Fire Alarm Smart System Technology (FASTech)

Sharifah Saon[1*], Amirrul Atiman[1] and Abd Kadir Mahamad[1]

[1]Faculty of Electrical and Electronic
Engineering,
Universiti Tun Hussein Onn Malaysia,
Batu Pahat, 86400, Johor,
MALAYSIA
sharifa@uthm.edu.my

1. Introduction

Fire alarm system is the most essential elements of building's safety systems. This is one of the protection systems that can be used to safe human life from the fire strikes in the building whether at home, warehouse, office or etc. Not only to save lives when fire strikes happen but, it is often regulate other systems in the building and able to save huge amounts of money by reducing damage to the building structures and the appliances. Besides that, fire alarm system also contribute in reducing environmental damage cause from fire accident. The first action toward halting a fire is identifying the incident properly, raise the occupant alarm and then notify the incident to professional's emergency response. This is often functioning of fire alarm system and fire detection. Several system types and option are available depend on the specific characteristics of the protected space.

The existing fire alarm system can be categories into two, which are conventional and addressable. Conventional fire alarms are ideal for small buildings such as individual offices, retail shop or residential [1]. The system activated automatically when smoke or heat are detected and warn people in the building. Almost all countries are using a set of conventional fire alarm control panels and detectors as fire alarm systems because it is economic compare to addressable fire alarm control panel. The traceable fire alarm system able to trace the exact location of a fire, detect multiple fires location that may occur simultaneously and can be used with conventional detectors without disrupting the other detectors operation. The traceable fire alarm system consists of a traceable fire alarm control panels based on the conventional fire alarm control panels and a traceable heat detector based on the rate-of-rise spot-type conventional heat detector.

Addressable fire alarms are necessary for large building such as complexes, campuses or government offices. Addressable fire alarm systems are typically more complex than conventional [2]. An addressable fire alarm system provides user with a device that initiates status consist with network system. Addressable fire alarm devices identifying the type and location of fire strikes. They are depending on the data communication path which interconnects the fire alarm devices. Addressable fire alarm meets the requirements for the electrical supervision of field devices and it provides the means of identifying the point in a building where the alarm has been initially activated [3]. This makes the system ideal for large buildings and particularly commercial premises for all countries.

However, data from "JBPM Statistik Bilangan Kematian Dan Kecederaan Dalam Kes Kebakaran Dan Menyelamat Tahun 2011 Hingga 2015" posted by Fire and Rescue Department of Malaysia, 20% - 50% from the total number of fire accident victims in 2011 to 2015 are deaths [5]. In normal condition, time taken to escape from the fire strikes in the building, are estimated more than 20 minutes [6],[7].

However, the time taken for the survivors to escape from the fire may be the cause of death, as the fire spreads very quick. People do not know the nearest and safe path of the targeted exits way. This may cause people using wrong exit path and the best escape opportunity can be easily lost [8]. Beside that the probability of victims to escape from this accident is low [6]. Therefore, this project was aimed the Fire Alarm Smart System Technology (FASTech) that intelligently guide user to escape from the building trough nearest exit.

FASTech is an Internet of Things (IoT)-based intelligent fire emergency response system that detects smoke from fire strikes and alarming the people in a building, notify victims about the fire accident occurred through smartphone, and light up the exit pathway navigators that able to navigate the people in the building escape through the nearest and safe exit path. This system automatically stores the information about the fire accident when a fire strikes happen in the building. The information consists of date, time and location of the incident which then can be stored in cloud storage service online, along with collaboration of fire department.

2. A Review of Fire Alarm Technology

Fire alarm systems detect and warn people when smoke or fire is present. Common fire alarm system will activated automatically when smoke detectors or heat detectors is activated [9][10]. Smoke detectors is activated when smoke is present and heat detectors is activated if the temperature increase more than normal condition. Standard fire alarm system are using motorized bell to alarm people inside the building [10].

Conventional fire alarm systems able to be set up in zones with each zone hardwired to control panel [10],[11]. Lamp on the fire alarm control panel is shows as a zones, the lamp will light up once fire strike occur. These systems are using bells, electronic sounders or other audible devices as a sounder to warn people. These systems are inexpensive and require significantly less labour to install.

