



Child Safety Button with GPS Location Tracking and GSM Alert Using ESP32

Mr. A. Kuppuswamy¹, Mr. P. Prakash², Mr. M. Vigneshkumar³, S. Arunkumar⁴, M. Nithin⁵, N. Kaviarasu⁶

Department of Electrical and Electronics Engineering, P. A. College of Engineering and Technology (Autonomous), Pollachi, Tamil Nadu, India

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ABSTRACT

This paper presents the design and implementation of a compact Child Safety Button that helps a child or other vulnerable user call for help quickly during an emergency. The prototype uses an ESP32 development board as the central controller, a TTP223B capacitive touch sensor as the emergency trigger, a momentary push button for cancellation, an NEO-6M GPS module for location acquisition, a SIM800L GSM module for SMS communication and a buzzer for local indication. When the touch sensor is activated, the controller starts a 30-second cancellation period. If the user has touched the sensor accidentally, the push button cancels the alert. If the button is not pressed within 30 seconds, the controller reads the latitude and longitude from the GPS module and sends an SMS containing the emergency message and a map link to a predefined guardian number. Power is supplied by a 9 V battery regulated by a buck converter. Tests documented in the project report indicate successful touch detection, alert cancellation, GPS location acquisition and SMS transmission to the registered contact. The prototype is intended for educational demonstration and preliminary personal-safety applications, rather than as a certified emergency-response product.

Keywords: Child safety, ESP32, touch sensor, GPS, GSM, SMS alert, emergency notification, cancellation timer.

1. Introduction

Personal safety and emergency communication have become important requirements, particularly for children who may face accidents, medical emergencies or threats. During such an event, quickly notifying a trusted person and sharing the exact location can improve the chance of timely help. Conventional methods require the user to unlock a phone, select a contact and make a call or send a message, which may not be possible in a critical situation [1]–[3].

The project described here is a dedicated embedded device that provides a simple and rapid method of raising an alert. An ESP32 controller manages a touch sensor, a cancel button, a GPS module, a GSM module and a buzzer. A short cancellation period is built into the sequence so that an unintended touch does not generate a false emergency message. After the period expires, the device sends the guardian an SMS containing the user's latitude and longitude.

The scope of the present work is limited to a bench-level prototype that demonstrates touch-based activation, cancellation, GPS location acquisition and SMS notification. It does not implement continuous tracking, a mobile application, cloud logging, voice calling or automatic emergency-service dispatch.

1.1. Objectives

The objectives are to: (i) develop a compact, low-cost emergency alert device; (ii) provide quick activation through a capacitive touch sensor; (iii) reduce accidental alerts with a 30-second cancellation period; (iv) obtain the current location using a GPS module; (v) send the location to a predefined guardian by SMS through a GSM module; and (vi) give a local audible indication using a buzzer.

1.2. Problem Definition

Three problems motivate the work. First, a person in danger may be unable to operate a mobile phone. Second, even when a message is sent, the guardian may not know where the person is, which delays the response. Third, systems that transmit immediately after activation can send unnecessary alerts when the trigger is touched by mistake. A simple, low-cost device that is easy to activate, allows a short cancellation window and automatically shares the location addresses all three problems.

1.3. Design Considerations

The principal design considerations are simplicity of operation, availability of components, portability and suitability for a student-level demonstration. The touch sensor output must be read by the controller, the GPS and GSM modules must communicate with the controller over serial interfaces, and the GSM module must be supplied from a source that can deliver its peak transmission current. The modules also require a common ground and a regulated supply.

2. Related Work

Prior work on child and personal safety has combined emergency triggers with GPS tracking and wireless alerts. Al-Khafaji et al. [1] review the role of IoT in child safety and note that sensing, location tracking and wireless communication together support faster response. Arduino-based panic-button devices that send GPS coordinates by SMS are reported in [3], [4] and [10], while [6] describes a child safety device with GPS tracking alerts and a buzzer. Wearable and ornament-style implementations are discussed in [7] and [9], and an SOS device with automatic alerts and geolocation sharing is presented in [8]. A cross-platform mobile application for child safety with real-time alerts is described in [11]. Earlier GPS/GSM systems [12]–[15] and Raspberry Pi based designs [18], [19] follow the same pattern of trigger, location and alert.

