

## Development of a Call Location Tracking System Tailored for Enhancing the Efficiency of Police Responses to Distress Signals

Yusuf K., Ajayi O., Ibrahim I., Lawal A.O., Ajikanle A.A.  
Computer Engineering Department,  
Ahmadu Bello University, Zaria

### ABSTRACT

*This project focused on the design, development, and testing of a wrist distress call device aimed at providing reliable emergency communication through Global Positioning System (GPS) and Global System for Mobile Communications (GSM) technologies. The system was meticulously assembled, integrating a Neo-6M GPS Module, Arduino Pro Mini, SIM800L GSM Module, and a capacitive touch sensor, all within a compact, ergonomic wrist device designed for ease of use. The device was engineered to capture precise GPS coordinates and transmit them via SMS to predefined contacts upon activation in distress situations. During the testing phase, the device consistently demonstrated its capability to deliver accurate location data, significantly enhancing the speed and accuracy of emergency responses. The project demonstrated that the wrist distress call device is not only effective in emergency communication but also practical for everyday wear, seamlessly integrating into the user's daily routine. The successful development of this device underscores its potential as a vital tool for emergency preparedness, offering a user-friendly solution that ensures prompt assistance during critical situations. The intuitive activation mechanism, combined with the device's compact design, proved to be a practical and reliable tool for safeguarding individuals, thereby reinforcing its role as an essential asset in emergency scenarios. The project has laid a solid foundation for further innovations in wearable emergency communication technology, highlighting the device's impact on improving safety and response times in critical situations.*

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### INTRODUCTION

Addressing safety concerns has become increasingly important due to the rise in incidents such as kidnappings, child abuse, disappearances, and various forms of misconduct affecting individuals of all ages [1]. The development of a wearable location tracking system for police response to distress calls offers a proactive measure to monitor the well-being of Nigeria's populace. This system allows for the rapid location and assistance of individuals in distress through the activation of an emergency button, which sends an instant location signal via a message to both emergency contacts and law

enforcement authorities [2]. Nigeria continues to face challenges with violent and minor crimes, including assault, burglary, mugging, carjacking, and home invasions, with victims often receiving little assistance from the police due to outdated communication technologies and limited internet access [3]. Additionally, road safety remains a significant issue in Nigeria, with frequent armed robberies and hijackings exacerbated by poor road conditions and traffic congestion, creating a dangerous environment for drivers. These circumstances often lead to accidents, leaving victims in need of immediate help from law enforcement or other safety agencies [4]. This

Corresponding author: Yusuf, K.

✉ [yusufkabiru143@gmail.com](mailto:yusufkabiru143@gmail.com)

Computer Engineering Department, Ahmadu Bello University, Zaria.

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project, involving the design and implementation of a call location tracking system for police response in urban areas, is designed to be worn continuously by individuals and operates autonomously, except in emergencies that require the activation of the emergency button. The initiative aims to improve personal safety by enhancing the reliability and efficiency of current location technologies, addressing issues of communication, adaptability, and cognitive performance. It also evaluates the strengths and weaknesses of existing technological solutions, with the system relying on the PIC16F877A microcontroller, GPS, and the A6 mini-GSM module to provide deeper insights into the practical application of location technology [5].

### LITERATURE REVIEW

A power supply system plays an essential role in providing the required energy for electronic circuits. According to [1], a battery, an integral part of this system, consists of one or more electrochemical cells, which feature terminals for delivering electrical energy. Each cell comprises two distinct metals immersed in an electrolyte that facilitates the movement of ions. These cells are classified into primary and secondary types. A primary battery generates energy until it depletes, at which point it cannot be recharged and must be discarded. In contrast, a secondary battery, also referred to as a rechargeable battery, can be restored to its original state by reversing the chemical reaction through the introduction of an external electrical potential [6].

The LM7805 IC Voltage Regulator is an essential component in maintaining stable voltage levels in electronic circuits. As illustrated in Figure 1 below, this integrated circuit offers an affordable and reliable means of regulating voltage, especially in circuits requiring consistent 5-volt outputs. This three-terminal regulator provides robust protection against overheating and short circuits, making it a popular choice for various applications [7].

