SOLAR-POWERED E-UNIFORM SYSTEM FOR THERMAL REGULATION

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ABSTRACT

This project presents the design and development of a solar-powered E-uniform system for thermal regulation in extreme environmental conditions. Soldiers operating in harsh climates are exposed to severe heat and cold stress, which can significantly affect their performance and safety. To address this challenge, a smart wearable thermal management system is proposed.

The system utilizes a photovoltaic solar panel as the primary energy source, with a 12V DC lead-acid rechargeable battery for energy storage and continuous operation. A regulated power supply is used to provide stable voltage to the control circuitry. The core of the system is an embedded controller that manages sensing, processing, and actuation.

The proposed system operates in two modes: summer mode and winter mode. Based on the selected mode, a relay-based switching mechanism controls the polarity of a Peltier module, enabling heating or cooling effects. The thermal output is transferred through a conductive interface to provide comfort to the user. Additionally, the system integrates basic monitoring features and is designed as a prototype module that can be incorporated into a wearable uniform. The use of renewable energy ensures sustainability and reduces dependency on conventional power sources.

This work demonstrates a compact and efficient solution for enhancing soldier

comfort and operational efficiency in extreme weather conditions.

Keywords: E-uniform, Solar energy, Peltier module, Thermal regulation, Wearable system.

1. Introduction

Warriors are the Army's most imperative asset. Warriors assume an important part to make sure one's nation. The term warriors incorporate administration men and ladies from the military, Air Force, Navy, and Marine. While giving security to the country, they could challenge inconveniences in hot/frosty climate conditions. Both exceptionally hot and icy temperatures might be unsafe for well-being. This venture may be a solution for this circumstance. during this venture, an E-Uniform is planned which provides better security to the officers who are working in great climate conditions. Soldiers are the most important resource of a

country. They protect its people and come to aid whenever called upon. They are always ready for performing their duties no matter how harsh the conditions are. The soldiers sacrifice many things for their country. There are many problems the soldier may face during his/her deployment. The Soldier may get lost or abducted by enemies or may need to contact the army or base. At very low temperature one of the major Problem is the risk of hypothermia. Hence the soldiers must be well equipped with technology.

2. PROBLEM STATEMENT:

1.The man/military in ice land or in snow they work 24 hours and 7 days so their temp. is below zero degree centigrade. They have to survive their and also in desert their temp. Is above 40 degrees centigrade, and their also we have to maintain body temp. 27 degree centigrade so we have need to prepare the heating and cooling jacket.

2.In this project we are going to design an E-Uniform which gives better protection to the soldiers who are working in extreme weather condition Proposed System.

The concept of E-Uniform or E-Jacket to be precise, discussed in this paper is especially designed for the safety and security of soldiers. The safety measure which is taken into account is at extreme weather conditions Peltier plate is used to provide normal temperature to body when there is excessive heat or cold. To make the system eco-friendly solar panels are used as the power source of the system. Arduino nano board is used as the controlling device interfaced with other functional modules of the system. Temperature sensor (LM35) is used to detect the temperature of the environment which cause effect on the Peltier plates with the help of Two channel relay. The Peltier plates are responsible for heating and cooling sensations inside the jacket. The metal detector placed inside E-Jacket for safety has made it more advanced because it detects the nearby metals like bomb, etc.

The proposed system is an effective security and safety system which is made by integrating the advancements in wireless and embedded technology. It helps for a successful secret mission. This system can be used in critical conditions. The smart army jacket is proposed in such a way that it could monitor the health, internal temperature as well as emergency notification in the form of short message service for the soldier. The project is operated in two modes summer mode and winter mode. By selecting the mode of operation such that it can drive body heater/cooler. The heater/cooler in turn will help us to provide chilling or warming effect inside the uniform which helps the soldier to bear to any kind of external environment and he can work efficiently without heat stress or cold stress. The metal sensor will detect the metal like bomb and intimate the soldier with a buzzer indication.

Fig 1.3: proposed solar uniform.