Most of these systems use a push button or panic switch that sends the alert immediately. Official guidance for India's 112 service also recognises that unintended panic-button activation is a recurring issue. The present prototype therefore adds a touch-based trigger with a cancellation period on a low-cost ESP32 platform. The references below are reproduced from the supplied project report; bibliographic details should be verified against the original publications before external submission.

2.1. Limitations of Existing Systems

- Most systems use a push button or panic switch as the only trigger.
- Alerts may be sent immediately, which increases accidental alerts.
- Smartphone-based systems need the user to reach a phone or application during an emergency.
- Some systems depend on internet connectivity or mobile applications.
- Continuous GPS tracking in some designs increases power consumption.
- A dedicated cancellation period is rarely provided.

Table 1. Comparison with a typical existing system

Feature	Typical panic-button device	Proposed device
Trigger	Push button	Capacitive touch
Alert timing	Immediate	After 30 s window
False-alert control	None	Cancel button
Location	GPS (varies)	GPS in SMS
Smartphone needed	Often	No

3. System Design and Methodology

The system is divided into power, control, sensing, location, communication and indication blocks, as shown in Fig. 1. The battery supplies a buck converter that provides the regulated voltage for the ESP32 and the connected modules. The ESP32 reads the touch sensor and the cancel button, receives location data from the GPS module, commands the GSM module to send the SMS and drives the buzzer. A common ground provides a shared electrical reference. The complete circuit is shown in Fig. 2.

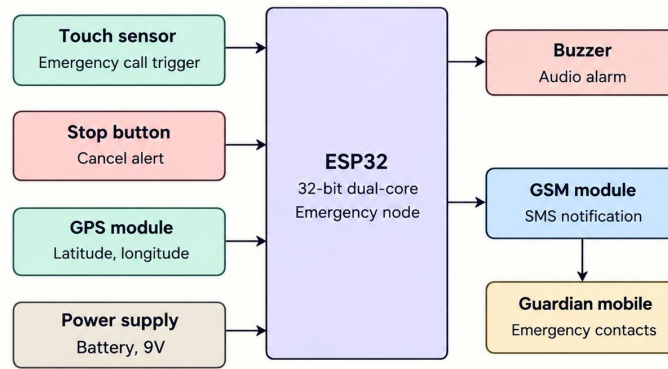


Fig. 1. Block diagram of the Child Safety Button.

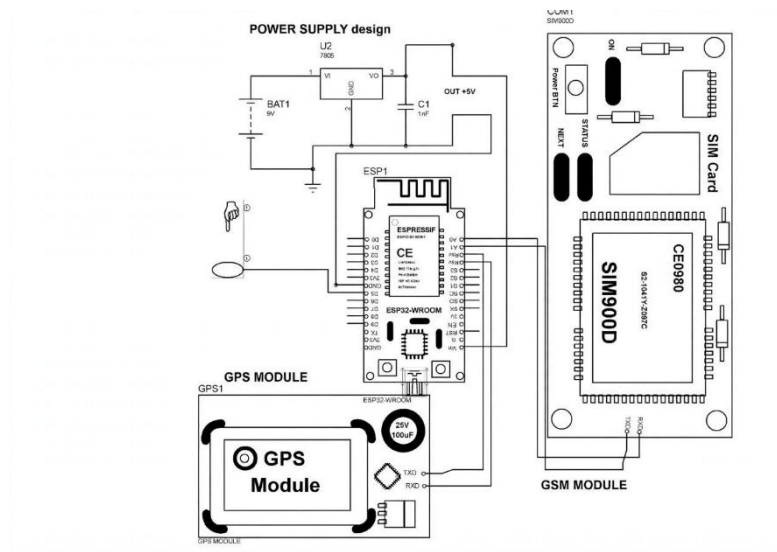


Fig. 2. Circuit diagram of the Child Safety Button (from the supplied project report).

