

      // Petunjuk arah roll
      char dirRoll[2];
      if (roll > 1) strcpy(dirRoll, ">");
      else if (roll < -1) strcpy(dirRoll, "<");
      else strcpy(dirRoll, "-");

      // Tampilkan hasil
      lcd.setCursor(0, 0);
      lcd.print("Pitch:");
      lcd.print((int)pitch);
      lcd.print(" ");
      lcd.print(dirPitch);

      lcd.setCursor(0, 1);
      lcd.print("Roll :");
      lcd.print((int)roll);
      lcd.print(" ");
```

```
    lcd.print(dirRoll);
  }

  delay(200);
}
void showLoadingScreen() {
  digitalWrite(buzzerPin, HIGH);
  delay(100);
  digitalWrite(buzzerPin, LOW);

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Memulai...");

  for (int i = 0; i <= 100; i += 10) {
    int barLength = map(i, 0, 100, 0, 16);
    lcd.setCursor(0, 1);
    lcd.print("[");

    for (int j = 0; j < barLength; j++) {
      lcd.print("#");
    }
    for (int j = 0; j < 16 - barLength; j++) {
      lcd.print(".");
    }
    lcd.print("] ");
    lcd.print(i);
    lcd.print("%");
```

```
    delay(150);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Memulai...");
  }

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Sensor Siap!");

  // Bunyi panjang sebentar
  tone(buzzerPin, 1000);
  delay(400);
  noTone(buzzerPin);

  delay(1000);
  lcd.clear();
}
void kalibrasiSensor() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Kalibrasi");
  lcd.setCursor(0, 1);
  lcd.print("Mohon Tunggu...");

  delay(1000);
```

```
  mpu.begin();
  for (int i = 0; i <= 100; i += 10) {
    lcd.setCursor(0, 1);
    lcd.print("Progress: ");
    lcd.setCursor(11, 1);
    lcd.print(i);
    lcd.print("%");
    delay(300);
  }

  mpu.calcGyroOffsets(); // Kalibrasi akhir

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Kalibrasi");
  lcd.setCursor(0, 1);
  lcd.print("Selesai!");

  // Bunyi konfirmasi kalibrasi selesai
  tone(buzzerPin, 1200);
  delay(300);
  noTone(buzzerPin);

  delay(1000);
  lcd.clear();
}
void showHeader() {
  lcd.clear();
```

```
  lcd.setCursor(0, 0);
  lcd.print("Instrumen");
  lcd.setCursor(0, 1);
  lcd.print("Kemiringan v1.1");

  // Bunyi saat header tampil
  tone(buzzerPin, 800);
  delay(100);
  noTone(buzzerPin);

