

Smart Pillow Alarm System with Heat and Vibration Features

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Abstract

It is difficult to be able to wake people with different sleeping patterns such as deep sleepers and people with impaired hearing particularly with use of conventional sound-based alarm systems. This project solves the problem by the invention of a Smart Pillow Alarm System where sound, vibration and heat are combined to establish an individual and multi-sensory alarm factor. These are to develop a hands-on functioning prototype, configure users on it through a mobile application, and carry out real life test to gauge its performance. The system is based on ESP32 microcontroller and incorporates a vibration motor, Peltier module, buzzer, and RTC module, allowing to control it through the Blynk app. The user can set the alarm time, its intensity, and the combination of desired stimuli with the profile of sleep habits. The results of the test show that the system improves greatly user satisfaction, level of comfort, and response time during the wake-up process. This is potentially one of many applications in the fields of assistive technology, smart home ecology, and health-oriented consumer electronics, where the need to wake up is already a subject of a more flexible and user-oriented solution.

1. Introduction

Advances in embedded systems and personal instrumentation have opened up new ways of conducting activities of daily living, including waking-up. The usual alarm clocks use only auditory alarms and do not satisfy the requirement for people who have different sleeping participants, such as heavy sleepers, people with hearing problems [1][2]. These systems are often associated with either overshooting the desired wake time or anxiety-provoking awakening, which can negatively affect cognitive function and mood during the day [1]. To address these issues, the Smart Pillow Alarm System combined a multisensorial approach, sound, vibration, and heat as modalities for personalizing and optimizing the wake-up event [4][5][6].

In this work, we present a user-oriented approach that use the ESP32 microcontroller to interact with several embedded devices. The system brings together a buzzer for sound, a Peltier module for heat, and vibration motors inside the pillow to achieve a style of waking up best described as gentle and guaranteed. All these are programmable and adhered to the specific user's preference through software interfaces, which can customize the strength of alarm and the combination of sensory information. It offers users a comfortable grip and an essential attrition for functional integration into everyday life in a variety of environments.

Our aim is to produce a functional prototype of the Smart Pillow Alarm System that enhances the waking experience of a wide range of users. The system will be clinically tested under controlled testing ranging in sleep profile, for evaluation of performance, comfort and patient acceptance. This also includes measuring efficacy via

user surveys and feedback systems, to ensure that the system doesn't just work, but also increases their users' quality of life in the morning.

Through overcoming the limitations of traditional alarms, this work demonstrates the potential for embedded systems to play a vital role in human-centric smart technologies. The Smart Pillow Alarm System is an example to show that a microcontroller-based device can be combined with ergonomic design to provide technological solutions in assistive technology [6]. The findings of this study may guide the next generation of smart home platforms with improved accessibility, comfort, and personalised user interaction.

Essentially this project is not just a technology project, it is a journey into what technology could do, when it's combined with everyday lifestyles in a positive and healthful way. In an age where hardware & software can live together in perfect harmony, the Smart Pillow Alarm System plans to revolutionize your wake-up call; making an unpleasant, unnerving experience a thing of the past.

2. Methodology

The prescribed methodology of development for the Smart Pillow Alarm System with Heat and Vibration Features is concerned with a wing down approach involving systematic design, development and comprehensive testing of a new waking system that encompasses multiple functional alarms in as sustainable a manner as possible. This project is one of structured type to solve various limitation of tradition alarms with consideration of sound and heat besides the vibration in accordance with the different sleeper types. The physical part will incorporate heating pads, vibration motors, buzzer and many sensors all controlled by ESP32 as the central hardware controller. It stresses on components constitution, software conception and an application of the real users for developing a small, light, and effective alarm. The project also contains customization options that will allow users to set alarms depending on the heat intensity, the vibration strength of the case, and the sound volume of an alarm that will allow waking up comfortably. Therefore, testing will entail trying out the effectiveness of the system with different sleeper users, factors that the system can capture from the user feedback and generate data for further tweaking of the prototype. To prevent misidentification of phony obstacles and guarantee the Smart Pillow Alarm System is an effective and comfortable waking method, the methodology incorporates a detailed design process accompanied by real world testing and iterations of improvements.

2.1 Materials

Under this section shows all the component that been used during the testing and the data collection result.