3.1. Main Controller

The ESP-WROOM-32 development board contains a dual-core 32-bit Xtensa LX6 processor with an adjustable clock of 80 to 240 MHz, 520 KB of on-chip SRAM and 4 MB of flash memory. It supports Wi-Fi (802.11 b/g/n) and Bluetooth, although only its GPIO and UART interfaces are used in this prototype. The board operates at 3.3 V logic and includes an on-board regulator that converts a 5 V input to 3.3 V. Its multiple hardware UARTs allow the GPS and GSM modules to be connected to separate serial ports.

3.2. Capacitive Touch Sensor

A TTP223B capacitive touch sensor serves as the emergency trigger. It operates from 2 to 5.5 V and has three pins: GND, VCC and SIG. In the idle state the signal output remains low, and when a finger touches the sensing area the output changes to high. The ESP32 reads this output and starts the alert sequence. Capacitance is given by $C = \epsilon_0 \epsilon_r A/d$, where A is the electrode area and d is the separation; a finger approaching the electrode increases the measured capacitance, and the sensor circuit converts this change into a digital signal. Because a conductive object is enough to trigger the sensor without any force, accidental or moisture-related triggers are more likely than with a push button, which is the reason for the cancellation period described below.

3.3. GPS Module

The NEO-6M is a stand-alone GPS receiver based on the u-blox 6 positioning engine in a miniature package. It operates from 3.3–5 V, outputs data through a UART interface and supports a maximum navigation update rate of 5 Hz. Typical time-to-first-fix is about 32 s for a cold start, 23 s for a warm start and under 1 s for a hot start. The module outputs position data serially, and the controller must use a matching baud rate. In this work the module is read at 9600 baud and decoded to latitude and longitude values.

3.4. GSM Module

A SIM800L GSM module sends the emergency SMS prepared by the ESP32. The controller communicates with it over a UART interface using AT commands. The module operates from 3.7–4.2 V and must be powered from a supply that can deliver sufficient peak current during transmission; the ESP32 GPIO pins carry only signals and must not supply the modem load. The module and controller share a common ground and the UART logic levels must be compatible. A SIM card with SMS service is required.

3.5. Power Supply

The prototype is powered by a 9 V battery. A buck converter, which reduces a higher DC voltage to a lower one with high efficiency using a switching transistor, inductor and capacitor, provides the regulated voltages required by the ESP32, GPS module and GSM module. Peak current during SMS transmission can affect supply stability, so wiring quality and the converter's current rating remain important design considerations.

Table 2. Components and specifications

S.No	Component	Specification	Qty
1	ESP32 dev board	3.3 V, Wi-Fi/Bluetooth, 32-bit	1
2	Capacitive touch sensor	TTP223B	1
3	GSM module	SIM800L, 3.7–4.2 V	1
4	GPS module	NEO-6M, 3.3–5 V	1
5	Battery	9 V DC supply	1
6	Voltage regulator	Buck converter, regulated output	1
7	Emergency stop button	Momentary push button	1
8	Connecting wires	Jumper wires	As req.

3.6. Working Principle

The device detects an emergency through the touch sensor and sends the user's location to the guardian if the alert is not cancelled within the specified time. The sequence is as follows.

- **Initialisation:** The ESP32 initialises the serial ports, touch sensor, stop button, GPS and GSM modules and remains in standby while monitoring the touch sensor.
- **Touch detection:** A touch on the sensor is treated as a possible emergency and starts a 30-second timer.
- **Cancellation period:** If the touch was accidental, pressing the stop button during this period cancels the alert and no SMS is sent.
- **Confirmation:** If the button is not pressed within 30 seconds, the emergency is confirmed.
- **Location and SMS:** The GPS latitude and longitude are read, an SMS with a map link is prepared and the GSM module transmits it to the predefined number.
- **Reset:** After the alert process, the system returns to standby for future events.