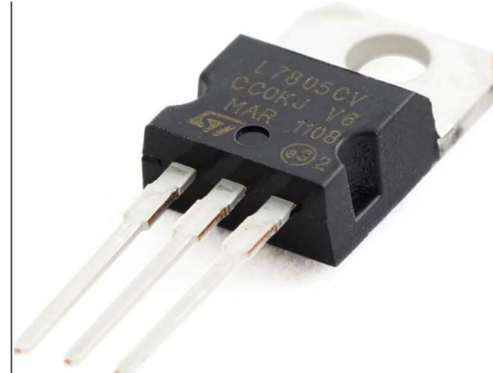


Fig. 1. LM7805 IV Voltage Regulator [7]

The PIC Microcontroller, specifically the PIC16F877 model, is favored in many applications due to its advanced capabilities and ease of installation. This microcontroller offers features such as EEPROM data memory, an Analog-to-Digital converter, and serial communication interfaces, which make it suitable for automotive, industrial, and consumer electronics. As shown in Figure 2, the 40-pin configuration allows for multiple connections to input/output ports, which can be utilized to implement sophisticated control mechanisms [8].

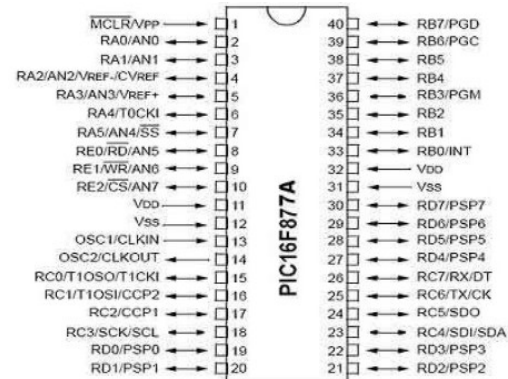


Fig. 2. The PIC Microcontroller Circuit with 40 pins [8]

The Global Positioning System (GPS) Module is an indispensable tool for location tracking and navigation. It operates by receiving radio signals from a network of over 20 satellites to determine precise geographical positions in

Corresponding author: Yusuf, K.

✉ [yusufkabiru143@gmail.com](mailto:yusufkabiru143@gmail.com)

Computer Engineering Department, Ahmadu Bello University, Zaria.

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real-time. Regardless of weather conditions or time of day, GPS remains reliable for a range of applications, from navigation to scientific research, including earthquake monitoring. This system has become integral to modern navigation and timing solutions worldwide [9].

The Global System for Mobile Communications (GSM) Module, widely recognized for its ability to enable communication over mobile networks, functions either as a modem or a mobile phone within embedded systems. This module requires a SIM card to access the services provided by a telecommunications network and finds applications across industries, including security, remote monitoring, and transaction processing. Additionally, GSM modules are versatile in handling data transfer via GPRS, supporting applications like weather stations and tracking systems [10].

#### METHODOLOGY

The methodology for creating and deploying a call location tracking system, aimed at enhancing the efficiency of police responses to distress signals, follows a series of steps. The first task involved developing the power storage unit by designing both a block diagram and a circuit, integrating various components for optimal functionality. The block diagram outlined the minimal battery power storage system, where the Battery Management System (BMS) monitored the battery's status and communicated with the microcontroller, which processed data to ensure battery health and safety. Additionally, the charger regulated power flow to maintain optimal battery performance and longevity. The block diagram is presented in Figure 3 below. The circuit diagram followed in Figure 4, showing the connections between the battery, BMS, charger, and sensors, ensuring real-time data monitoring and regulation of the charger's operation for safe and efficient energy storage.