Other technology is called addressable fire alarm systems, which use digital encoding and multiplex technology to more accurately identify alarm location and device conditions [9][11]. Each fire alarm device in a system is programmed with a unique address [9]. When the detectors active, the devices address shows up on the main control panel to telling exact location of the activated detectors [9].

Wireless fire alarm systems are managed in simple installation [10]. These systems installed with no hardwire between the panel and devices. This also means that the system is easy to install at anywhere without any disturbances. It is a simple concept, that provides many unique benefits with a full of analogue addressable fire alarm system [12]. Most of the wireless fire alarm device are integrated with the smoke detector, horn and build in battery as a set of devices [13].

While, intelligent fire alarm system use advance devices to detects fire or smoke and warn people as fast as possible. This system easy to install at the small building or large building and the cost is effective. Besides that, this system can identify the location of a fire and it is easy for maintenance. The design of intelligent system to monitoring the situation of fire and the leakage of housing is based on microcontroller and sensor. Once there is encounter dangerous, it trigger the alarm system, same as system for intelligent residential burglary, fire, gas leakage prevention function so that protect residences from the loss of life and property [14].

In order to solve the problem of complex cabling, missing in declaration and alarm of traditional fire alarm system, an intelligent fire alarm system based on global system for mobile communications (GSM) network is designed [15]. Besides that, an intelligent system can use general packet radio service (GPRS) to send notification to user. GPRS is for long-distance wireless communications. GSM and GPRS send short message service (SMS) as a fire strikes notification, to the user. Compared with traditional fire detection alarm system, the system saves a lot cost of hardware and improves the efficiency of the fire detection alarm [16].

Nevertheless, IoT technologies is an intelligent system that is combination of electronic devices and system that has internet connection, gave an excellent opportunity. The system called IoT, need cloud computing to store or control data. While, cloud computing is a platform to store and share data with has internet connection by using electronic devices [17]. The information in cloud can be accessed everywhere at any time. Besides that, cloud is a safe place to store data due to security protection. This is one of the technologies that enables elasticity and provide flexibility of system deployment, dynamic, auto-provisioning and cloud management [18][19].

3. Research Methodology

Developing of this intelligent fire alarm system is divided into four phases; which are, Phase 1: design system architecture, Phase 2: develop the hardware circuit, Phase 3: programming development and Phase 4: develop building prototype.

3.1 Phase I: Design System Architecture

Figure 1 shows the operation flow of the FASTech system. Once the smoke detector triggered by the fire smokes, information automatically sends to the mobile phone application, showing location of fire. At the same time, the LED strip indicators that placed on the pathways of the building, automatically lighted up showing the safe and nearest escape and the buzzer was turn on. As an example, the fire strikes occurs at level 2 on left side of the building, the LED strip indicator lighted up the pathway toward exit path to nearest door at right side of building for level 2 and both side door for level 1 and ground level.

On the other hands, the fire incident information is recorded. The recorded data are the information of date, time, level of the floor and the location of the fire incident occurs. This data captured and recorded on the Blynk cloud. The data can be view at the smartphone Blynk application.

