CHAPTER THREE

SYSTEM DESIGN AND IMPLEMENTATION
3.1 General description of system

According to our work there are two main scenarios in firefighting system in gas complex.

- Gas leakage scenario
  When gas leakage is detected the controller turn off the gas valve, set alarm and send message to the web server to show that their a problem accrued.

- Fire scenario
  Four flame sensor is used to cover the area .In this scenario the controller turn off the power from the complex , turn off the gas valve , turn on the water pump , set alarm and send message to the web server that shows the exact location of the fire to the civilian defense unit. The block diagram below illustrate how the system works.

![Diagram](image)

Figure 3-1 System Block Diagram

**Detection:**

In detection two types of sensors are used the first one is IR flame sensor and it is used to detect fire (as it mentioned in chapter two the best flame sensor available is UV/IR sensor but in this project IR sensor is used because of the cost).
The second type is MQ2 gas sensor and it can detect the leakage of the gas in the area.

**Controller:**

The unit used as the main controller is Arduino LinkIt ONE.

**The actions:**

The output actions depends on the kind of the detected problem.

**Upload to the web server:**

All data that come out from the controller will be uploaded to the web server.
3.1.1 Gas Complex Location

The real location of the gas complex is at southern Khartoum, the area cover 815 square meter, figure 3-3 shows the complex location as seen in WikiMapia.

3.2 Hardware Design

Hardware design contain many part as below:

3.2.1 Main Controller
All smart implementation have chip or circuit serve as processor at this implementation we use Arduino Linkit ONE chip.

Figure 3-4 the pin-out configuration of LinkIt ONE source [9]

**Programming of actual Arduino**

The chip can be easily programmed by uploading the code from PC by using USB cable to the flash memory of the chip.

The Arduino linkit one can be programmed with the Arduino software (download). Select "Arduino linkit one from the Tools > Board menu (according to the microcontroller on your board).
The MT2502A (Aster) on the Arduino LinkIt One comes preburned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header.

The MT2502A (Aster) firmware source code is available. LinkIt ONE SDK is released as a plug-in for Arduino IDE. The APIs in the SDK provide access to all the connectivity functions provided by LinkIt ONE development platform in addition to core Arduino functions, such as the ability to control digital pins and parse analog sensor inputs. This enables you to build prototypes and demonstrations of connected wearable and IoT devices quickly and easily. As shown in Figure 2, using the LinkIt ONE SDK you create an Arduino Sketch to make use of the LinkIt ONE APIs. These APIs execute over the run-time environment to enable you to access the features of the LinkIt ONE development board.

Figure 3-5 the architecture of the LinkIt ONE development platform source [9]
3.2.2 Sensors

This section describes in detail the types of sensors used in this work.

3.2.2.1 Flame Sensor

The system depends on discovering fire using flame sensor module. The flame sensor used in this work is Grove-Flame Sensor. It can be used to detect fire source or other light sources of the wavelength in the range of 760nm - 1100 nm. It is based on the YG1006 sensor which is a high speed and high sensitive NPN silicon phototransistor. Due to its black epoxy, the sensor is sensitive to infrared radiation. In firefighting system, the sensor plays a very important role, it can be used as an eyes to find the fire source.

![Flame Sensor]

Figure 3.6 flame sensor

Feature

- Grove Interface
- High Photo Sensitivity
- Fast Response Time
- Easy to use
- Sensitivity can adjustable

Table 3-1 shows the parameter used to connect the flame sensor to the main controller.

**Table 3-1 Flame sensor parameter**

<table>
<thead>
<tr>
<th>Arduino</th>
<th>Flame Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
<td>VCC</td>
</tr>
<tr>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>Digital D3</td>
<td>SIG</td>
</tr>
</tbody>
</table>

The module is mainly used to detect the infrared light. It outputs digital signal 0 and 1 through a Comparator output. The output value will be 0 when infrared light is detected. And the sensitivity is adjustable by the precision potentiometer.

When the output value is 0, the led will light up. Connect the module to the D3 using the 4-pin grove cable.

**3.2.2.2 Mq2 Gas Sensor**

The system depend on discover gas leakage to mq2 gas sensor module (MQ2) module is useful for gas leakage detecting (in home and industry). It can detect H2, LPG, CH4, CO, Alcohol. Based on its fast response time. Measurements can be taken as soon as possible. Also the
sensitivity can be adjusted by the potentiometer. Figure 3-7 below shows Mq2 gas sensor.

![MQ2 gas sensor](image)

**Figure 3-7 MQ2 gas sensor**

**Features**

- Wide detecting scope
- Stable and long life
- Fast response and High sensitivity

Grove products have aneco-system and all have a same connector. Connect this module to the D5, by jumper wires, Table 3-2 Shows the parameter that is used to connect the Mq2 Gas sensor to the main controller.

**Table 3-2 Mq2 Gas sensor parameter**

<table>
<thead>
<tr>
<th>Arduino</th>
<th>Gas Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
<td>VCC</td>
</tr>
<tr>
<td>GND</td>
<td>GND</td>
</tr>
</tbody>
</table>
You can gain the present voltage through the SIG pin of sensor. The higher the concentration of the gas, the bigger the output voltage of the SIG pin. Sensitivity can be regulated by rotating the potentiometer.

### 3.2.3 Servo Motor

The system depend on control the gas valve to servo motor. Servo motor is an actuator with a built-in feedback mechanism that responds to a control signal by moving to and holding a position, or by moving at a continuous speed. Figure 3-8 shows the principle of servo motor.