  delay(2000);
  lcd.clear();
}
void playStableBeep() {
  tone(buzzerPin, 1000); // Frekuensi 1kHz
  delay(100);
  noTone(buzzerPin);
  delay(50);
  tone(buzzerPin, 1000);
  delay(100);
  noTone(buzzerPin);
}
```

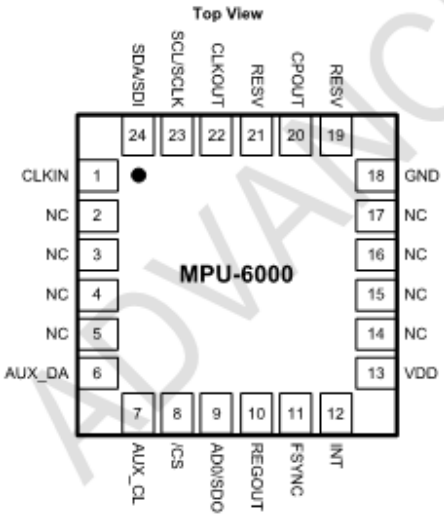
Lampiran 2 Datasheet MPU6050 (GY521)

7 Applications Information

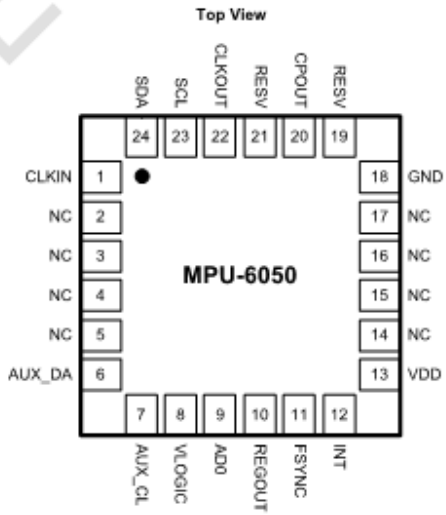
7.1 Pin Out and Signal Description

Pin Number	MPU-6000	MPU-6050	Pin Name	Pin Description
1	Y	Y	CLKIN	Optional external reference clock input. Connect to GND if unused.
6	Y	Y	AUX_DA	I^2C master serial data, for connecting to external sensors
7	Y	Y	AUX_CL	I^2C Master serial clock, for connecting to external sensors
8	Y		/CS	SPI chip select (0=SPI mode)
8		Y	VLOGIC	Digital I/O supply voltage
9	Y		AD0 / SDO	I^2C Slave Address LSB (AD0); SPI serial data output (SDO)
9		Y	AD0	I^2C Slave Address LSB (AD0)
10	Y	Y	REGOUT	Regulator filter capacitor connection
11	Y	Y	FSYNC	Frame synchronization digital input. Connect to GND if unused.
12	Y	Y	INT	Interrupt digital output (totem pole or open-drain)
13	Y	Y	VDD	Power supply voltage and Digital I/O supply voltage
18	Y	Y	GND	Power supply ground
19, 21	Y	Y	RESV	Reserved. Do not connect.
20	Y	Y	CPOUT	Charge pump capacitor connection
22	Y	Y	CLKOUT	System clock output
23	Y		SCL / SCLK	I^2C serial clock (SCL); SPI serial clock (SCLK)
23		Y	SCL	I^2C serial clock (SCL)
24	Y		SDA / SDI	I^2C serial data (SDA); SPI serial data input (SDI)
24		Y	SDA	I^2C serial data (SDA)
2, 3, 4, 5, 14, 15, 16, 17	Y	Y	NC	Not internally connected. May be used for PCB trace routing.

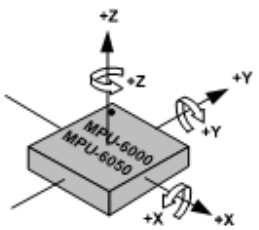
