SAFE HOME: Solar-Powered Fire, Smoke, and Smart Irrigation System

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***Abstract*—This project presents a Solar-Powered Smart Home Safety and Automation System using Arduino. The system operates on renewable energy through a solar panel and solar charge controller, ensuring energy efficiency and eco-friendly operation. It integrates multiple sensors, including an IR sensor for automatic fan and light control, an MQ2 sensor for fire and smoke detection, an HC-SR04 ultrasonic sensor for intruder detection, and a soil moisture sensor for automatic plant watering. The system also provides manual switches for fan and light control, allowing both automatic and manual operation. When motion is detected, lights and fan activate automatically, while gas, fire, or smoke triggers a buzzer alert and warning messages on a 16x2 I2C LCD. The soil moisture sensor automatically activates a water pump when the soil becomes dry. This project combines solar power, home automation, safety, and smart irrigation, creating an energy-efficient, sustainable, and self-sustaining smart home solution.**

I. Project Overview

The SAFE HOME project is a hybrid-powered smart automation system that enhances home safety and energy efficiency. It runs on both solar energy and a rechargeable battery, ensuring continuous operation even without sunlight. The system uses an Arduino UNO to control sensors for fire, smoke, motion, and soil moisture, along with actuators such as fans, lights, buzzers, and a water pump. By combining renewable energy with sensor-based automation, it provides an affordable and sustainable smart home solution.

II. System Components

A. Hardware Components

1. **Solar Panel (5V – 150mA):** Provides renewable power for the entire system.

Fig. 1: Solar Panel.

2. **Solar Controller:** Regulates voltage and current from the solar panel to charge the battery safely.

Fig. 2: Solar Controller.

3. **Rechargeable Battery:** Stores solar energy for continuous operation.

Fig. 3: Rechargeable Battery.

4. **Arduino UNO:** Central control unit for sensor data

processing and automation.

Fig. 4: Arduino UNO.

5. **16x2 I2C LCD Display:** Displays live sensor data and alerts.

Fig. 5: 16x2 I2C LCD Module.

6. **Mini DC Fan:** Activates automatically based on motion or temperature.

Fig. 6: Mini DC Fan.

7. **MQ-2 Smoke Sensor:** Detects harmful smoke or gas levels.

Fig. 7: MQ-2 Gas Sensor.

8. **Flame Sensor:** Detects fire presence and triggers immediate alarm.

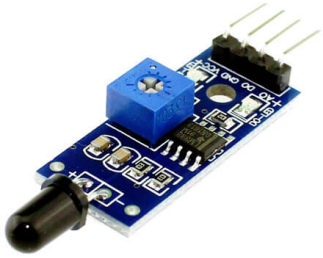

Fig. 8: Flame Sensor.

9. **Buzzer and Relay Module:** Used for audible alerts and device switching.

Fig. 9: Buzzer.

10. **Soil Moisture Sensor:** Detects the humidity level of soil and activates automatic watering.

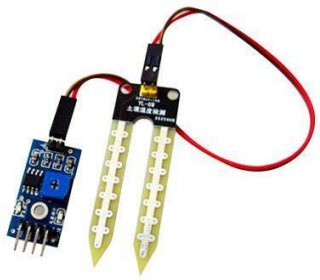

Fig. 10: Soil Moisture Sensor.

11. **Mini Water Pump:** Controlled by relay to irrigate plants when soil is dry.

Fig. 11: Mini Water Pump for Automatic Plant Watering.

B. Software Components

- Arduino IDE for coding and testing.
- Serial Monitor for debugging and calibration.

III. Working Principle

The SAFE HOME system functions as an integrated smart network powered by solar energy. The solar panel charges the battery through a solar charge controller, providing uninterrupted DC power to the Arduino and all components.

The Arduino UNO serves as the central hub, processing input signals from multiple sensors and controlling actuators (fan, light, buzzer, pump) based on specific conditions.

- **IR Sensor:** Detects human motion and activates the fan and light automatically.
- **Flame Sensor:** Detects infrared radiation from flames, triggering alarms and LCD warnings.
- **MQ-2 Gas Sensor:** Monitors air quality; when gas or smoke exceeds thresholds, it alerts the user.
- **Ultrasonic Sensor:** Measures distance and detects intrusions; if an object enters the threshold range, an intruder alert is activated.
- **Soil Moisture Sensor & Water Pump:** Continuously measures soil moisture via an analog signal. When the reading exceeds the dry threshold, the Arduino turns ON the water pump (through relay). Once soil moisture rises above the wet threshold, the pump turns OFF automatically — maintaining optimal soil hydration without human intervention.
- **LCD Display:** Displays all sensor readings, alerts, and system states in real-time.
- **Buzzer & Relay:** Provide alarms and control electrical devices as required.

