Embedded Floating Bag for Military Use

Mrs. R. Shashikala,
Assistant Professor,
Department of Electronics and Communication Engineering,
Guru Nanak Institutions Technical Campus

Ms. A. Bhavitha
Department of Electronics and Communication Engineering,
Guru Nanak Institutions Technical Campus.

Ms.Ch. Srilaxmi
Department of Electronics and Communication Engineering,
Guru Nanak Institutions Technical Campus.

Mr. B. Shiva
Department of Electronics and Communication Engineering,
Guru Nanak Institutions Technical Campus.

Abstract- The purpose of this research is to develop an innovative Suspended Floating Bag (SFB) for military load carriage which is meant as a solution to problems associated with conventional backpacks. This excess weight exposes infantry soldiers to higher levels of energy expenditures associated with decreased performance. This load is controlled by one of the mechanisms used in the SFB which comprises springs, pulleys, and elastic ropes that suspend and minimize the vertical displacement thereby reducing movement within the structure. In addition, these products feature a lightweight and strong frame coupled with rack and pinion for enhanced stability and precision. Real-time location tracking and anti-theft function supported by embedded technologies such as Arduino Uno micro utility controller, Global Positioning System (GPS), Global System for Mobile Communications (GSM) modules, and buzzer system. Furthermore, it is also fitted into a self-sustaining power generation system by way of a rack and pinion as well as a dynamometer. Reduction in vertical excursion and total ground reaction force during field trials provides an enduring solution and diminishes the likelihood of conventional back pain. The research has thus made progress in the development of load carriage systems that could improve endurance as well as the comfort of military forces during critical engagements off the battlefield.

Keywords- ***Suspended Floating bag (SFB), backpack, fatigue stress, Embedded system, rack and pinion, Global Positioning System (GPS), and Global System for Mobile Communications (GSM) system.***

I. INTRODUCTION

Suspended-load backpacks have evolved through the general history of backpacks in response to particular needs of different circumstances, activities, or technical modifications. The modern hanging backpacks are a must-have in a hiker's inventory or baggage of any climber and professional who carries a heavy load. Carrying large loads on their backs was a common practice for people in previous centuries. However, traditional backpacks are quite different from modern suspended load designs. Several problems may arise due to carrying heavy loads inside of a knapsack such as injuries, modified gait cycles, and low backache. Such a study focuses on lowering the heavy load carried by a teenage child and not exceeding 10% of its body weight. Nevertheless, luggage overload in traveling, especially, requires deep consideration of its causes. The hardware and cargo in India's military operations go hand-in-hand with the backpacks. Since these soldiers carry weights more than thirty percent of the size of their bodies these weights reduce the efficiency with which they perform because it increases the energy intake for them by these weights. Walking with a carried load involves transferring the load center toward the soldier's center of mass, thus increasing acceleration forces and energy consumption. The project offers an alternative to traditional combat backpacks to improve soldiers carrying capacity, and consequently, their wellbeing in a variety of operations.

II. LITERATURE SURVEY

Extensive research in the fields of biomechanics, ergonomics, and wearable systems has significantly contributed to the development of intelligent backpacks designed to reduce the physical strain on the human body while improving comfort and performance. Andy L. Ruina, Laurence C. Rome et al. presented an innovative design of a detachable ergonomic backpack, which reduces energy expenditure and metabolic cost by approximately 82–86%. Their work highlights how mechanical optimization, such as independent load suspension, allows users to carry heavier loads (above 5.2 kg) with less effort, offering a substantial improvement over conventional backpacks. Evan Campo and Camilla Perez emphasized the challenges faced by military personnel, who frequently carry gear exceeding 30% of their body weight. This excessive loading leads to increased energy demands and a decline in physical performance, primarily due to the vertical displacement of the body's center of mass. Their findings stress the importance of load stabilization and redistribution to reduce fatigue and musculoskeletal strain.

In a related study, Everett Harman, Katy Reynolds, and Joseph Knapik conducted a historical and biomechanical analysis of military load carriage and discovered that before the 18th century, soldiers rarely carried more than

15 kg. However, due to advancements in gear, communication, and weapon systems, modern infantry now handle significantly heavier loads. Their research underscores the physiological necessity of aligning the load's center of mass with that of the human body to minimize energy consumption, while also recommending the use of rucksack hip belts to distribute weight more effectively and reduce shoulder pressure. Further supporting this, Madhu Sudan Pal, Dhurjati Majumdar, and Deepti Majumdar studied the kinematic and postural effects of carrying military loads ranging from 4.2 kg to 17.5 kg. Their analysis revealed significant changes in stride length, gait rhythm, and joint movement (especially in the ankle and hip), indicating the body's adaptive response to increasing load. They caution that improper load distribution or prolonged exposure to even moderate weights may lead to joint injuries and long-term musculoskeletal issues.