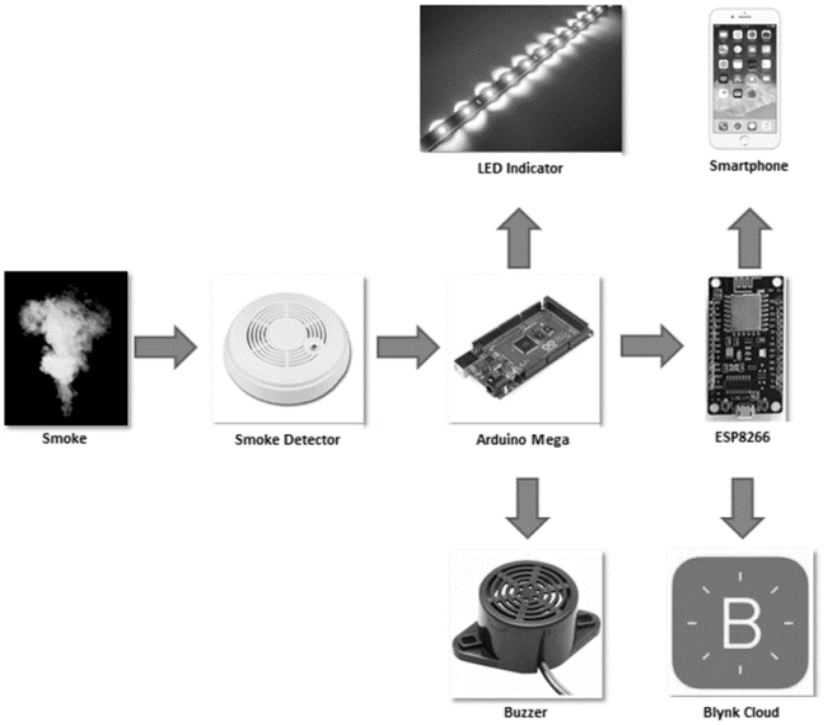


Fig. 1 - Diagram of the system

3.2 Phase II: Develop the Hardware Circuit

The main circuit of this project are power supply circuit, backup power supply circuit, LED controller circuit and buzzer controller circuit. Proteus 8 was used for the circuit simulation. Once the circuit was successful developed and tested on Proteus 8, circuit was printed on the transparent paper thus can be transferred on PCB board. UV light was used in order to transfer the printed circuit to the PCB board. Next, PCB board was placed to the developing machine to remove the dry film that not exposed to UV light. The process was continued with etching process for corrosive layer of cooper PCB which is not needed throughout the chemical process. Then PCB board was placed to the stripping machine for removal all dry film and then get the desired layout circuit. Once the process of the desired circuit layout on the PCB board was completed, components were soldered on the board properly to ensure the functionality of the circuit.

3.3 Phase III: Programming Development

Arduino are used for developing the program of FASTech system. The generated program is uploaded to the Arduino Mega 2560 board and ESP8266 NodeMCU module. Arduino Mega Board 2560 is used to control the whole system and ESP9266 is used to send data to the Blynk application.

Arduino Mega 2560 program is the main program of the FASTech system. In this program, 27 pins was declared and used as an input/output; which are 6 pins for input and 21 pins for output. The input pins A0 until A5 are used for smoke detectors. The digital output pins 30 until 43 and pin 50 are used for LED strips and buzzer. The others output pins are pins 44 until 49 used to send signal to ESP8266 NodeMCU module.

Program for ESP8266 NodeMCU module is setup to connect the system with the Wi-Fi and send notification to victims through smartphone. Besides that, ESP8266 was send data to Blynk apps for recorded on the database. Figure 2 shows the command to connect the ESP8266 with Wi-Fi. Character for SSID and PASS is important to allow ESP8266 connected with the Wi-Fi.

```
char auth[] = "6c5860987c644b6ca92ca673f7d2db16";
char ssid[] = "DiGi_Internet_00F5";
char pass[] = "digiwifi1234";
SimpleTimer timer;
```

Fig. 2 - Command to connect ESP8266 with Wi-Fi

3.4 Phase IV: Develop Building Prototype

There are three level of building prototype, which are ground level (GL), level 1 and level 2. Each level divided into two side, right (R) and left (L). The building prototype has two stairs at the left and right site of the building. The dimension of the building prototype is 39.5cm X 27.5cm X 51.5cm, as in Figure 3.