Together, these components create a responsive and efficient home automation environment that manages fire safety, intrusion, and smart irrigation — all powered by renewable energy.

IV. Features

- **Hybrid Power:** Operates on solar energy with a rechargeable battery for backup.
- **Fire and Smoke Detection:** MQ-2 and flame sensors trigger alarms and LCD alerts.
- **Intruder Detection:** Ultrasonic sensor detects unauthorized movement.
- **Smart Irrigation:** Soil moisture sensor and relay-controlled pump automate watering to prevent over- or under-irrigation.
- **Automatic Fan and Light:** IR sensor activates them based on human presence.
- **LCD and Buzzer Alerts:** Real-time status and warnings displayed with audible alerts.
- **Manual Override:** Fan, light, and pump can be manually controlled if needed.
- **Energy Efficient:** Reduces grid power use through solar charging and automation.

V. Arduino Implementation

A. Main SAFE HOME System

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);

const int flamePin = 8, gasPin = A0, irPin = 2;
const int trigPin = 3, echoPin = 4, buzzerPin = 9;
const int fanRelayPin = 10, ledPin = 11;
const int smokeThreshold = 130, distanceThreshold = 50;

void setup() {
  Serial.begin(9600);
  lcd.init(); lcd.backlight();
  lcd.print(" Smart Solar Home ");
  delay(2000); lcd.clear();

  pinMode(flamePin, INPUT); pinMode(gasPin, INPUT);
  pinMode(irPin, INPUT); pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT); pinMode(buzzerPin, OUTPUT);
  pinMode(fanRelayPin, OUTPUT); pinMode(ledPin, OUTPUT);
}

void loop() {
  int flame = digitalRead(flamePin);
  int ir = digitalRead(irPin);
  int gas = analogRead(gasPin);

  digitalWrite(trigPin, LOW); delayMicroseconds(2);
  digitalWrite(trigPin, HIGH); delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  long duration = pulseIn(echoPin, HIGH);
  int dist = duration * 0.034 / 2;
```

```
  bool alert = false;
  String msg = "All Safe";

  if (flame == LOW) { msg="Fire ALERT!"; tone(buzzerPin
      ,1000); alert=true; }
  else if (gas > smokeThreshold + 100) { msg="Gas Leak!";
      tone(buzzerPin,900); alert=true; }
  else if (dist < distanceThreshold && dist > 0) { msg="
      Intruder!"; tone(buzzerPin,1200); alert=true; }
  else noTone(buzzerPin);

  digitalWrite(fanRelayPin, (ir || alert));
  digitalWrite(ledPin, (ir || alert));

  lcd.setCursor(0,0); lcd.print("G:"); lcd.print(gas); lcd.
      print(" D:"); lcd.print(dist);
  lcd.setCursor(0,1); lcd.print(msg);
  delay(700);
}
```

Listing 1: Arduino Code for SAFE HOME System

B. Automatic Plant Watering System (Soil Moisture Sensor)

```
const int sensorPin = A0;   // Soil probe analog pin
const int relayPin  = 7;    // Relay control pin
int sensorValue = 0;

// Threshold values
const int dryThreshold  = 200;  // Dry soil
const int wetThreshold  = 50;   // Wet soil

void setup() {
  Serial.begin(9600);
  pinMode(relayPin, OUTPUT);
  digitalWrite(relayPin, HIGH);  // Relay OFF initially
}

void loop() {
  sensorValue = analogRead(sensorPin);
  Serial.print("Soil Moisture: ");
  Serial.println(sensorValue);

  if (sensorValue > dryThreshold) {
    digitalWrite(relayPin, LOW);   // Turn ON pump
    Serial.println("Soil Dry > Pump ON");
  }
  else if (sensorValue < wetThreshold) {
    digitalWrite(relayPin, HIGH);  // Turn OFF pump
    Serial.println("Soil Wet > Pump OFF");
  }
  delay(1000);
}
```

Listing 2: Arduino Code for Soil Moisture and Water Pump Control

VI. Future Scope

- Integration of Wi-Fi or Bluetooth for IoT-based monitoring.
- Mobile app or voice control for remote access.
- Cloud data logging for sensor analytics.
- AI-based adaptive control for better decision-making.
- Scalable design for farms, offices, or community use.

VII. Conclusion

The enhanced SAFE HOME system now integrates fire, smoke, motion, and soil moisture sensing — achieving full smart home functionality with renewable energy. It demonstrates how automation and sustainability can coexist, ensuring safety, comfort, and eco-friendliness in modern living.

VIII. References

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