3.7. Design Rationale

A dedicated controller is used instead of a smartphone application so that the device can work independently. The user does not have to unlock a phone, open an application or select a contact; a single touch starts the process. The ESP32 is chosen because it provides several hardware serial ports, sufficient memory and an Arduino-compatible programming environment, so the GPS and GSM modules can be serviced at the same time without software serial emulation.

The cancellation period is the central design decision. Capacitive touch sensing needs no force, so a touch caused by handling, a bag or a pocket is easily generated. Rather than sending at once, the device waits for 30 seconds, during which an accidental activation can be cancelled by a deliberate

press of a separate button. The trade-off is that a genuine alert is delayed by the same period, so the length of the interval must balance false alerts against response time.

The behaviour of the controller is deliberately simple. It uses the current state of the touch input, button input and GPS data to decide the next action, and it keeps only a few state variables: the last touch state, the waiting flag, the time of touch and the debounce timer. This keeps the firmware small and easy to follow in a student-level demonstration, and it makes each stage of the sequence easy to test separately.

3.8. Advantages of the Proposed System

- **Quick activation:** a simple touch starts the emergency process.
- **Accidental-alert prevention:** the 30-second period allows cancellation before any SMS is sent.
- **Automatic location:** the guardian receives latitude, longitude and a map link.
- **Independent operation:** no smartphone application or internet connection is required.
- **Low cost and portability:** commonly available modules keep the device economical and compact.

4. Implementation and Operating Sequence

The firmware is written in Embedded C/C++ using the Arduino IDE with ESP32 board support, and the TinyGPS++ library decodes the GPS data. The setup() function starts the serial interfaces, configures the touch pin as an input and the button pin with an internal pull-up, opens the GPS and GSM serial ports at 9600 baud and initialises the GSM modem with the AT, ATE0 and AT+CMGF=1 commands, which select SMS text mode. The loop() function repeatedly reads the GPS stream, checks the touch sensor, checks the cancel button with debouncing and evaluates the 30-second timer.

Table 3. Pin assignment in the firmware

Function	Module / signal	ESP32 GPIO
Emergency trigger	Touch sensor output	27
Cancel button	Push button to GND	25
GPS serial	NEO-6M (RX / TX)	18 / 19
GSM serial	SIM800L (RX / TX)	16 / 17

A new touch is accepted only on a low-to-high transition and only when no alert is already waiting. During the waiting state the elapsed time is compared with the 30-second limit. If the cancel button is pressed first, the waiting flag is cleared and no SMS is sent. When the time expires, the program checks that the GPS location is valid. If it is valid, the SMS routine sets text mode, addresses the registered number, writes an alert message with latitude, longitude and a map link, and terminates the message with the Ctrl+Z character. If no valid fix is available, the SMS is not sent. Installation of the ESP32 board package and the TinyGPS++ library is required before compilation.

4.1. Subsystem Integration

Integration follows a staged process so that faults can be isolated more easily. The supply voltage and converter output are checked first, followed by the ESP32 and its serial monitor output. The touch sensor and cancel button are then tested by printing their states, the GPS module is connected and checked until a valid fix is reported, and the GSM module is tested with basic AT commands before an SMS is attempted. The complete sequence is run only after each module works on its own. After each stage the relevant function is checked before moving to the next one.

4.2. Operating Cycle

In standby the controller continuously feeds GPS characters to the decoder, so that a position is already available when an alert is confirmed. Every five seconds it prints the GPS status, either the latitude, longitude and number of satellites or a message that it is waiting for a fix. A touch starts the timer, and the program prints a countdown message at 25, 20, 15, 10 and 5 seconds. If the stop button is pressed, the alert is cancelled; otherwise the SMS routine runs at 30 seconds. A debounce delay on the button prevents contact bounce from being read as several presses.