ADVANCE INFO



QFN Package
24-pin, 4mm x 4mm x 0.9mm



QFN Package
24-pin, 4mm x 4mm x 0.9mm



Orientation of Axes of Sensitivity and Polarity of Rotation

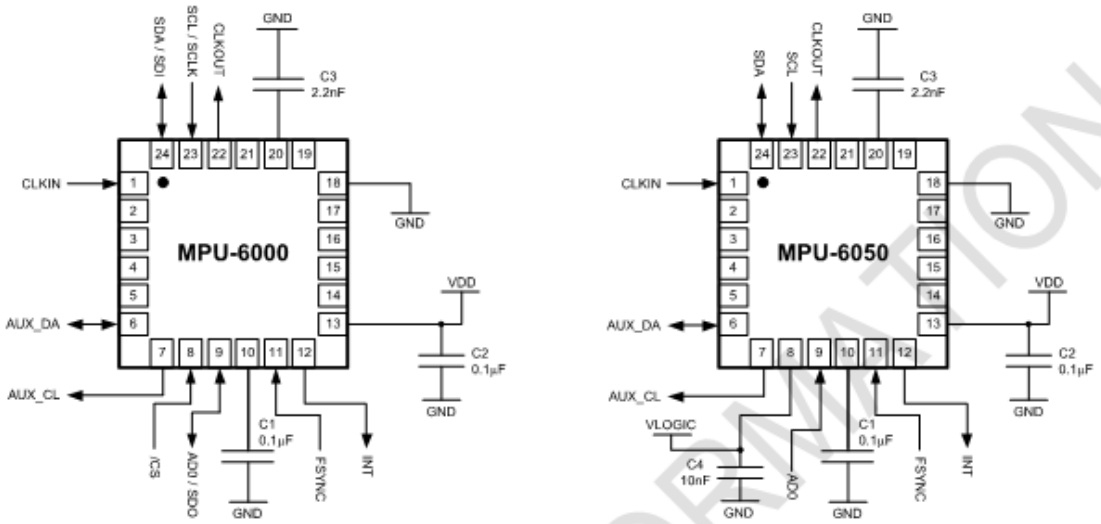
6.9 Absolute Maximum Ratings

Stress above those listed as "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to the absolute maximum ratings conditions for extended periods may affect device reliability.

Parameter	Rating
Supply Voltage, VDD	-0.5V to +6V
VLOGIC Input Voltage Level (MPU-6050)	-0.5V to VDD + 0.5V
REGOUT	-0.5V to 2V
Input Voltage Level (CLKIN, AUX_DA, AD0, FSYNC, INT, SCL, SDA)	-0.5V to VDD + 0.5V
CPOUT (2.5V ≤ VDD ≤ 3.6V)	-0.5V to 30V
Acceleration (Any Axis, unpowered)	10,000g for 0.2ms
Operating Temperature Range	-40°C to +105°C
Storage Temperature Range	-40°C to +125°C
Electrostatic Discharge (ESD) Protection	2kV (HBM); 200V (MM)
Latch-up	JEDEC Class II (2),125°C ±100mA

ADVANCE INFORMATION

7.2 Typical Operating Circuit



Typical Operating Circuits

7.3 Bill of Materials for External Components

Component	Label	Specification	Quantity
Regulator Filter Capacitor (Pin 10)	C1	Ceramic, X7R, 0.1µF ±10%, 2V	1
VDD Bypass Capacitor (Pin 13)	C2	Ceramic, X7R, 0.1µF ±10%, 4V	1
Charge Pump Capacitor (Pin 20)	C3	Ceramic, X7R, 2.2nF ±10%, 50V	1
VLOGIC Bypass Capacitor (Pin 8)	C4*	Ceramic, X7R, 10nF ±10%, 4V	1

* MPU-6050 Only.

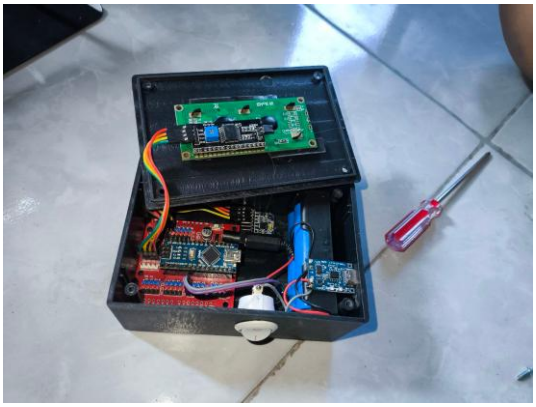
ADVANCE INFORMATION

Lampiran 3 Dokumentasi

PROSES PERAKITAN ALAT

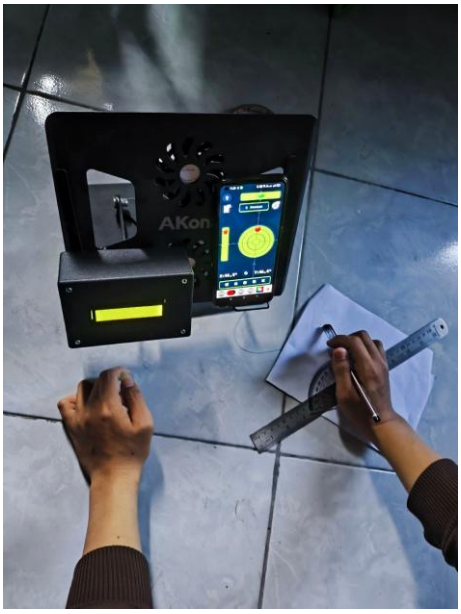








PENGUJIAN ALAT VS SMARTPHONE







PENGUJIAN KEMIRINGAN BERBASIS GEOMETRIK







PENGUJIAN LAPANGAN