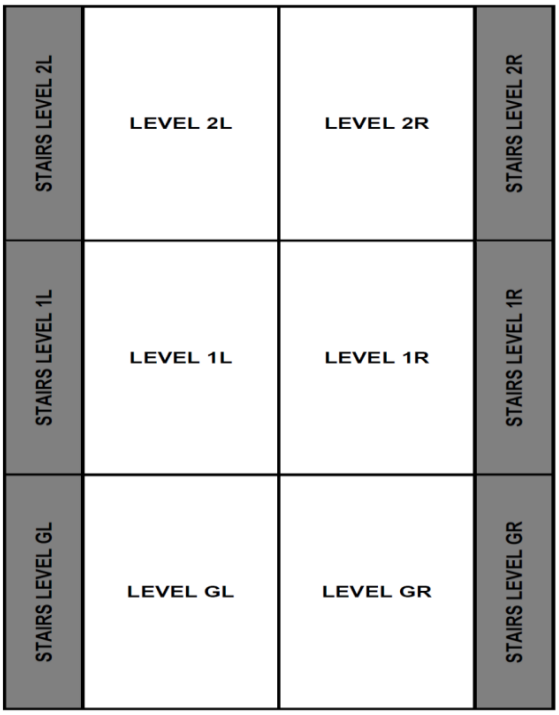


Fig. 3 - Layout of building prototype

4. Results and Analysis

The result and analysis of the FASTech system is based on the method that has been described and discussed. This section shows the result of the FASTech system performance according the desired operating with the actual operating. FASTech system was installed on the building prototype to test the performance of the system. iPhone 7Plus with operating system iOS 12.1 was used to evaluate the respond of the system with the Blynk application. The analysis is focusing on the performance of the fire alarm system operation and impact to society.

4.1 Programming of FASTech System

Three parts of programming of FASTech System, which are programme for FASTech system, programme for the Wi-Fi connection and programme for mobile application.

Program for FASTech system is to operate the process of the system and control the input and output. This programme actually focuses the operation of the system works if the smoke is present. The command code is uploading to the Arduino Mega 2560 board. Figure 4 shows a part of the generated command of the ground level sensor using Arduino software.

Programming to ensure the communication between the Ardunio Mega 2560 board and Wi-Fi connection is done by assisting with ESP8266 NodeMCU module. ESP8266 NodeMCU module is connected with Wi-Fi and sends data to the Blynk application. Figure 5 shows a part of command for ESP8266 NodeMCU module.

```
WidgetMap myMap(V7);

char auth[] = "6c5860987c644b6ca92ca673f7d2db16";
char ssid[] = "RumahParitDaun";
char pass[] = "2444666668888888";
SimpleTimer timer;

void setup()
{
  pinMode(16,INPUT);
```

Fig. 4 - Command of FASTech System

```
if (inputState1 == LOW) {
tone(buzzer, 10000);
digitalWrite(44, HIGH);
digitalWrite(led2, HIGH);
digitalWrite(led6, HIGH);
digitalWrite(led11, HIGH);
delay(250);
```

Fig. 5 - Command coding of ESP8266 Node MCU module

Blynk apps are programmed to trigger notification when the smoke detectors detect smoke. The program is setup on the Eventor Blynk apps on the smartphone. Figure 6 shows a part of Blynk apps command.

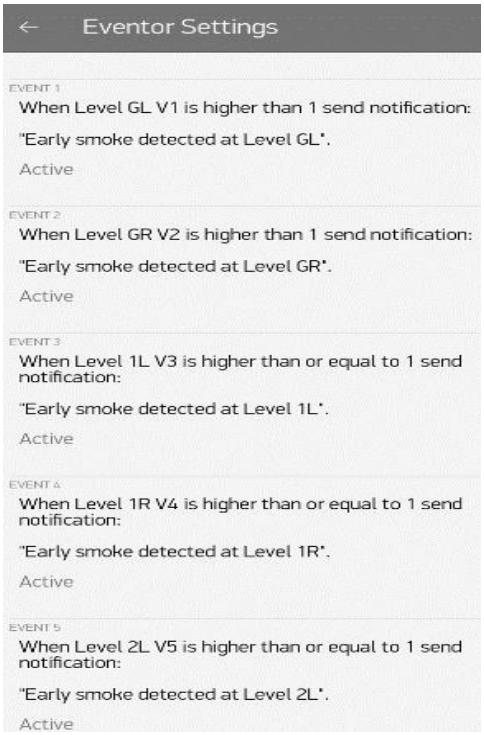


Fig. 6 - Eventor Bynk apps

4.2 Hardware Circuit

Four parts of circuits, which are power supply circuit, backup power supply circuit, LED circuit controller and buzzer circuit controller. Figure 7 shows power supply and backup power supply circuit. The input is from DC adapter 9V. The power supply circuit are separate the voltage between 9V and 5V. 9V power supply is for LED strip and 5V power supply are for buzzer, Arduino Mega 2560 Board, ESP8266 NodeMCU Module and LED indicator. For 9V power supply is direct from the DC adapter and 5V power supply is regulate from DC adapter power supply by using voltage regulator 7805. Relay is used for backup power supply that connected with Li-Ion Battery 7.9V 2200mAH. Backup power supply is for backup power supply when the main supply is breakdown. Thus, system is continuing operate if the main supply is breakdown.