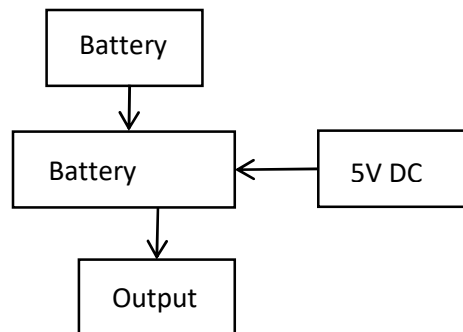


Fig. 3. Block diagram of Power Storage

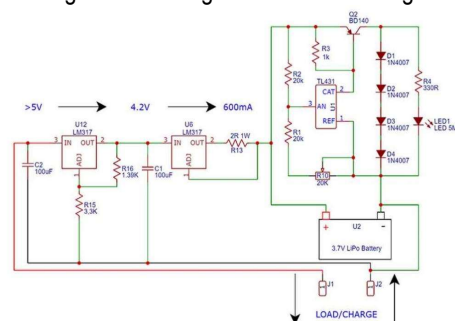


Fig. 4. Circuit Diagram of Power Storage

The hardware components of the system were then designed, beginning with the system architecture that optimized police responses to distress signals. The architecture featured a structured flow, starting with a distress signal and ending with the dispatch of assistance. Key elements included GPS for location tracking, GSM for communication, and a microcontroller for data management. The flowchart in Figure 5 below visually represents this process, showing the interaction of hardware and software components in minimizing response times while ensuring location accuracy. The Arduino Pro Mini microcontroller was employed due to its compact design and low power consumption, making it suitable for portable and embedded applications, as discussed in the next section.

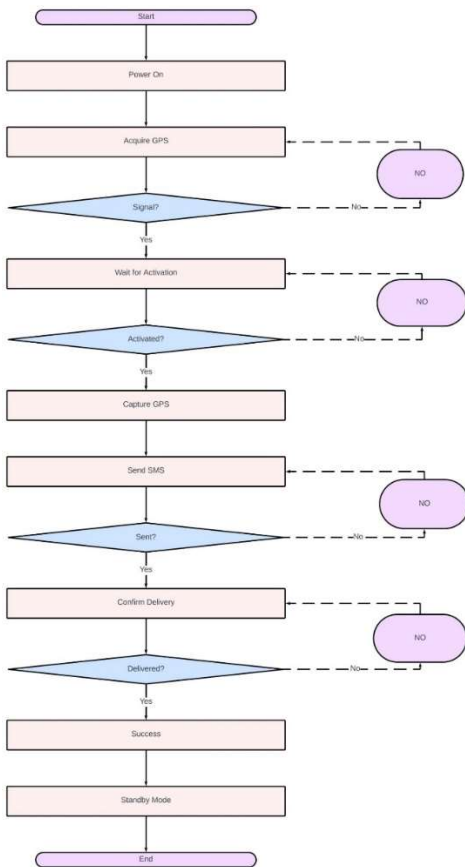


Fig. 5. System Flowchart

The NEO-6M GPS module, used for accurate location data, provided position, speed, altitude, and time information. Its triangulation method calculated precise location by processing signals from multiple satellites. The SIM800L GPRS GSM module was integrated to handle voice calls, SMS, and GPRS data transfer, supporting global communication through a UART interface. Together, these components ensured real-time transmission of distress signals, facilitating prompt responses by police units.

To develop the distress call device, a block diagram was first created, illustrating the interaction between the Arduino Pro Mini, NEO-6M GPS module, capacitive touch sensor, and SIM800L GPRS GSM module. The device's workflow involved the touch sensor triggering the GPS module to transmit location data to the

Arduino, which then forwarded this information via the SIM800L module as a text message. The block diagram for this device is shown in Figure 6 below.

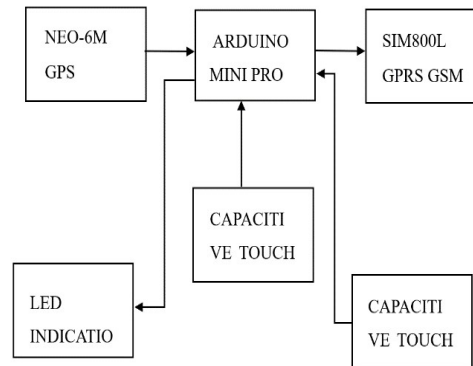


Fig. 6. Block diagram of the distress call device

Once a working prototype was verified, the device was assembled. The connections were made by linking the GPS and GSM modules to the Arduino Pro Mini, with proper attention to voltage regulation and current requirements. Careful checks ensured no short circuits or loose connections, and components were secured with hot glue. Figure 7 below details the Arduino IDE interface, which was employed to program the system. The process involved writing, compiling, and uploading the code to the Arduino, which then controlled the system's operation. After programming, the system was tested by powering it on and checking its functionality, including GPS coordinate acquisition and SMS transmission.

