



Prototype of Early Fire Detection Device at Marshalling Kiosk

Putu Agus Mahadi Putra^{1,*}, Kadek Amerta Yasa¹, I Made Purbhawa¹,
I Wayan Teresna¹, and Muhammad Sholahudin Sunardiyan¹

¹ Electrical Engineering Department, Politeknik Negeri Bali, Bali, Indonesia
mahadi.putra@pnb.ac.id

Abstract. Marshalling Kiosk in general is a control panel that functions to protect the electrical components inside it, the marshalling kiosk itself has a very crucial role in the switching process because the role of the marshalling kiosk is as a connection point to various equipment, usually there are also several marshalling kiosks at the main substation that are connected. Overheating in Marshalling Kiosk panels is a major issue that negatively impacts the reliability of power distribution systems. Heat trapped inside the enclosure can accelerate the degradation of electrical components, trigger system failures, and even pose a fire risk. This study aims to analyze the main causes of excessive temperature rise, such as loose connections and potential component overheating. This study aims to develop a prototype capable of detecting early changes in temperature within a marshalling kiosk. The components used are the LM35 temperature sensor, 5 channel fire sensor, and MQ2 smoke sensor (Rochim & Nilogiri, 2018). It is hoped that by conducting experiments using this prototype, it can detect disturbances more quickly based on temperature in the marshalling kiosk.

Keywords: Marshalling Kiosk, Prototype, Overheating, Temperature

1 Introduction

Electrical energy has become a fundamental necessity in daily life; our needs and routines rely on it, and without it, we would be unable to maintain our usual levels of productivity. It serves a wide range of sectors, including households, the hospitality industry, manufacturing, public facilities, and transportation (Farsa et al., 2025). The largest generator and distributor of electricity in Indonesia is PT Perusahaan Listrik Negara (PLN) Persero (Kaluase et al., 2025). The process of supplying electricity to customers is complex but can be broken down into three main stages: first, generation using natural resources whether renewable or non-renewable; second, transmission; and finally, distribution to the end consumers (Hasrul et al., 2023).

A facility that receives electricity from the transmission system is known as a substation. Substations feature a multi-layered control system that allows for operation via a central system known as SCADA or through local control directly at the substation itself (Iskandar, 2011). If remote operation of substation equipment by the dispatcher fails, local control is performed using a panel known as a marshalling kiosk; this panel

serves as the termination point for equipment connections and facilitates switching operations.

The marshalling kiosk has the main function as a backup control medium if control via SCADA and the control building fails, because the function of the marshalling kiosk is as a connection point to the equipment in the main substation. According to IEC 61439, the optimum temperature for outdoor control panels is 40°C; exceeding this nominal limit can reduce the service life of electrical components(Williams, 2015). Furthermore, loose connection terminals pose a risk of sparking, while malfunctions in the marshalling kiosk's cooling system can lead to overheating, a highly risky situation as heat generated by the components cannot be dissipated(Saputri et al., 2021). Therefore, this study requires a device capable of detecting conditions before a fire breaks out, thereby enabling the transmission of SMS alerts to personnel so they can more quickly address the rise in temperature(Meunasah & Rahmadani, n.d.).

2 Methodology

In creating the prototype for this research, a block diagram was created to explain the components needed to form a unified tool. This can be seen in Figure 1.