1.1 Objectives of the Project.

The use of solar-based e-uniforms for soldiers can have several objectives, including:

1. Increased Comfort: Soldiers often have to work in harsh conditions and wearing heavy and uncomfortable uniforms can add to their physical stress. The use of lightweight and breathable e-uniforms can improve the comfort level of soldiers and reduce the risk of heat exhaustion.
2. Enhanced Performance: Solar-powered e-uniforms can include various sensors and devices that can monitor soldiers' vital signs, movement, and location. This information can be used to optimize their performance, prevent injuries, and ensure their safety in hazardous environments.
3. Reduced Maintenance Costs: E-uniforms can be designed to be durable, and their components can be easily replaced or upgraded. Solar-powered uniforms can also reduce the need for battery replacements or charging, leading to lower maintenance costs.
4. Sustainability: The use of solar energy in e-uniforms can reduce the reliance on fossil fuels and contribute to a more sustainable future. Additionally, the lightweight and durable nature of e-uniforms can reduce the environmental impact associated with traditional uniforms' production and disposal.

Overall, the objectives of solar based e-uniform for soldiers are to improve their comfort, performance, and safety while reducing maintenance costs and promoting sustainability

1.4 Scope of the Project.

For the future expansion, this jacket can easily Powered by a small portable solar panel and make it more echo friendly. The use of solar panel gives continuous output of power with less maintenance. We can utilize this jacket to protect us from over-heating and over-cooling. For the future development, this uniform will simply Powered by a small movable solar array.

Here are some potential future developments for solar based e-uniform for soldiers:

1. Artificial intelligence (AI) integration: AI algorithms could be used to analyse data from the temperature, heartbeat, and metal sensors to provide real-time feedback to soldiers and commanders. For example, AI could be used to alert soldiers to dangerous levels of heat or to identify potential threats based on metal sensor data.
2. Wireless connectivity: E-uniforms could be equipped with wireless connectivity, allowing soldiers to transmit data from their

sensors to a central command centre in real-time. This would allow for faster response times and more efficient monitoring of soldier health and safety.

3. Energy storage improvements: As energy storage technology continues to improve, e-uniforms could be equipped with smaller, more efficient batteries that can store more energy and provide longer battery life. This would reduce the weight and size of the e-uniform, making it more comfortable for soldiers to wear.

4. Improved sensor accuracy and durability: As sensor technology improves, we can expect to see sensors that are more accurate, durable, and reliable. This would improve the quality of data collected by the sensors and reduce the risk of sensor failure in the field.

5. Enhanced environmental protection: E-uniforms could be designed with materials that provide enhanced protection against the elements, such as extreme heat or cold. This would further improve soldier comfort and safety in the field.

2. LITERATURE SURVEY

1. M. Sivalingamaiah, E. Satheesh Kumar and M. Vijaya Lakshmi [1] studied solar powered electronic uniforms provide safeguard for the service men who are survive in greatest climates. Photovoltaic cells are used to generate the electricity for E-Jacket. The battery is used to store the energy. You can also use a regular battery charger to charge the battery.

2. P. S. Kurhe and S. S. Agrawal [2] studied Real Time Tracking& Health Monitoring System of Remote Soldier Using Arm7.And soldiers will be able to communicate their distress with GPS coordinate information. Location trackinghas a great use, it is able to send parameters of soldier in real time.

3. Yemul [3] studied solar based e-uniform for soldiers who work at extreme high temperature or extreme low temperature, The LM35 is an exactness circuit Temperature sensor, 12V DC lead corrosive rechargeable battery is utilized for putting away the vitality, and AT89S52 controller is used and ADC0808 is to get Voltage produced from battery.

4. S. Annapurna Devi and P.R. Kumar [4] Adaptable Jacket Based on Climate Conditions Using ATmega328 Microcontroller. This jacket allows the user to control and monitor the internal temperatures, with the use of the thermoelectric effect and displays the results in both GPS, GSM Modules.