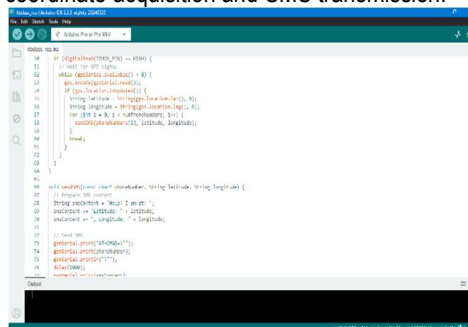


Fig. 7. Arduino Interface

Testing and evaluating the system ensured the GPS and GSM modules were

Corresponding author: Yusuf, K.

[yusufkabiru143@gmail.com](mailto:yusufkabiru143@gmail.com)

Computer Engineering Department, Ahmadu Bello University, Zaria.

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functioning correctly, with SMS notifications successfully sent to a predefined number containing the correct GPS coordinates. Finally, the system was packaged in a sleek plastic enclosure resembling a wristwatch, with secure compartments for all components and adequate ventilation. A Polymer Lithium-Ion battery was used due to its high energy density and lightweight properties, ensuring reliable and efficient power delivery. The integration of a capacitive sensor and LED indicator provided user feedback and ensured proper device functionality.

## RESULTS AND DISCUSSION

The wrist distress call device's power storage system was designed to ensure reliability and efficiency. It utilized a Polymer Lithium Ion (Li-Po) battery integrated with a Battery Management System (BMS) for safe and controlled charging and discharging. During testing, the system demonstrated a consistent ability to provide steady power to the device, though the battery required regular recharging. Figure 8 below shows the power storage of the device.

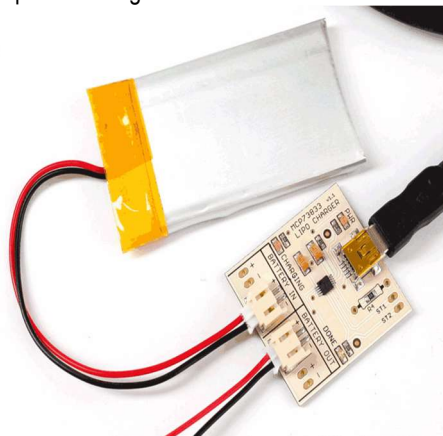


Fig. 8. Power Storage

The design of the hardware components was geared toward both functionality and user convenience. Essential components, such as the Arduino Pro Mini, NEO-6M GPS module, and SIM800L GPRS GSM module, were selected for their seamless integration. A capacitive touch sensor was incorporated to enable easy activation of the distress signal. The GPS module efficiently

captured location data, which the GSM module then transmitted via SMS. The hardware components were arranged in a compact, user-friendly layout as shown in Figure 9 below, contributing to the device's functionality and meeting the project's objectives.

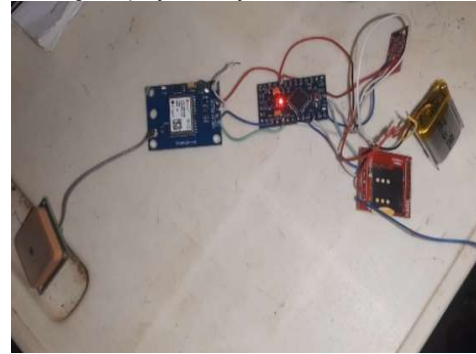


Fig. 9. Hardware Component Integration

The culmination of the hardware integration and design efforts resulted in the development of a functional wrist distress call device. This compact, wearable prototype, as shown in Figure 10 below, allowed users to send distress signals by activating the capacitive touch sensor, which prompted the GPS module to capture location data and the GSM module to transmit this information via SMS to predetermined contacts. Testing confirmed the device's reliability in sending distress signals as expected, ensuring user safety in emergency situations.

Corresponding author: Yusuf, K.

✉ [yusufkaboru143@gmail.com](mailto:yusufkaboru143@gmail.com)

Computer Engineering Department, Ahmadu Bello University, Zaria.