Figure 8 shown a buzzer circuit controller. Once the smoke is present and detected, buzzer is activated and turn ON. Figure 9 shows a LED controller circuit to control the LED strip that light up and functioning as running light to navigate victims for safe and nearest exit path. The circuit is controlling 14 LED strips that was built in the building prototype. The circuit is receiving signal from Arduino Mega 2560 board to activate the LED strip by sequence operate as a running light.

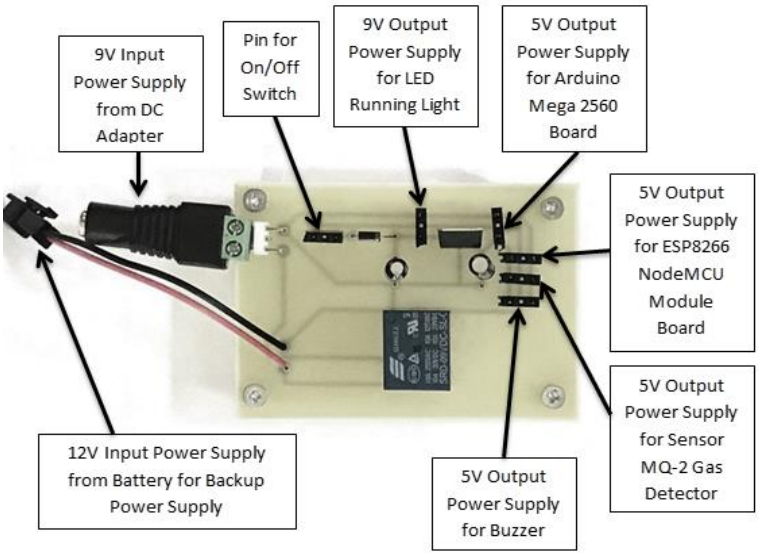


Fig. 7 - Power supply and backup power supply circuit

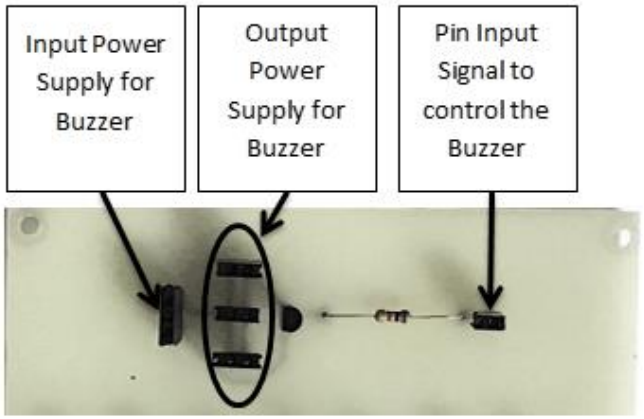


Fig. 8 - Buzzer controller circuit

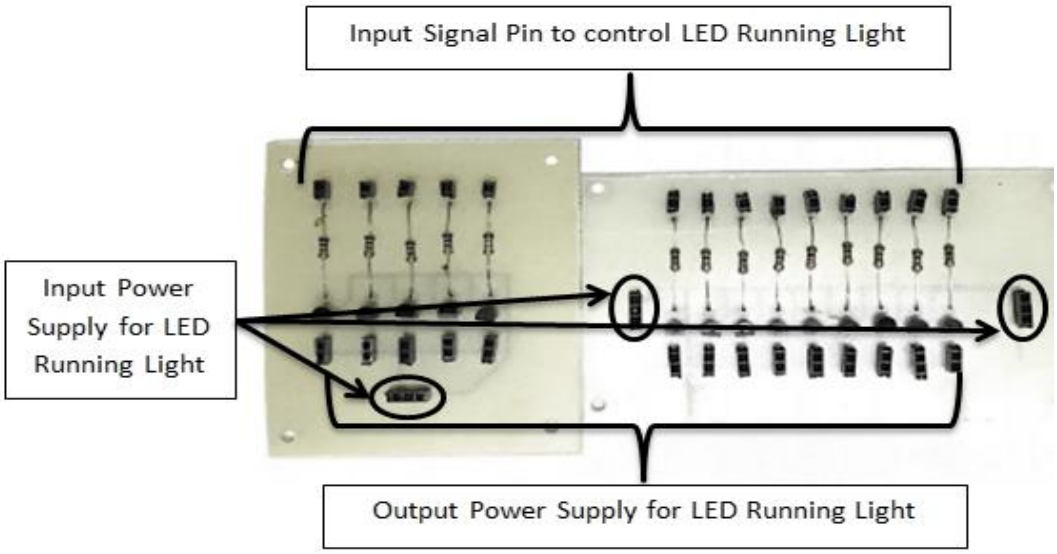


Fig. 9 - LED controller circuit

4.3 Operation of FASTech System

The operation of FASTech system are starting from detecting smoke from fire strikes, then buzzer was turn ON to warning people in the building and the pathway LED strip was light up to navigate people exit from the building by using the safe pathway. At the same time FASTech system was send notification through the smartphone to notify people are occurrences fire strikes in the building and was inform where the fire strikes occurs. Table 1 shows how the FASTech system operates when each sensor are trigged.

Table 1 - Operation of FASTech

	Sensor GL	**Sensor GR**	**Sensor 1L**	**Sensor 1R**	**Sensor 2L**	**Sensor 2R**
Level G	LED strip to the right	LED strip to the left	LED strip to the right and left	LED strip to the right and left	LED strip to the right and left	LED strip to the right and left
