

Enhancing Laboratory Safety with an Arduino-Based Emergency Response Button (ActiMerge)

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1. Product Description

ActiMerge consists of three push buttons that are assigned to different types of emergencies, such as chemical spills, mercury spills and emergency aid. The use of a button offers a lowstress solution to laboratory users since it is intuitive and does not require complex steps (single press only). These help reduce hesitation and confusion during panic situations. As the central processing unit, the Arduino Mega 2560 coordinates with the GSM module (SIM800L EVB) to enable real-time communication via SMS. Since an emergency is highly time-sensitive in nature, this innovative system supports good health and well-being (Sustainable Development Goal (SDG) 3) by enabling rapid emergency response and reducing the risk of injury or university property damage. A predefined message format ensures consistent and effective communication of emergency alerts to multiple recipients. This feature is crucial to overcoming communication delays from a distressed laboratory user. Instead of requiring detailed information to be explained verbally or typed manually by the laboratory user, this system provides predefined messages. Apart from reducing pressure on the user, this system ensures clear and consistent communication every time. The system is powered by an adapter to ensure stable and continuous operation. It is also designed to be user-friendly and reliable for emergency situations. The system functionality is tested to ensure each component operates correctly. Several evaluations and tests are carried out to measure the response time (time taken from button activation to alert reception), reliability testing (ensuring system performance under different emergency scenarios) and usability testing (lab personnel assess the system's effectiveness and ease of use).

Figure 1 shows a block diagram that illustrates the overall system and the interaction between hardware components, communication modules, and response mechanisms, while Figure 2 provides the schematic diagram detailing the wiring connections between these components. This system demonstrates affordable cost and local technological innovation and also can be adapted to different working environments and hazard types, which makes the system align with SDG 9 (Industry, Innovation, and Infrastructure).