Lastly, Andar Bagus Sriwarno, Suprijanto, and Narendra Kurnia Putra introduced a computational model for load-suspension backpacks that use spiral and clock spring mechanisms to minimize ground reaction forces. Their research focuses on adjusting spring stiffness to adapt to the user's movement and terrain, providing a cost-effective, mechanical solution to improve carrying comfort. This design philosophy supports the integration of smart embedded systems that can dynamically adjust load tension, monitor user conditions, and optimize comfort in real time. Collectively, these studies provide a comprehensive scientific basis for designing an advanced embedded backpack system that combines ergonomic features with sensor technology, load redistribution, and real-time alerts to enhance user safety, performance, and mobility.

DESIGN AND IMPLEMENTATION

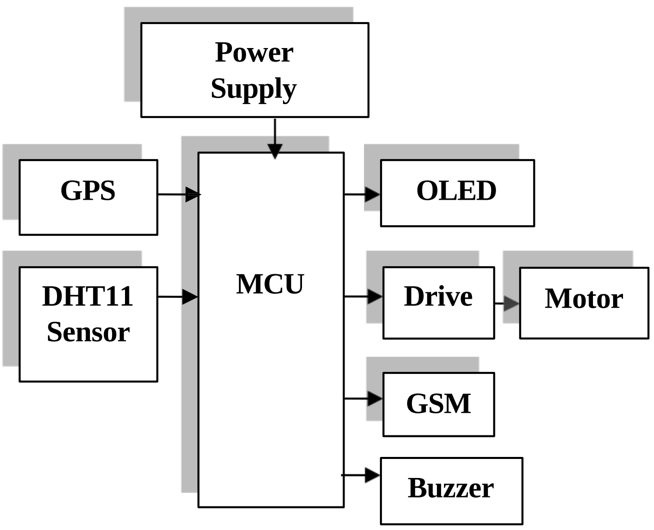

Figure 1: Block diagram of Embedded bag

Displays the block diagram of embedded work. A floating bag, featuring GPS, a buzzer, and a rack and pinion mechanism, presents an innovative solution for power generation, particularly in aquatic environments. This floating bag, usually filled with a buoyant gas, is tethered to the seabed or a fixed structure, enabling it to oscillate with the natural motion of waves or currents. The embedded GPS facilitates precise location tracking, ensuring optimal placement for harnessing energy from the kinetic forces of the water.

The rack and pinion mechanism is essential to converting the vertical movement of the floating bag into rotational motion. As the bag moves up and down, the rack engages with the pinion, translating the mechanical energy into a rotating shaft. This rotational motion can be further connected to a generator, converting the mechanical energy into electrical power. To enhance the functionality and safety of the system, a buzzer integrated with the GPS can serve as a warning or signaling device. It can alert nearby vessels or personnel to the presence of the floating power generation unit.

COMPONENTS:

Power Supply: Provides the required voltage and current to all modules.

Details: It can be rechargeable battery, power bank, or Li-ion cell.

A voltage regulator (eg, AMS1117 or 7805) ensure consistent voltage, typically 5v or 3.3v to prevent damage to sensitive components.

Why Important: All modules like GPS, GSM, Sensors, and the microcontroller need a steady power source to function reliably.

MCU (Microcontroller Unit): Acts as the central controller of the embedded system.

Details: Interface with all components: sensors, motor, display, buzzer, GPS, GSM.

Runs the main program which-Reads data from sensors, Sends data to display, Controls the motor through the drive, Sends alerts via GSM, Activates the buzzer when needed.

EX: Arduino Uno/Nano, ESP32, STM32

Why Important: It processes data and the controls operations-like the brain in the human body.

GPS Module: Provide real- time geographical location of the bag.

Details: Use satellites to receive coordinates and communication with the MCU via serial communication.

Common modules like NEO-6M, Ublox GPS.

Why Important: Allows tracking of the bag in case it's lost or stolen. Enhances security and monitoring.

DTH11 Sensor: Measures temperature and the humidity levels inside or around the bag.

Details: Temperature range from 0-50°C and Humidity range from 20-90%RH. Sends digital signal to MUC via a single wire protocol.