Level 1	LED strip to the right	LED strip to the left	LED strip to the right	LED strip to the left	LED strip to the right and left	LED strip to the right and left
Level 2	LED strip to the right	LED strip to the left	LED strip to the right	LED strip to the left	LED strip to the right	LED strip to the left

4.4 FASTech Notification

The notification is sended to the smartphone victims in the building when fire strikes exist. Notification indicated a parts of the fire strikes location, that can help victims to decide which safe pathway by assisting with running light to rescue their self. Figure 10 shows the example of notification on mobile phone. Smartphone notification is an alternative of warning, beside sounder bell to warn people in the building about the fire incident.

4.5 Result of Cloud Computing

The function of cloud computing is storing data of the fire strikes accident. The stored data are date, time and location of the accident. Figure 11 shows the interface of Blynk platform, graph represented data of date and time of the accident, while the map show the location of the building. The colour for every sensor is different, which are light blue for sensor Level Ground Left (GL), black for Level Ground Right (GR), orange for Level 1 Left (1L), red for level 1 Right (1R), dark blue for Level 2 Left (2L) and green for Level 2 Right (2R).

The data also can be monitored through computer on Google Sheet, which can accessed online and downloaded for future action. Figure 12 shows the interface of Google Sheet. Recorded data, which are column A for date and time, column B shows the device used and column C shows the location of fire strikes occur.