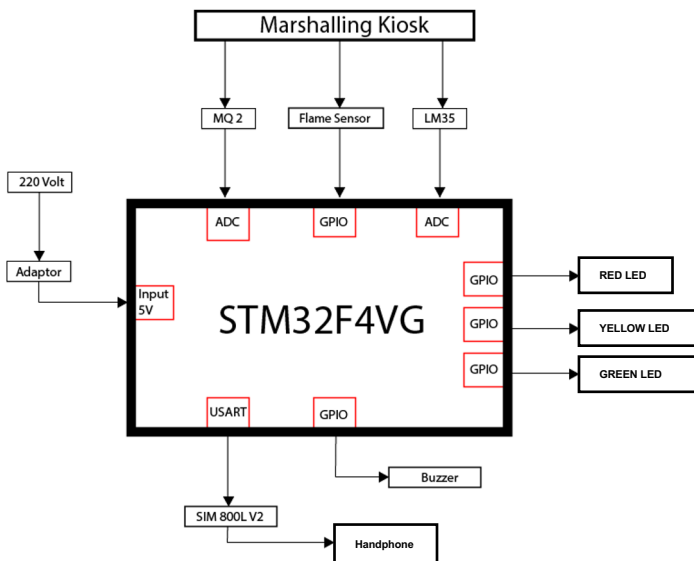


Figure 1. Prototype Block Diagram

In this prototype, a 5 V DC supply is fed into the STM32F4 microcontroller. The device activates upon detecting temperature-related disturbances or anomalies within the marshalling kiosk specifically, a temperature rise exceeding the 40°C standard, the appearance of sparks, or the generation of smoke caused by burnt connections. The system utilizes a green LED to indicate when the temperature exceeds the standard, a

red LED to signal the presence of fire, and a yellow LED to indicate the appearance of smoke within the marshalling kiosk.

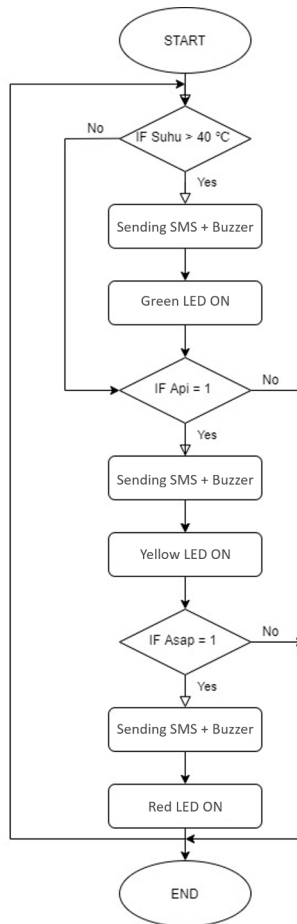


Figure 2. Flowchart System

If the temperature rises above 40°C, the LM35 sensor detects the increase and the microcontroller processes the input; it then sends a warning message to the personnel including the recorded temperature reading from the Marshalling Kiosk instructing them to proceed to the Marshalling Kiosk immediately. If the personnel have not arrived and the temperature at the Marshalling Kiosk has not dropped within five minutes, the system sends another message to the personnel at the substation. If smoke or a fire occurs, the device will immediately send an SMS alert to the personnel at the substation.



Figure 3. Design of Prototype Box

The marshalling kiosk prototype to be used for testing is constructed from plywood. Plywood has relatively low thermal conductivity and higher thermal insulation properties than metallic enclosures. Consequently, heat distribution within the plywood test box may occur more slowly and differently compared to an actual metallic Marshalling Kiosk. In addition, the response of plywood to steam or water vapor differs from that of metal, which may affect the thermal and environmental conditions during testing. The prototype test enclosure was constructed from plywood, with dimensions of 96 cm in length, 48 cm in width, and 134 cm in height; these dimensions were derived by scaling the actual marshalling kiosk which measures 120 cm by 60 cm by 170 cm down to 80% of its original size. A 12 cm x 12 cm exhaust fan is installed on the unit, matching the specifications of the marshalling kiosks used in the field, and a smoke sensor were positioned next to this exhaust fan.

In contrast, a metallic Marshalling Kiosk enclosure has significantly higher thermal conductivity, allowing heat to spread more readily through its walls. Its thermal mass also differs from that of plywood, resulting in different internal heating characteristics. Furthermore, an industrial enclosure has specific construction characteristics and an IP rating that are not represented by the plywood test box. Therefore, the thermal conditions observed during the plywood-based experiments may not fully represent those occurring inside an actual metallic Marshalling Kiosk.

In this case, plywood was used as a prototype test enclosure to facilitate experimental validation and does not represent the thermal characteristics of an actual industrial Marshalling Kiosk enclosure. Therefore, the experimental results should be interpreted as functional validation of the prototype rather than a direct representation of the thermal conditions within an industrial metallic enclosure.

3 Result and Discussion

3.1 Result

The following is a 3D system design illustrating the planned placement of devices within the substation's marshalling kiosk. The unit incorporates several detection components specifically an LM35 temperature sensor, a 5-channel fire sensor, and an MQ2 smoke sensor each positioned within the marshalling kiosk as shown in the figure 4.