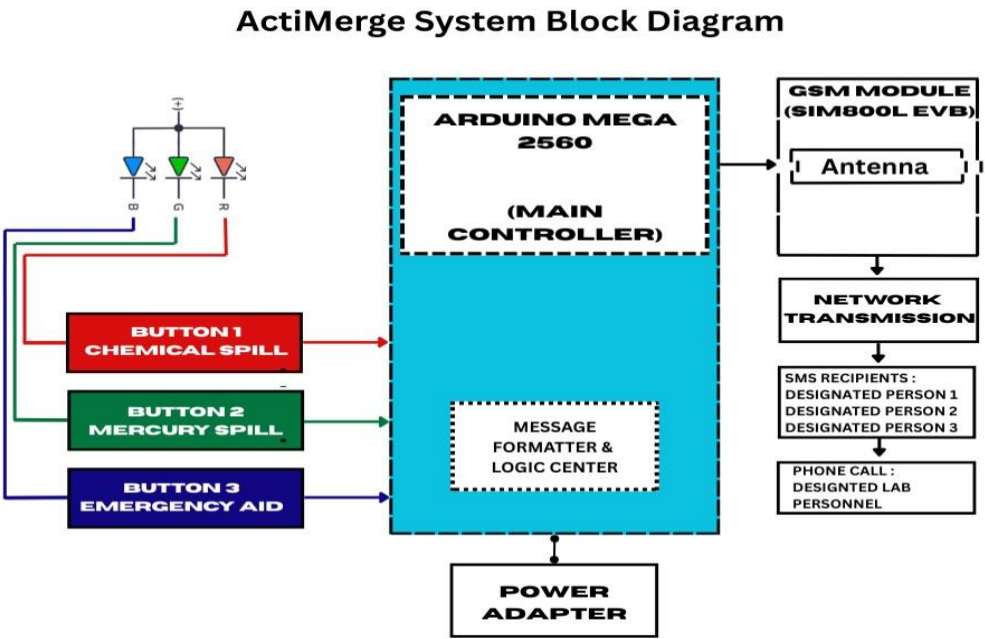


Figure 1: Block diagram of ActiMerge

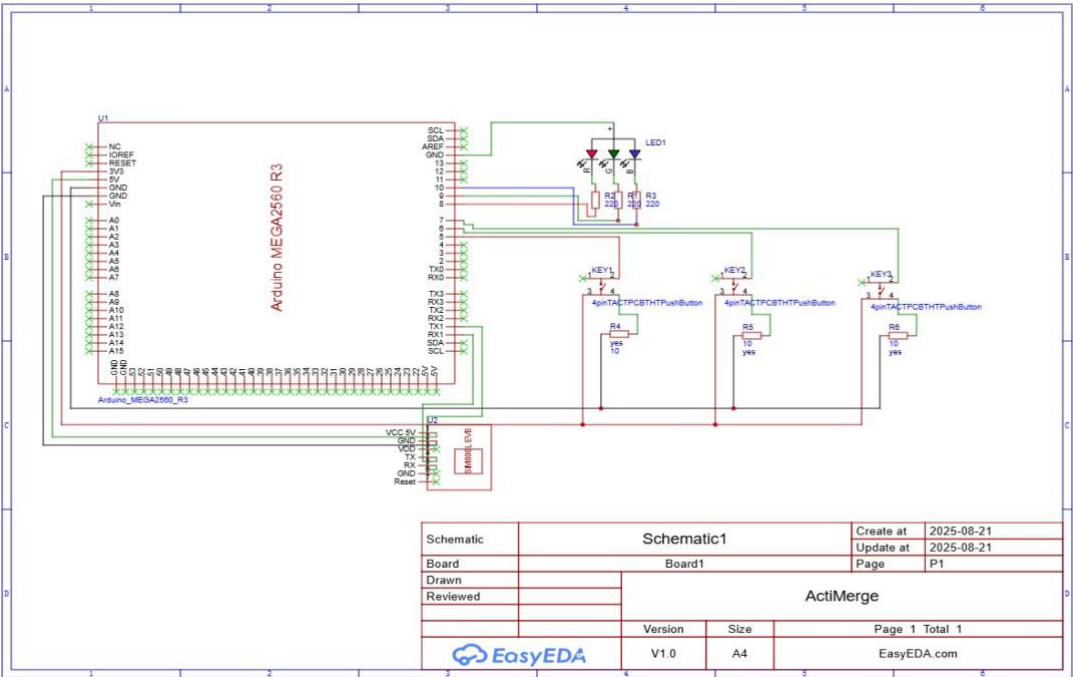


Figure 2: Schematic diagram of ActiMerge

2. Innovation Objectives

The primary objective of ActiMerge is to enhance laboratory safety through the following goals:

- To provide a rapid, automated alert system that eliminates delays in communication during chemical spills, mercury exposure, and emergency aid by sending real-time SMS notifications and calls to designated responders
- To offer a dedicated, low-stress solution for laboratory users to get help in emergency situations.

3. Problem Statement

A laboratory refers to a space equipped with facilities to carry out scientific experiments, research, testing, or analysis. As academic institutions grow, the number of laboratories handling hazardous materials has risen, leading to a higher risk of incidents that can threaten life and even damage properties. Laboratories are also among the workplaces where lone work may occur. Lone workers often spend long hours in the laboratories or fieldwork without direct supervision, which means many risks go unaddressed. This leaves them more vulnerable to safety hazards, as they have no immediate assistance to help during an emergency. Although safety training covering both theoretical and practical aspects is given to all users, their effectiveness remains limited as users do not encounter real emergencies.

During real emergencies, high-stress conditions involving threats, uncertainty, and time pressure significantly impact human behaviour. These conditions can disrupt normal reasoning and decision-making, influencing individuals' actions and their tendency to respond appropriately under pressure. In these critical moments, help becomes essential to neutralise such a situation whereby the existing laboratory safety systems only monitor environmental parameters such as gas detection, smoke alerts and temperature control but do not offer direct user support during emergencies. Thus, this gap, which is a lack of direct user assistance, has led to the design and development of the emergency alert system known as ActiMerge, an emergency alert system that sends notification messages based on the triggered emergency button and places alarm calls to designated laboratory personnel for rapid response.