Why Important: Useful when carrying medicines, electronics, or food. The system can alert the user if temperature/humidity exceeds safe limits.

OLED DISPLAY: Display information to the user such as finding location coordinates, temperature and humidity readings and System status or warnings.

Details: Type: 0.96" or 1.3" SSD1306-based OLED

Communicates via I2C or SPI

Low power, high contrast display

Why Important:

Provides a simple user interface.

No need to connect to external device for basic info.

Motor + Driver Circuit: Performs mechanical actions like as Opening a compartment, Moving the bag (if it's a smart or automated bag)

Details:
Motor cannot be driven directly by MCU due to high current requirements.
Motor Driver IC (e.g., L298N or L293D) acts as an interface.
The MCU sends signals to the driver which powers the motor accordingly.

Why Important:
Enables physical movement or action, adding automation.

GSM Module: Enables wireless communication through the mobile network.

Details: Common modules: SIM800L, SIM900.
Sends/receives SMS messages or data.
Used to send location or environmental alerts to user's mobile phone.

Why Important:
Allows remote tracking and alerts.
Improves security—can notify user instantly if the bag is moved or tampered with.

Buzzer: Provides audio alerts or alarms.

Details:
Small electronic speaker that can be turned ON/OFF by the MCU.
Can produce beeps or continuous sound based on programming.

Why Important:
Alerts the user in case of: Temperature warnings, Unauthorized access or movement, Low battery or system errors.

System Workflow Example:

1. Power ON → MCU starts.

2. Reads data from GPS & DHT11.

3. Displays data on OLED.

4. If values exceed threshold (e.g., temperature too high):

Triggers buzzer.

Sends alert message via GSM.

5. If movement is needed, motor is activated through driver.

WORKING:

The Embedded Bag System is a smart, multi-functional setup designed for enhanced security, environmental monitoring, and remote tracking. The operation begins with the power supply unit, usually a battery backed by a voltage regulator, which distributes stable power to all electronic modules. Once activated, the Microcontroller Unit (MCU) starts executing its embedded program. It immediately begins communication with connected sensors and modules. The DHT11 sensor continuously monitors the temperature and humidity levels inside or near the bag and sends the digital data to the MCU. In parallel, the GPS module locks onto satellite signals and provides accurate real-time location data (latitude and longitude), which is also passed to the MCU via serial communication. All this collected data is displayed on the OLED screen, giving users real-time updates on environmental conditions and location. If any abnormal readings are detected, such as a sharp increase in temperature or a sudden change in humidity, the MCU takes action by triggering a buzzer, providing a local audible alert. At the same time, the MCU uses the GSM module to send a text message (SMS) to the user's mobile number containing the exact GPS coordinates and sensor values, ensuring that the user is notified remotely even when away from the bag. If the system design includes a mechanical feature—like an automatic compartment or robotic movement—the MCU activates the motor driver circuit (e.g., L298N), which in turn drives a DC or servo motor to perform physical tasks like moving the bag or opening a smart locker. This entire system works in real-time and operates autonomously, making the bag intelligent, user-friendly, and highly secure, especially in scenarios like travel, school safety, or transporting temperature-sensitive goods such as medicines or electronics.

RESULTS

Embedded Floating Bags (EFBs) revolutionize load carriage by effectively redistributing the impact on the body, minimizing localized stress on specific body parts. The overall impact of the burden on the body is significantly reduced by 60 - 70% as a result of this creative design. In contrast to conventional backpacks that concentrate stress on the shoulders and the spine, EFBs employ advanced suspension mechanisms and load distribution systems, ensuring even load dispersion. This not only enhances comfort but also reduces the risk of injuries and markedly improves endurance during heavy load-bearing activities such as military engagements.