5. Adarsh K S, Arun Dinesh and JyothyElizebeth D [5] studied Solar Based E-Uniform for Soldier's Who Work at Extreme Temperature Regions. Solar panels would be woven into the fabric of these e-uniform to produce electricity and this jacket avert the heat stroke in extremely hot weather.

6. Dr .S .M.Kannan, R.Krishnavenishri, S.Kamalika, B .Kanagalakshmi[6]; "solar and IOT Based Health monitoring,controlling and

trackingsystem for soldiers", SSRG International journal of Electrical and Electronics Engineering(SSRG-IJEEE) There has been increasing interest in the development of IoT-based health monitoring systems in recent years. Thesesystems utilizesensorsand devices to monitor various health parameters, such as heart rate, blood pressure, and body temperature, and transmit that data to a centralized platform for analysis andinterpretation. IoT based health monitoring systems have the potential to provide early warning signs of potential health issues and enable proactive interventions to prevent serious health problems.

7. Sonali Kavitake, Onkar Jallapelli [7]: "E-Jacket", IJARIIE-ISSN(O) Volume 3, Issue 2, 2017. Proposed ane-uniform which gives better assurance to the troopers in outrageous climatic conditions. Temperature sensor is utilized to check the temperature which gives simple voltage which is changed over to computerize by utilizing ADC in the PIC microcontroller (PIC16F877A). Theadvanced qualitiesare checked with the warmth and cold limit level of temperature. If the temperature is more than the edge cooler and fan will be initiated. Clock begins and the status of the framework is appeared on the LCD show.

8. Kawad Pranali, Dahiwalar Gayatri [8] "E-UNIFORM", International Journal of Advance Engineering and Research Development, Mugginess sensor is utilized for checking the temperature whenever. The lm35 is an accuracy circuit temperature sensor, whose yield voltage is directly relative to the Celsius temperature. Sensor gives the simple voltage which is changedover intocomputerized by utilizing ADC in the Arduino. These computerized qualities are checked with the warmth andcold edge level of temperature. On the off chance that the temperature is more than the warmth limit, coolerandfan will be actuated. Onthe off chance that the temperature is not exactly the chilly limit, radiator and fan will be actuated and estimations of temperature are shown in lcd. Sunlight based boards and piezoelectric plates are utilized to give supply to inward circuit. The accompanying segments we will introduce the square outline, depiction use followed by end.

9. Karthikeyan N1, Murugesan K.S2, Senthil Kumar P3, Pooranachandran S4[9]: "Solar Powered E-Military", International Journal of Advanced Research in Computer and Communication Engineering, A 12 V DC lead corrosive rechargeable battery is utilized for putting away the vitality. We are utilizing routine battery charging unit additionally to give supply to the hardware. AT89S52 miniaturized scale controller is the heart of the circuit as it controls every one of the capacities. A

voltage sampler is interfaced with the framework utilizing ADC 0808 to get the voltage produced from battery as a showcase on a 16X2 LCD. The undertaking is worked in two modes summer mode and winter mode.

By selecting the method of operation, we are working the H-Bridge IC such that it can drive body radiator/cooler. The warmer/cooler thus will help us to give chilling or warming impact inside the uniform which helps the officer to stand to any sort of outer environment, and he can work proficiently without warmth stress or frosty anxiety.

METHODOLOGY

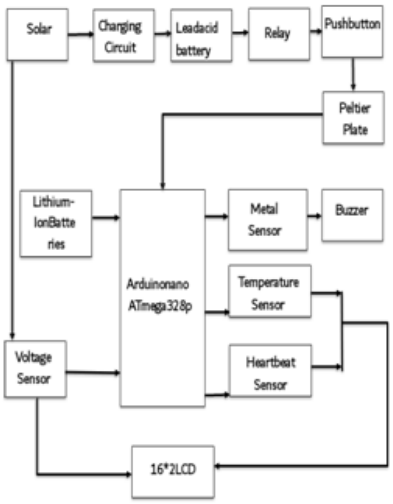


Fig 3.17: Block diagram of proposed system

3.2 : Procedure:

Fig 3.18: Setup of E-Jacket.