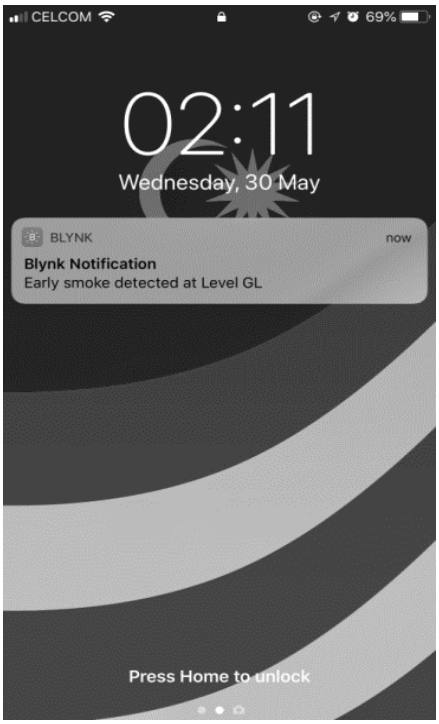


Fig. 10 - Notification on smartphone

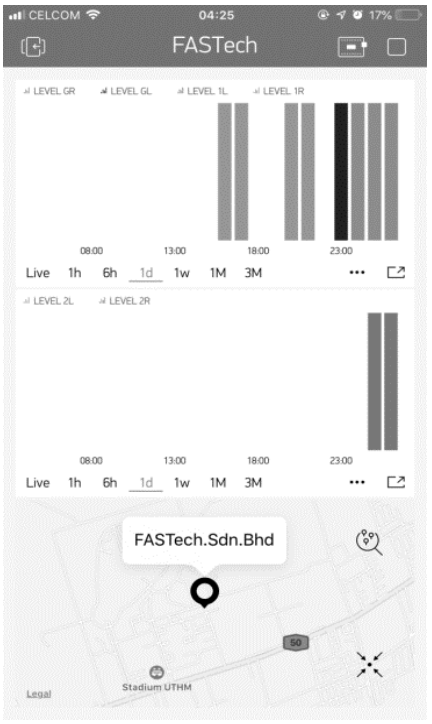
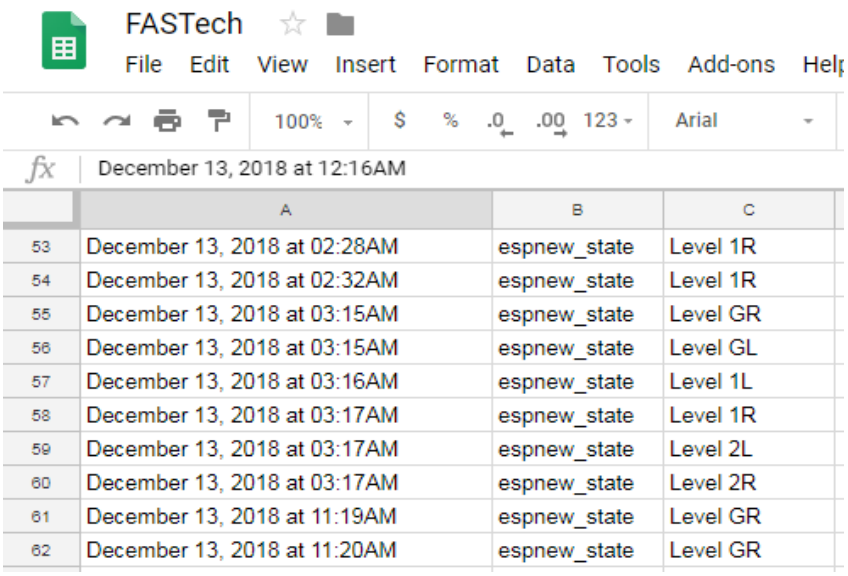


Fig. 11 - Data on Blynk apss



	A	B	C
53	December 13, 2018 at 02:28AM	espnew_state	Level 1R
54	December 13, 2018 at 02:32AM	espnew_state	Level 1R
55	December 13, 2018 at 03:15AM	espnew_state	Level GR
56	December 13, 2018 at 03:15AM	espnew_state	Level GL
57	December 13, 2018 at 03:16AM	espnew_state	Level 1L
58	December 13, 2018 at 03:17AM	espnew_state	Level 1R
59	December 13, 2018 at 03:17AM	espnew_state	Level 2L
60	December 13, 2018 at 03:17AM	espnew_state	Level 2R
61	December 13, 2018 at 11:19AM	espnew_state	Level GR
62	December 13, 2018 at 11:20AM	espnew_state	Level GR

Fig. 12 - Data recorded on Google Sheet

5. Conclusion

FASTech was successful designed and functioned as an intelligent fire emergency response system. Three-level building prototype and the main circuit for the system was successfully developed to ensure the successfulness of the system. Besides that, the IoT concept was interfaced using Blynk apps.

FASTech system able to detect the present of smoke from fire strikes and alarming person inside the building. Besides that, the incoming notification through the smartphone with Blynk apps is activated and data is stored on the Blynk database. Thus, we believe this project can give positive impact and awareness to the society on the important of fire alarm system.

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