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Fig. 10. Distress Call Device

Programming was critical to ensuring the wrist distress call device's performance. The Arduino IDE was used to develop and upload the code that controlled the interaction between the Arduino Pro Mini, the GPS module, and the GSM module. The code efficiently processed location data and triggered the GSM module to send an SMS when the distress signal was activated. Additionally, the system was programmed to respond swiftly to the capacitive touch sensor, making the device both functional and user-friendly. The code was tested and executed as intended, bringing all the components together to form a cohesive and efficient system. Figure 11 below shows a section of the code that was used to program the system.

```

kbclass_rep.ino
50 if (digitalRead(TOUCH_PIN) == HIGH) {
51   // Wait for GPS signal
52   while (gpsSerial.available() > 0) {
53     gps.encode(gpsSerial.read());
54     if (gps.location.isUpdated()) {
55       String latitude = String(gps.location.lat(), 6);
56       String longitude = String(gps.location.lng(), 6);
57       for (int i = 0; i < numPhoneNumbers; i++) {
58         sendSMS(phoneNumbers[i], latitude, longitude);
59       }
60       break;
61     }
62   }
63 }
64 }
65
66 void sendSMS(const char* phoneNumber, String latitude, String longitude) {
67   // Prepare SMS content
68   String smsContent = "Help! I am at: ";
69   smsContent += "Latitude: " + latitude;
70   smsContent += ", Longitude: " + longitude;
71
72   // Send SMS
73   gsmSerial.print("AT+CMGS=\");
74   gsmSerial.print(phoneNumber);
75   gsmSerial.println("\n");
76   delay(1000);
77   gsmSerial.print(smsContent);
  
```

Fig. 11. Programming the System

Testing and evaluating the functionality of the wrist distress call device was necessary to ensure its effectiveness. The system was rigorously tested, consistently performing as intended by accurately capturing GPS coordinates and sending SMS alerts upon activation. The capacitive touch sensor was responsive and reliable, making the device practical for real-world use in emergencies. The tests confirmed that the device was ready for practical deployment as illustrated in Figure 12 below, having met the predefined criteria for functionality and user safety.





Fig. 12. Testing the System

Packaging played a significant role in enhancing the device's usability. The wrist distress call device was enclosed in a durable, lightweight casing resembling a wristwatch. This packaging ensured ease of wear, making it comfortable for everyday use. The design also included ventilation for heat management, while the touch sensor remained easily accessible for emergency activation as shown in figure 13 below. Overall, the packaging not only protected the device's components but also made it practical and user-friendly in everyday situations.



Fig. 13. Packaging the System

The combination of the Arduino Pro Mini, GPS module, and GSM module, together with the capacitive touch sensor, allowed the wrist distress call device to function as a reliable emergency communication tool. Testing confirmed its effectiveness in capturing and transmitting location data during emergencies,

making it a valuable asset for real-time distress signaling. The device's wearable design and ease of use increased its practicality for everyday scenarios, while its ability to send timely and accurate alerts enhanced its overall effectiveness as a life-saving tool. The device proved to be a robust solution for emergency response, with future improvements focused on extending battery life and increasing its resilience to environmental conditions.

## CONCLUSION

The design and development of a wrist distress call device aimed to provide reliable and rapid emergency communication. This project focused on creating a device capable of capturing GPS coordinates and sending them via SMS upon activation of the distress call. The process included designing electronic components, integrating them into a compact wrist-worn device, and conducting functionality testing. While the device successfully transmitted accurate location data, several limitations were noted, including the influence of environmental factors on GPS accuracy, the dependency on mobile network availability for the SIM800L module, the limited battery life requiring frequent recharging, and potential discomfort for varying wrist sizes. Despite these challenges, the device's effectiveness in capturing and transmitting location information, combined with its ease of use through a capacitive touch sensor and wearable design, demonstrated its potential as a practical solution for emergency situations.

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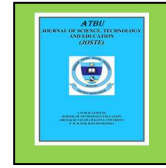
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Corresponding author: Yusuf, K.

✉ [yusufkabiru143@gmail.com](mailto:yusufkabiru143@gmail.com)

Computer Engineering Department, Ahmadu Bello University, Zaria.

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Corresponding author: Yusuf, K.

✉ [yusufkabiru143@gmail.com](mailto:yusufkabiru143@gmail.com)

Computer Engineering Department, Ahmadu Bello University, Zaria.

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