3.3.1 Flow chart:

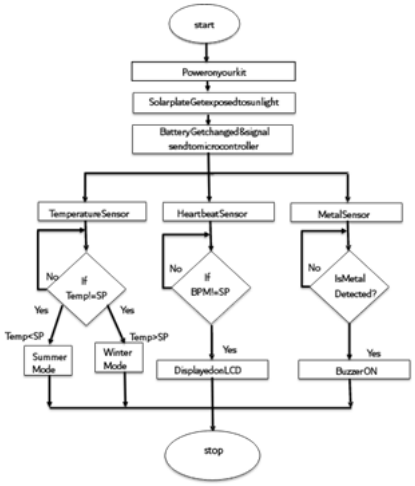


Fig 3.19: Flow chart of proposed system

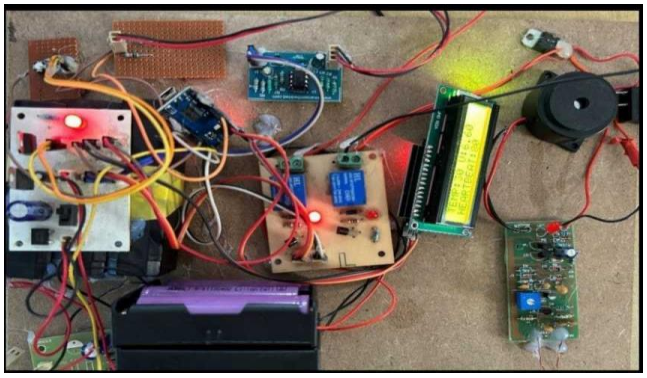


Fig 5.1: Overall Prototype of the Proposed Solar-Powered E-Uniform System Discussion

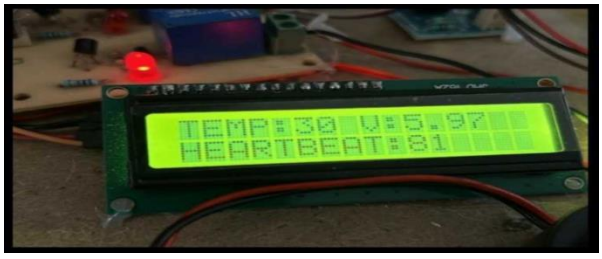
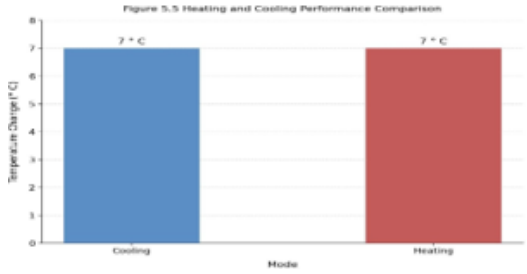


Fig 5.2: Temperature, Heartbeat, and Solar Voltage Displayed on LCD



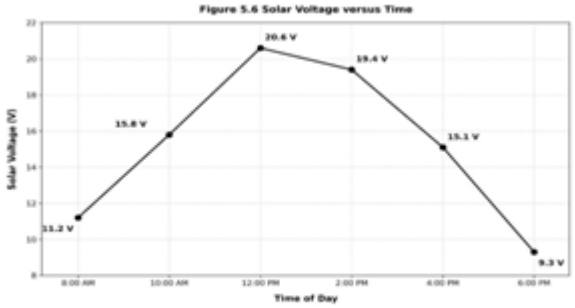


Figure 5.6: Solar voltage variation observed at different times of the day. The solar panel output increased from 11.2 V in the morning to a peak value of 20.6 V at noon and gradually decreased during the evening hours. The results demonstrate the effect of solar irradiance on photovoltaic power generation.

Discussion

The experimental observations confirm that the proposed system can provide both heating and cooling functions using the same thermoelectric module through polarity reversal.