![Servo Motor Principle](image)

Unlike dc motors, servo motors can position the motor shaft at a specific position (angle) using control signal. The motor shaft will hold at this position as long as the control signal not changed. This is very useful for controlling the valve, unmanned airplanes control surface or any object that want it to move at certain angle and stay at its new position.
Servo motors may be classified according to size or torque that it can withstand into mini, standard and giant servos. Usually mini and standard size servo motors can be powered by Arduino directly with no need to external power supply or driver table 3-3 show the main differences between servo and dc motors.

Table 3-3 Compression between DC Motor and Servo Motor

<table>
<thead>
<tr>
<th>DC Motor</th>
<th>Servo Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion is continuous</td>
<td>Capable of holding a position</td>
</tr>
<tr>
<td>Speed controlled by applied voltage</td>
<td>Speed controlled by delay between position updates</td>
</tr>
<tr>
<td>Hybrid of motor and controller.</td>
<td>Hybrid of motor, gears and controller.</td>
</tr>
</tbody>
</table>

3.2.3.1 Internal component of Servo Motor

The internal components of servo motor are:

- Potentiometer
- Dc motor
- Gears train
- Drive shaft
- Control electronics
Figure 3-9 shows the internal component of servo motor.
3.2.3.2 Servo Motor Configuration

The Arduino software contains servo library, which make the programming procedure easier. These are the servo motor configuration to connect it to the main controller.

1. Connect the black wire from the servo to the Gnd pin on the Arduino
2. Connect the red wire from the servo to the +5V pin on the Arduino
3. Connect the third wire (usually orange or yellow) from the servo to a digital Pin on the Arduino

3.2.4 Wi-Fi antenna

LinkIt MT5931 Module is a low-cost and low-power consumption Wi-Fi Sip module. The module is targeted to mobile devices including smartphone, PDA, Wi-Fi phone, DSC, DVC which need small Wi-Fi module. The highly integrated module allows the usage of web browsing, VoIP application.

The wireless Sip module support IEEE 802.11b/g/n standard and it can provide up to 72Mbps (GI=400ns) for IEEE 802.11n, 54Mbps for IEEE 802.11g, 11Mbps for 802.11b to connect your wireless LAN

3.2.4.1 Connecting to the web using Wi-Fi
This section describes how to configure your LinkIt ONE development board and the code needed to connect to a Wi-Fi access points (AP) and retrieve the content of a web page.

**Hardware setup**

To prepare your LinkIt ONE development board, as shown in Figure 3-10, by attaching a Wi-Fi antenna to the antenna connector.

![Figure 3-10 The LinkIt ONE development board with a Wi-Fi antenna attached](source[9])

**Software setup**

This section describes the steps necessary to create the code to setup a Wi-Fi connection as well as retrieve web content.

*Include the Wi-Fi library* the Wi-Fi library should be included in the code, to do this, with Sketch active in Arduino IDE, on the Sketch menu point to Import Library and click LWiFi. The Wi-Fi headers are now included in your Sketch. In this guide LinkIt ONE is used as the Wi-Fi client, so keep the first 2 headers and remove the others.

```c
#include <LWiFi.h>
```
#include <LWiFiClient.h>

#include <LWiFiServer.h>

Ht-tight body or package with metal legs for the electrical connections as shown.

### 3.2.5 Relay Driver

Relays are components which allow a low-power circuit to switch a relatively high current on and off, or to control signals that must be electrically isolated from the controlling circuit itself. Newcomers to electronics sometimes want to use a relay for this type of application, but are unsure about the details of doing so. Here’s a quick rundown. To make a relay operate, you have to pass a suitable And holding current (DC) through its energizing coil. And generally relay coils are designed to operate from a particular supply voltage often 12V or 5V, in the case of many of the small relays used for electronics work. In each case the coil has a resistance which will draw the right pull-in and holding currents when it’s connected to that supply voltage. So the basic idea is to choose a relay with a coil designed to operate from the supply voltage you’re using for your control circuit (And with contacts capable of switching the currents you want to control), and then provide a suitable relay driver circuit so that your low-power circuitry can control the current through the relay’s coil. Typically this will be somewhere between 25mA and 70mA. Often your relay driver can be very simple, using little more than an NPN or PNP transistor to control the coil current. All your low-power circuitry has to do is provide enough base current to turn the transistor on and off, as you can see from diagrams A and B. In A, NPN transistor Q1 (say a BC337 or BC338) is
being used to control a relay (RLY1) with a 12V coil, operating from a +12V supply. Series base resistor R1 is used to set the base current for Q1, so that the transistor is driven into saturation (fully turned on) when the relay is to be energized. That way, the transistor will have minimal voltage drop, and hence dissipate very little power as well as delivering most of the 12V to the relay coil. How do you work out the value of R1? It’s not hard. Let’s say RLY1 needs 50mA of coil current to pull in and hold reliably, and has a resistance of 240Ω so it draws this current from 12V. Our BC337/338 transistor will need enough base current to make sure it remains saturated at this collector current level. To work this out, we simply make sure that the base current is greater than this collector current divided by the transistor’s minimum DC current gain hFE. So as the BC337/338 has a minimum hFE of 100 (at 100mA), we’d need to provide it with at least 50mA/100 = 0.5mA of base current. In practice, you’d give it roughly double this value, say 1mA of base current, just to make sure it does saturate. So if your control signal Vin was switching between 0V and +12V, you’d give R1 a value of say 11kΩ, to provide the 1mA of base current needed to turn on both Q1 and the relay. Figure 3-11 illustrate the relay controller circuit.
3.3 Web Server Configuration

To create a web server using Arduino, its code should be included within Arduino main code, when included it will generate a web page. The way to access the page is through its IP address, using typical web browser.

In this work the IP address is “192.168.43.119”.

Figure 3-11 the relay controller circuit.