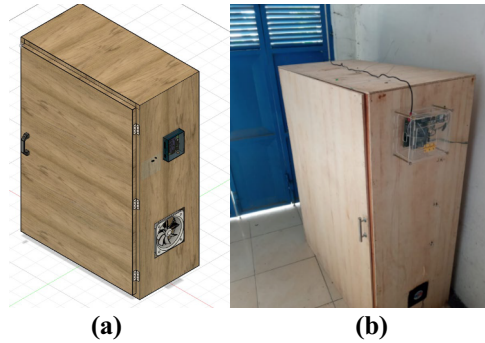


Figure 4. (a) 3D Design. (b) Device Installation Results

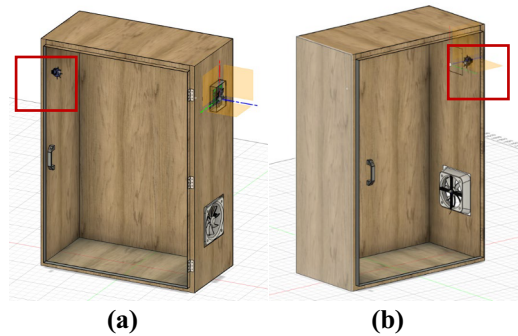


Figure 5. (a) Channel A Fire Sensor Position. (b) Channel B Fire Sensor Position

Fire sensor A is to be positioned on the right side, as shown in the red box in Figure 5(a); ideally, however, fire sensors should be installed along both the left and right sides of the marshalling kiosk in a parallel arrangement, ensuring that sensors positioned parallel or opposite to one another can effectively detect fire within their respective rows. Next, fire sensor B will be positioned on the left side, as shown in Figure 5(b), directly facing its counterpart, fire sensor A. During subsequent testing, the sensors will remain facing each other, though their vertical placement will be adjusted; this is intended to determine whether this specific sensor configuration maximizes detection effectiveness regarding the outbreak of fire within the Marshalling Kiosk.



Figure 6. (a) MQ-2 Smoke Sensor Position. (b) LM35 Temperature Sensor Position.

The MQ2 smoke sensor is positioned at the center of the fan unit, facing the interior of the Marshalling Kiosk. This placement accounts for scenarios where smoke arises from internal component short circuits; as smoke-laden air is driven outward by the kiosk's exhaust fan, it passes the MQ2 sensor(Lowongan et al., 2015). Upon detecting smoke-related gases, the sensor transmits a signal to the microcontroller, triggering an alarm or warning for substation personnel. The LM35 temperature sensor is positioned centrally on the upper side to detect the internal temperature of the panel; this placement accounts for real-world conditions where excess heat generated by the panel rises accumulating at the top if internal air circulation is obstructed or otherwise compromised.

3.2 Discussion

Temperature Testing Above 40°C. The testing focused on a specific temperature range, using water heated on a stove as the trigger; the exhaust fan remained inactive to simulate a cooling system malfunction. Figure 7 illustrates the device installation process, showing the LM35 sensor mounted at the top of the panel so that the generated steam is directly detected by the sensor.



Figure 7. Temperature Stress Testing on Panels

In this test, a gas stove was used to heat water, with the resulting steam serving as the system's trigger; meanwhile, the panel was constructed from plywood, a material that does not retain heat well necessitating an extreme rise in panel temperature. Furthermore, the results of the tests conducted under temperature-related disturbances are presented in the table below.

Table 1. Test Results Under Temperature Stress

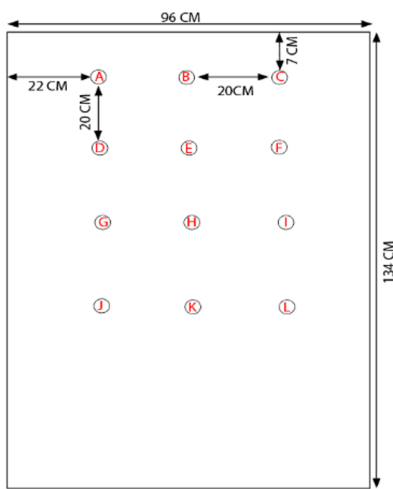
Temperature (°C)	Red LED	Yellow LED	Green LED	SMS	Buzzer	Message Sending Time
40,34	Off	Off	On	Transmitted	On	7 seconds
42,37	Off	Off	On	Transmitted	On	8 seconds
46,88	Off	Off	On	Transmitted	On	6 seconds
50,75	Off	Off	On	Transmitted	On	7 seconds
52,24	Off	Off	On	Transmitted	On	7 seconds

57,96	Off	Off	On	Transmitted	On	5 seconds
60,31	Off	Off	On	Transmitted	On	6 seconds
61,23	Off	Off	On	Transmitted	On	4 seconds
64,15	Off	Off	On	Transmitted	On	7 seconds
70,49	Off	Off	On	Transmitted	On	7 seconds
Average						6 seconds

Note: Time required for the message to be transmitted to the attendant after the LED lights up and the buzzer activates.