The GSM modem is controlled with standard AT commands: AT checks communication, ATE0 turns off command echo, AT+CMGF=1 selects text mode and AT+CMGS addresses the recipient. The message body is then written, and the Ctrl+Z character (ASCII 26) tells the modem to send it. A

short delay after this command allows the modem to complete the transmission. The message contains the alert text, the latitude and longitude to six decimal places and a map link built from the same coordinates, so that the guardian can open the location directly on a smartphone.

5. Results and Discussion

The project report records successful operation of the principal functions during testing. When the touch sensor was activated, the ESP32 detected the input and started the 30-second cancellation period. Pressing the stop button during this period cancelled the alert, which shows that the mechanism can help prevent accidental messages. When the button was not pressed, the emergency was confirmed, the GPS module supplied the latitude and longitude, and the GSM module sent an SMS with the location to the guardian's number. The report also records a buzzer indication after confirmation. The observed values are summarised in Table 4, and the assembled prototype is shown in Fig. 3.

Table 4. Experimental results

Parameter	Value	Remarks
Power supply (VCC)	9 V battery	System powered on
Touch sensor	Activated	Emergency sequence started
Stop button (Cancel)	Pressed / not pressed	Alert cancelled or confirmed
GSM module	4.0 V	SMS alert sent to parent
GPS module	3.3–5 V	Location obtained
Alert message (SMS)	1 message	Sent to registered number
GPS location	Latitude / longitude	Included in SMS
System status	Normal / alert	Changes with input
Response time	Few seconds	Depends on GSM network

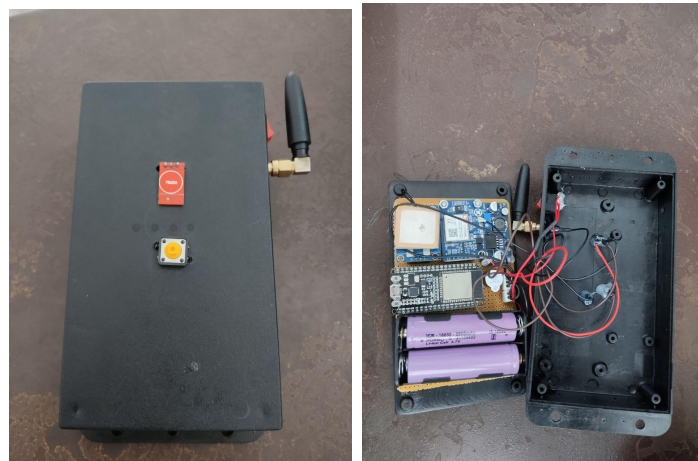


Fig. 3. Prototype hardware of the Child Safety Button (photographs from the supplied project report).

These observations demonstrate that touch detection, cancellation, location acquisition and SMS transmission can operate together in the prototype. The report does not provide a complete dataset, repeated-trial counts, measured response times or a measured GPS accuracy. The results should therefore be treated as functional test results rather than quantified accuracy or reliability statistics.

5.1. Practical Limitations

Performance depends on GPS signal availability, satellite acquisition time, GSM network coverage and environmental conditions. GPS cold-start fixes can take about half a minute, and the receiver may not obtain a fix indoors. Capacitive touch sensing can be affected by moisture or sweat. The

SIM800L draws high peak current and needs a stable supply. In the present firmware, if no valid GPS fix exists when the timer expires, the SMS is not sent and no retry is made. The device is not intended to replace certified emergency-response systems.

5.2. Suggested Further Testing

A more complete evaluation should repeat each scenario several times and record the number of trials and successful responses. The test log should include the date, location (indoor or outdoor), battery condition, network strength, time from touch to SMS delivery, and the difference between the reported and actual position. Cancellation should be tested at several moments within the 30-second period, and the supply voltage should be recorded before and during SMS transmission.

5.3. Interpretation of the Results

The prototype provides three kinds of response: an input stage that detects a touch, a decision stage that allows the user to cancel, and an output stage that sends the location. These stages support a basic emergency workflow in which a guardian is informed without the child having to operate a phone. The functions are complementary, but they do not give a complete picture of the situation. The device does not identify the nature of the emergency, and the guardian receives only the position at the moment the message is sent.