5.1 Solar Energy Utilization Analysis

5.1.1 Solar Voltage Observation

Table 5.4 Solar Panel Voltage at Different Time Intervals

Time	Solar Voltage (V)
8:00 AM	11.2
10:00 AM	15.8
12:00 PM	20.6
2:00 PM	19.4
4:00 PM	15.1
6:00 PM	9.3

Discussion

The maximum voltage output was observed during midday due to higher solar irradiance levels. The voltage gradually increased from morning to noon and then decreased towards evening. The highest recorded voltage was 20.6 V at 12:00 PM, which is very close to the rated voltage of the photovoltaic panel. This demonstrates the capability of the solar panel to provide sufficient charging voltage for the energy storage system during peak sunlight conditions.

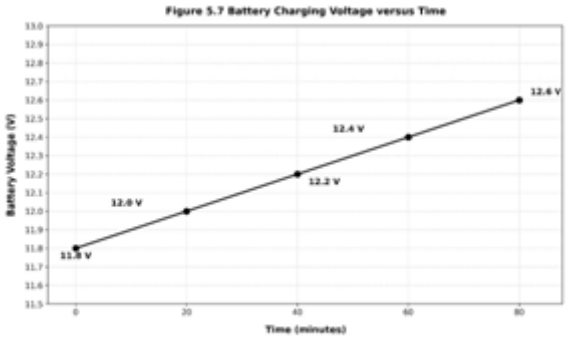


Figure 5.7: Battery charging voltage variation with charging time. The battery voltage gradually increased from 11.8 V to 12.6 V during the charging process, indicating successful energy storage from the photovoltaic solar panel. The steady rise in voltage confirms the effectiveness of the charging circuit used in the proposed Solar-Powered E-Uniform System.

Time (min)	Battery Voltage (V)
0	11.8
20	12.0
40	12.2
60	12.4
80	12.6

5.1.2 Battery Charging Analysis

Table 5.5 Battery Charging Voltage Discussion

The battery voltage increased gradually from $11.8, V$ to $12.6, V$, indicating effective charging from the photovoltaic solar panel.

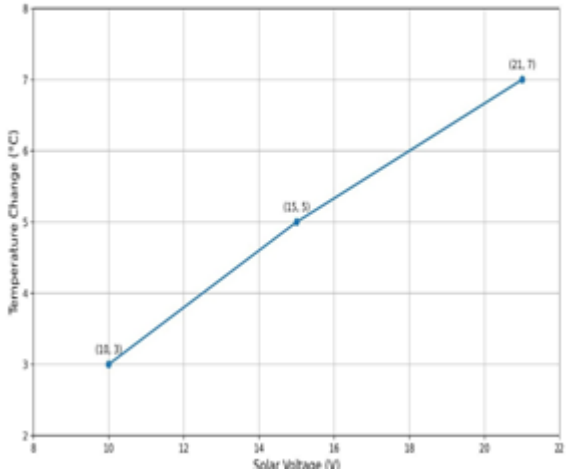
5.3 System Performance Evaluation

5.3.1 Effect of Solar Voltage on Thermal Performance

Table 5.6 Solar Voltage versus Thermal Regulation Performance

Solar Voltage (V)	Temperature Change ($°C$)
10	3
15	5
21	7

Figure 5.8 Solar Voltage versus Temperature Change



Discussion

The thermal regulation performance improves with increasing solar voltage. As the available solar power increases, the Peltier module receives sufficient electrical energy to achieve a larger temperature variation.

5.3.2 Overall System Effectiveness

The experimental results demonstrated that:

- The system achieved a temperature variation of approximately $7°C$ in both heating and cooling modes.
- The solar panel generated a peak voltage of $20.6, V$.
- The average solar voltage during operation was approximately $15.23, V$.
- The battery charging circuit successfully stored energy for system operation.

Temperature, heartbeat, and solar voltage were monitored in real time.

Conclusion

The performance evaluation confirms that the proposed Solar-Powered E-Uniform System successfully integrates solar energy harvesting, thermal regulation, battery charging, and physiological monitoring within a single wearable platform. The obtained results validate the feasibility of utilizing solar-powered thermoelectric technology for wearable thermal management applications.

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