Test results indicate that when the temperature exceeds 40°C, the system activates signaled by a green LED and a buzzer because the program is configured to trigger these alerts under such conditions; the LED and buzzer remain active as long as the temperature stays above 40°C, necessitating corrective action. The initial step involves opening the door and inspecting the exhaust fan. Notably, specific instructions for addressing the fault are not included in the SMS notification, as providing such details is considered impractical; the primary requirement for the technician is simply to be informed of the issue, while the subsequent corrective actions fall within the scope of their professional competence.

Testing the Prototype Using Smoke and Fire. In this testing process, the system was triggered using only the fire, with the sensor position adjusted according to 12 specific test points. The sensors will be positioned facing each other to enhance fire detection efficiency, and will subsequently be moved to different locations(Sunawar, 2017).



(a)



(b)

Figure 8. (a) Fire and Smoke Disturbance Test Layout. (b)Testing with Fire and Smoke Interference On the Panel

The results of testing the research prototype's response to smoke and fire disturbances are presented in the following table.

Table 2. Fire and Smoke Test Results

Spot	Peak Temperature (°C)	Red LED	Yellow LED	Green LED	SMS	Buzzer
A	43,29	On	On	On	Transmitted	On
B	51,65	On	On	On	Transmitted	On
C	44,21	On	On	On	Transmitted	On
D	47,87	On	On	On	Transmitted	On
E	49,63	On	On	On	Transmitted	On
F	43,59	On	On	On	Transmitted	On
G	42,44	On	On	On	Transmitted	On
H	46,21	On	On	On	Transmitted	On
I	48,82	On	On	On	Transmitted	On
J	49,13	On	On	On	Transmitted	On
K	44,61	On	On	On	Transmitted	On
L	45,59	On	On	On	Transmitted	On

Table 3. Active duration for the LED and buzzer, and message transmission.

Spot	LED Time Active + Buzzer (Second)			Message Transmission Time (Second)		
	Temperature Sensor	Fire Sensor	Smoke Sensor	Temperature Sensor	Fire Sensor	Smoke Sensor
A	87	6	35	6	7	8
B	82	6	36	7	8	7
C	75	7	29	7	7	7
D	88	5	34	5	7	8
E	72	4	31	6	5	8
F	74	4	40	7	6	6
G	77	5	38	7	6	5
H	69	6	32	6	7	6
I	88	4	31	5	8	6
J	81	6	30	5	7	7
K	73	5	25	6	5	7
L	71	5	27	7	6	8
Average	78	5	32	6	7	7

Based on the tests conducted, when the temperature exceeds 40°C, the system indicates overheating by activating the green LED and buzzer. If a fire is detected, the yellow LED and buzzer will activate. If smoke is detected, the red LED and buzzer will activate. The results can be seen in the following image.

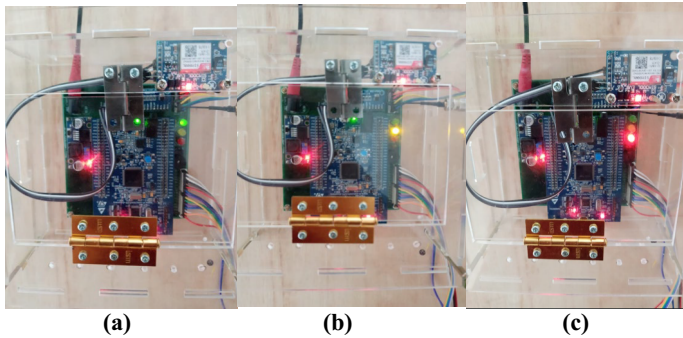


Figure 9. Indicators for detecting (a)temperature, (b)fire, and (c)smoke.