The reported observations indicate that the major functions were integrated at prototype level: touch detection, cancellation, GPS acquisition and SMS delivery. The timer is the feature that most clearly separates the design from an immediate panic button, since it gives a small window for correcting a mistake. However, the available test description does not contain enough repeated measurements to calculate a numerical false-alert rate, delivery success rate or location accuracy.

5.4. Suggested Test Plan

For touch and cancellation testing, the sensor can be touched deliberately and accidentally several times, and the stop button pressed at different moments within the 30 seconds. Each trial should record whether the timer started, whether the cancellation was accepted and whether an SMS was nevertheless sent. A trial with no button press should confirm that the SMS is sent when the timer expires.

For GPS testing, the module should be placed outdoors with a clear view of the sky and the time to the first valid fix recorded for cold and warm starts. The reported coordinates can be compared with a known reference point to estimate the position error, and the test repeated near buildings and indoors. For SMS testing, the delivery time, signal strength and message content should be noted, and the test repeated at different battery levels because the modem draws high peak current.

For power testing, the regulated output should be measured before and during transmission. A brief drop at that moment is a common cause of modem resets, and recording it would show whether the converter and battery are adequate. Any failure should be logged with the test conditions so that it can be reproduced.

6. Applications and Future Scope

Potential applications include child safety, elderly assistance, lone workers, students and travellers, and educational demonstrations of embedded control, GPS and GSM interfacing. Possible improvements, which are proposed extensions and not features of the current prototype, are:

- a mobile application showing alerts and the live position on a map;
- continuous GPS tracking and IoT cloud logging of emergency events;
- multiple emergency contacts and automatic voice calling along with SMS;
- voice-based activation and camera integration using an ESP32-CAM;
- a wearable form factor such as a band, pendant or keychain; and
- AI-based detection of abnormal situations from sensor data.

6.1. Maintenance and Safety Considerations

Before each demonstration, the battery connection, common ground and regulated output should be checked, and the SIM card should be confirmed to have an active SMS service and sufficient balance. The GPS antenna should have a clear view of the sky, and the GSM antenna should be connected before power is applied because transmission without an antenna can damage the modem. The device should be switched off before wiring is changed. A trial message to the guardian number should be sent before the device is relied on, and the guardian should be told that test messages may arrive.

The 9 V battery and converter arrangement is suitable for a demonstration but should not be treated as a certified power system. For a child-worn product, a rechargeable cell with protection, a secure enclosure and insulation of all connections would be needed, and the device should be tested to confirm that it cannot cause injury if damaged.

6.2. Future Development Priorities

Future work can be prioritised in stages. First, repeated trials can be carried out to measure false-alert rate, GPS accuracy and SMS delivery time. Second, the firmware can be improved so that the device retries when no GPS fix is available, or sends the last known position, instead of silently dropping the alert. Third, power monitoring and a rechargeable battery can be added. Finally, a mobile application, cloud logging and wearable packaging can be explored. Each upgrade should be evaluated separately, under the same test conditions, so that its effect on performance can be identified.

7. Conclusion

A Child Safety Button integrating an ESP32, TTP223B touch sensor, cancel button, NEO-6M GPS module, SIM800L GSM module and buzzer has been described. The touch sensor provides quick activation, the 30-second cancellation period reduces false alerts, and the GPS and GSM modules deliver the user's location to a predefined guardian by SMS. Results reported in the project document indicate that the major functions operated together during prototype testing. The system is suitable as a low-cost educational proof of concept, while quantified testing, power-supply refinement and the proposed enhancements are required before use in demanding real-world conditions.

The project demonstrates a simple approach to combining a quick activation method with accidental-alert protection and location sharing. Its main contribution is the integration of touch input, a cancellation timer, GPS and GSM communication in a single low-cost embedded device. The absence of a complete repeated-trial dataset limits quantitative conclusions, so further controlled testing and incremental refinement are the appropriate next steps.

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