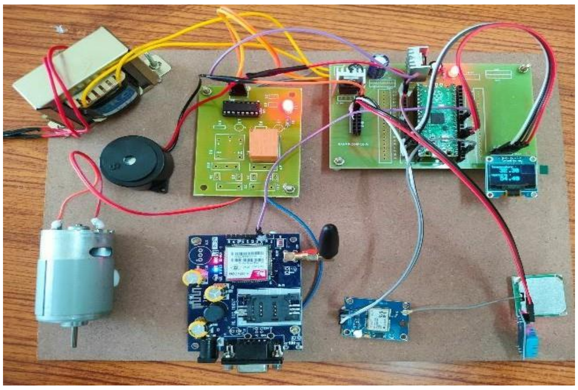

Figure 02: Working

Additionally, the integration of a suspended load floating bag pack with a GPS tracking system. Real-time GPS tracking supports environmental monitoring, and geospatial data collection, and facilitates asset recovery in the event of equipment malfunctions, ultimately optimizing logistics and ensuring regulatory compliance. Overall, GPS tracking emerges as a valuable asset in enhancing safety, precision, and operational efficiency revealing the practical implementation of the Floating Bag mechanism. The Embedded Floating Bag for Military Use is a technologically advanced solution designed to reduce soldiers' physical strain while carrying heavy loads by incorporating. It enhances operational efficiency with real-time tracking through GPS and GSM, an anti-theft buzzer system, and a self-sustaining power mechanism. The lightweight yet durable design ensures stability and endurance, minimizing back pain and energy expenditure. Despite challenges such as increased complexity, cost, and maintenance, its benefits in military, rescue, and outdoor applications make it a valuable innovation for enhancing mobility, security, and comfort in demanding environment.

CONCLUSION

In the world of load-carrying gear, suspended-load backpacks have shown to be a useful invention. Better load distribution, decreased chance of injury, and increased comfort make them the go-to option for anybody doing occupations that require prolonged heavy lifting. To fully benefit from this technology, proper selection, fitting, and upkeep of these backpacks are essential. The paper will examine the musculoskeletal and physiological problems that soldiers could have while performing their duties. Its support not only eases long excursions but also lowers the risk of injury from painful back, neck, or knee pain. be further enhanced to incorporate portable power generation as well as victim transport. Integrating sensors like the DHT11 which monitors humidity and temperature it also provide real-time environment data to ensure optimal comfort and safety for the user during filed operations.

REFERENCES

[1] Camilo Eduardo Perez and Oscar Ivan Campo "Design of a load carriage system oriented to reduce acceleration forces when carrying a backpack". DOI: 10.17533/udea.redin.20190734

[2] Matthias Lochmann, Elsevier B.V. "Effect of walking speed on gait sub-phase durations ",0167-9457/! 2015

[3] Prateek Bagari, Ankita Bhatia "Designing of Rack Pinion Mechanism for Power Generation at Speed Breaker" © March 2017 | IJIRT | Volume 3 Issue 10 | ISSN: 2349-6002

[4] Narcisa T. Morallo "Vehicle tracker system design based on GSM and GPS interface using Arduino as a platform", Vol. 23, No. 1, July 2021, ISSN: 2502-4752.

[5] Jordane G. Grenier, Nicolas peyrot. "Energy Cost and Mechanical Work of Walking during Load Carriage in Soldiers"

[6] Ahmad Hanif Faiz, "An Innovation for Hiking Backpack to Reduce Force and Load on the Back Part of Body with Hypothermia Early Prevention Function", ISBN: 978-623-7253-28-0.

[7] Chenglong Fu, "Design of an Elastically Suspended Backpack with a Tunable Damper" October 2019DOI: 10.1109/ARSO46408.2019.8948763.

[8] Dr. Kyaw Hlaing "Arduino-based tracking system using GPS and GSM", © 2019.

[9] Fabiana Rodrigues Silva, "Biomechanical alterations of gait on overweight subjects",doi.org/10.1590/2446-4740.180017.

[10] Sudip ray, Tanmayee puntambekar, "Accessible and Secure Backpacks for Daily Use", SSN: 2305-7246.

[11] A B Sriwarno and S Suprijanto. "Biomechanical analysis on human gait and posture for development of floating backpack" doi:10.1088/1757-899X/830/3/032052.

[12] A.M.Pimpley, "Frequency Damping Backpack Exoskeleton with Load Variable Spring Stiffness" doi:10.1088/1757-899X/1194/1/012006

[13] M. Sneha, J. Usha Kiran, "Electricity generation using rack and pinion mechanism ",© 2023 IJCRT | Volume 11, Issue 5 May 2023 | ISSN: 2320-2882

[14] Boffey D, Harat I, Gepner Y, Frosti Cl, Funk S, Hoffman Jr. Mil Med, “The Physiology and Biomechanics of Load Carriage Performance”, 2019 Jan 1, Doi: 10.1093/Milmed/usy218.pmid: 30252089.

[15] Attwellsrl, birrellsa, Hooper RH, Mansfield NJ.Ergonomics “Influence of Carrying Heavy Loads on Soldiers' Posture, Movements, and Gait”. 2006Nov15;49(14):152737.Doi:10.1080/00140130600757237. pmid: 17050392 .