The following are SMS messages sent by the device; the messages are categorized into several types based on the conditions occurring at the marshalling kiosk, as shown in the image below:

SISTEM WARNING PADA MARSHALLING KIOSK !!!WARNING!!! SEGERA KIRIMKAN PETUGAS *SUHU MARSHALLING KIOSK MELEBIHI 40 CELCIUS <Suhu Panel :51.65 Celcius kategori suhu BAHAYA>	SISTEM WARNING PADA MARSHALLING KIOSK !!!WARNING!!! SEGERA KIRIMKAN PETUGAS *TIMBUL API <Suhu Panel :39.41 Celcius kategori suhu aman>	SISTEM WARNING PADA MARSHALLING KIOSK !!!WARNING!!! SEGERA KIRIMKAN PETUGAS *TIMBUL ASAP <Suhu Panel :39.41 Celcius kategori suhu aman>
--	--	---

Figure 10. SMS Indicators for detecting temperature, fire, and smoke.

However, the use of steam as a testing medium has limitations in representing actual fire conditions in an industrial Marshalling Kiosk. Steam primarily introduces moisture and heat, whereas an actual electrical fire produces a combination of elevated temperature, smoke, and fire with different thermal characteristics. In addition, plywood was used as a prototype test enclosure and does not have the same thermal properties as a metallic industrial enclosure. Therefore, the steam-based test is intended primarily to verify the functional response of the detection system and should not be considered a direct representation of actual fire conditions inside an industrial Marshalling Kiosk.

4 Conclusion

Notification for temperature-based disturbance detection during testing took an average of 6 seconds after the buzzer and green LED activated; the delay in message transmission was likely due to network connectivity issues at the test site. Fire-based disturbances at designated points were successfully detected indicated by the yellow LED lighting up, the buzzer activating, and a message being sent followed by the detection of rising temperatures (via the LM35 sensor) and smoke (via the MQ-2

sensor), which triggered the red and green LEDs, the buzzer, and a notification to personnel.

Acknowledgment

The authors would like to thank the Director of Politeknik Negeri Bali for supporting this study.

References

- Farsa, F., Handoko, A., & Najmi, A. (2025). Rancang Bangun Alat Sensor Suhu Untuk Mendeteksi Suhu Panel Ketika Panas. *Jurnal Manajemen Dan Teknik (JuMat)*, 2(1).
- Hasrul, R., Utomo, R. M., Muslimin, M., Harjanto, A., & Alham, N. R. (2023). Studi Kelayakan Peralatan Voltage Transformator 150 kV Gardu Induk Tengkawang. *Prosiding SNITT POLTEKBA*, 6, 71–78.
- Iskandar, D. (2011). Sistem Informasi Gardu Induk dan Gardu Distribusi PLN. *Seminar Nasional Informatika 2011*.
- Kaluase, D. A. G., Patras, L. S., & Mangindaan, G. M. C. (2025). *Analisis Hot Point dan Monitoring Peralatan dengan Thermovisi di Gardu Induk 150kV*.
- Lowongan, T. R., Rahardjo, P., & Divayana, Y. (2015). Detektor LPG menggunakan sensor MQ-2 berbasis mikrokontroler ATmega 328. *Jurnal Spektrum*, 2(4), 53–57.
- Meunasah, A. R. S., & Rahmadani, A. (n.d.). *Prototipe Alat Monitoring Suhu dan Kelembapan Ruang Baterai pada Gardu Induk dengan Perangkat IoT*.
- Rochim, F. N., & Nilogiri, A. (2018). Simulasi Alat Pendeteksi Kebakaran Menggunakan Sensor Asap MQ2, Sensor Suhu LM35, Dan Modul Wifi ESP8266 Berbasis Mikrokontroler Arduino. *Fak. Tek. Univ. Muhammadiyah Jember*, 2, 12–17.
- Saputri, C. F., Susilo, K. E., & Arifin, M. N. (2021). Monitoring Suhu Non-Contact Sambungan Kabel Dengan Trafo Berkapasitas 20 kV Pada Gardu Induk Ngagel Berbasis IoT. *PROSIDING SEMINAR NASIONAL SAINS DATA*, 1(01), 66–74.
- Sunawar, A. (2017). Pencegah Kebakaran Akibat Panas Pada Instalasi Listrik Menggunakan Deteksi Thermal Camera Berbasis Mikroprosesor. *Journal of Electrical Vocational Education and Technology*, 2(1), 33–38.
- Williams, N. (2015). Verification of Low-Voltage Assemblies. *Engineering & Technology Reference*, (2015).

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