4. Authenticity / Novelty

Most existing emergency systems, whether for homes, hospitals, or laboratories, are general purpose, complex, or costly. ActiMerge offers a lab-specific, affordable emergency alert system using dedicated push buttons for different incident types combined with a SIM800L GSM module for real-time SMS alerts. The purpose of predefined SMS messages is to ensure fast, clear communication, while the simple one-press interface supports quick responses during

emergencies. This system provides a scalable, user-friendly, and affordable alternative to commercial lab alert systems, especially suited for resource-limited settings like rural schools or developing countries.

5. Implementation

- a) Current laboratory safety systems focus only on environmental monitoring without providing direct user support during emergencies.
- b) Categorise three types of emergencies based on frequency.
- c) System design and deployment (Figure 3)
- d) Test the effectiveness of the circuit to send emergency notifications via SMS and call. (Figure 4)

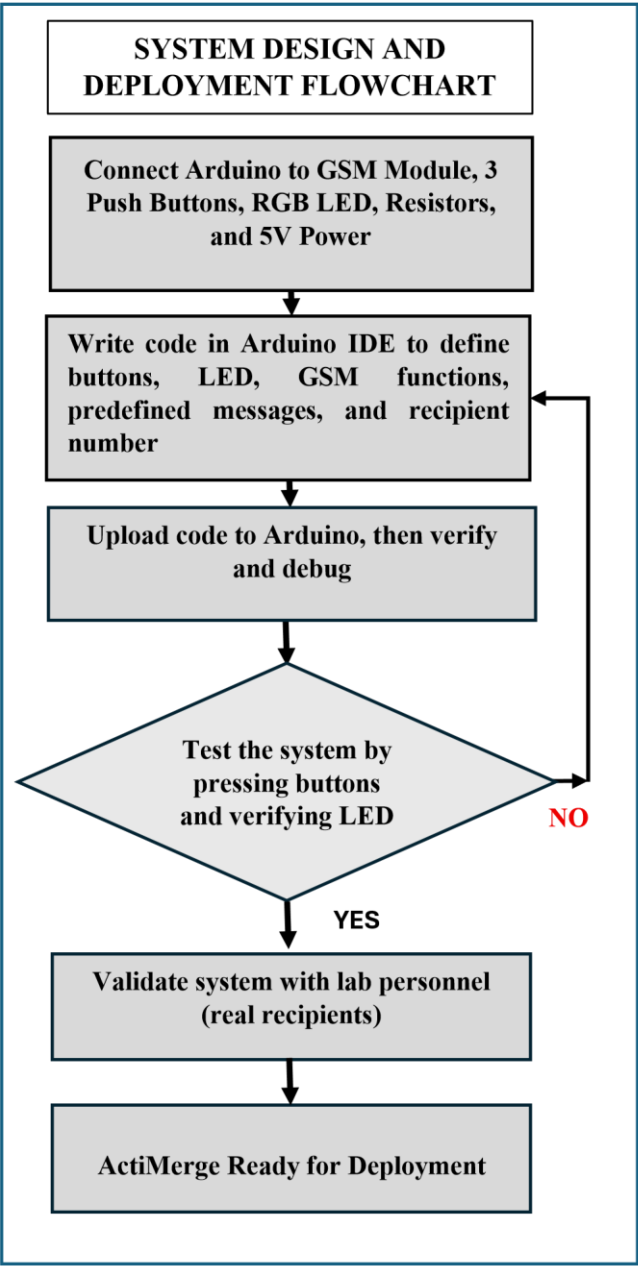


Figure 3: System design and deployment

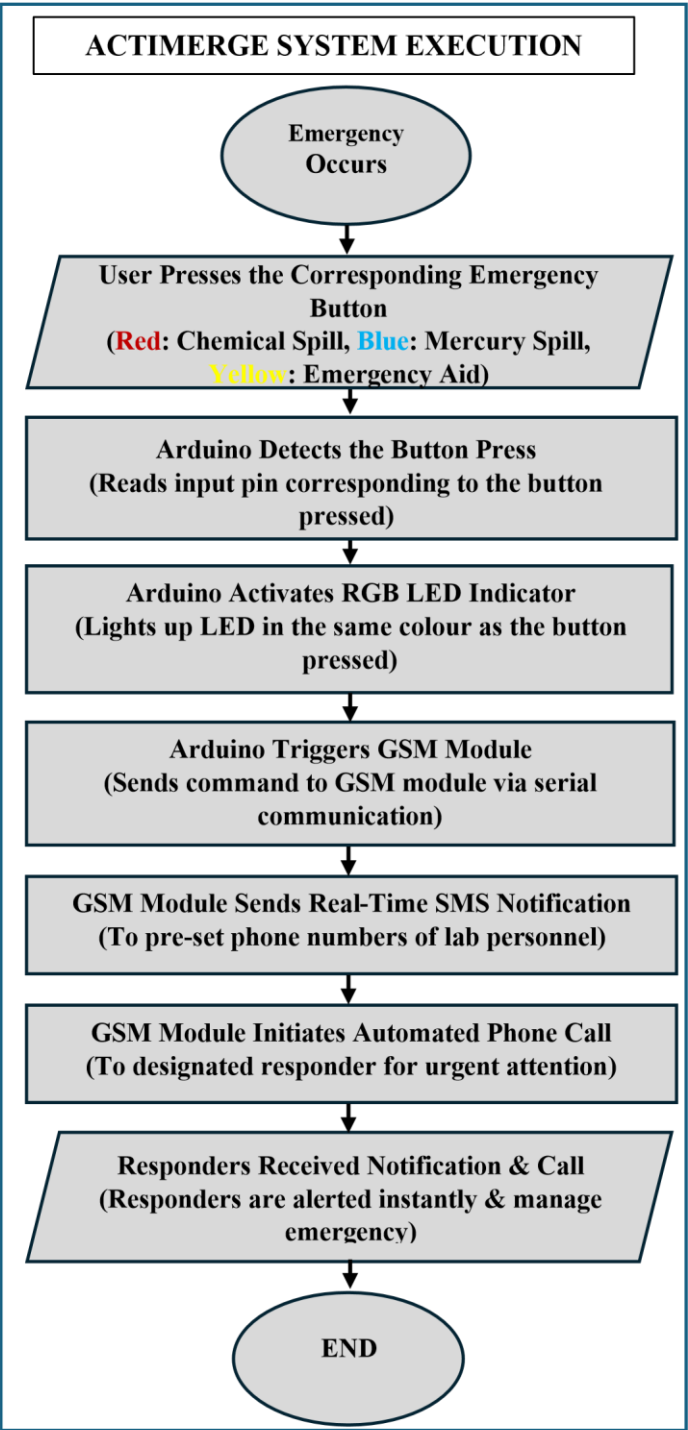


Figure 4: The operational sequence of ActiMerge during real emergency use

6. Uses and Applications

ActiMerge is designed specifically for laboratory environments. In critical situations, users often panic, which reduces their ability to think clearly, make decisions, or perform essential actions such as calling or messaging for help. These delays slow down rescue efforts and can increase the severity of accidents. ActiMerge overcomes this challenge by integrating three dedicated emergency buttons for chemical spill, mercury spill, and emergency aid, which provide immediate assistance with just a single press. By categorising emergencies, the system ensures that laboratory supervisors receive accurate information quickly, enabling faster, more precise, and better-coordinated responses.

7. Project Impact

ActiMerge provides a practical improvement to the existing emergency response systems in laboratories by enhancing communication systems, providing real-time alert mechanisms, notifying accident classification, and adopting a one-press interface that supports quick response during emergencies. This innovative system supports Sustainable Development Goal (SDG) 3: Good Health and Well-being by enabling rapid emergency response and reducing the risk of injury or university property damage. Additionally, this system aligns with SDG 9: Industry, Innovation, and Infrastructure, as it demonstrates affordable cost local technological innovation and also can be adapted to different working environments and hazard types.

8. Achievements / Advantages of ActiMerge

Completed the development of ActiMerge and carried out initial performance tests, which confirmed the feasibility of the concept and provided a foundation for further refinement and large-scale application. During pilot testing in the laboratory, users expressed satisfaction with the system, highlighting its ease of operation, enhanced safety features, and potential to improve emergency response time.