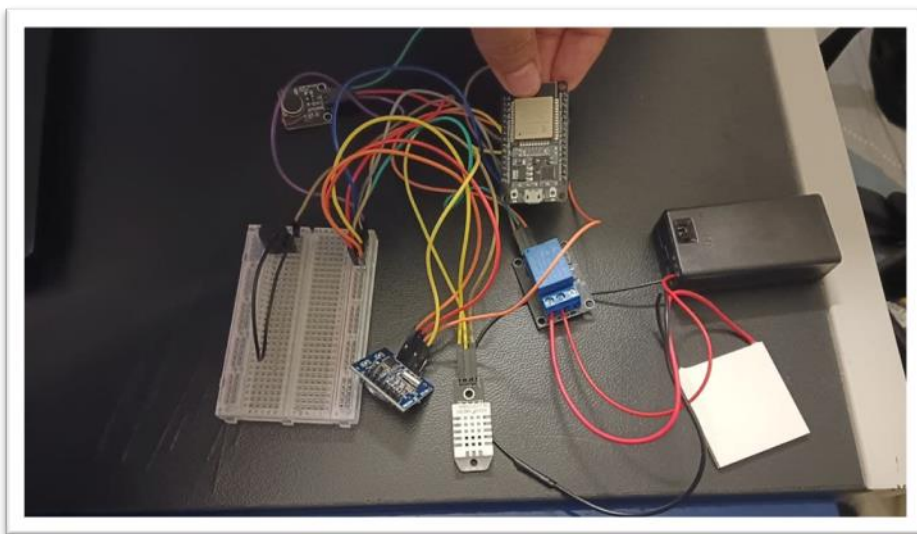


Fig. 1 Circuit Design

The Hardware of the Smart Pillow Alarm System is developed by integrating several components to the pillow for comfort and usage purpose such as Peltier Heater Module for thermal stimulation, Vibration motor for tactile stimulation, and Buzzer for Buzzer sound signals. The ESP32 development board acts as the controlling unit that controls all other sub units of the pillow and provides Wi-Fi connectivity and a web interface through which the device can be controlled and monitored. The main supporting players are a RTC (Real Time Clock) Module to

make sure I get consistent timing when activating the alarm with a backup battery for it, a Relay, to turn the heating element on, a DHT22 temperature sensor, along with jumper cables and foil for circuits.

2.2 System Block Diagram

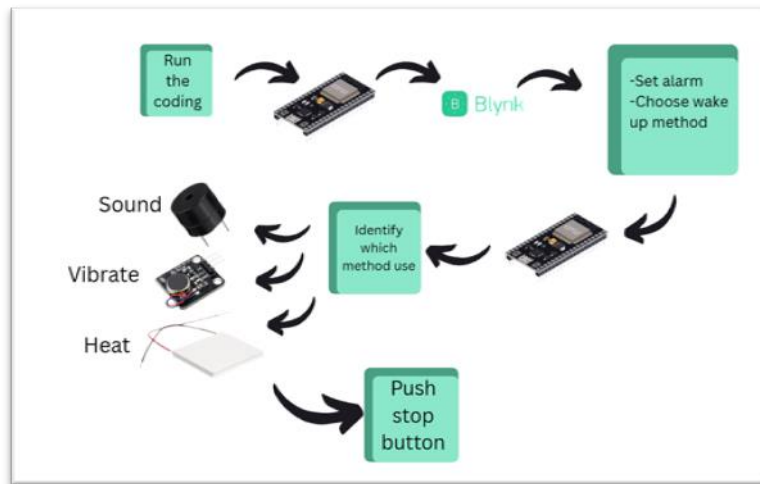


Fig. 2 System Block Diagram

This result in the system block diagram presented in Figure 2 showing an elaborated overview of the functional flow of the Smart Pillow Alarm System. This section involves adjustment of the RTC of the system and system configuration via the ESP32 in which the Blynk app enables users to schedule alarms and set preferred parameters remotely. It works as the microcontroller; the ESP32 is in charge of integrating the input signals with output wills. In the output section, the system allows the activation of wake-up motors such as the vibration motors, heater through the Peltier heater and also a noise maker through the buzzer. Another convenience is that it is also possible to disable the alarm using Blynk app on users' fingers. This block diagram shows the cohesiveness between the hardware and software parts of the system, and shows how it can provide an effective and variable morning alarm in a multi-sensory manner.

2.3 System Flowchart

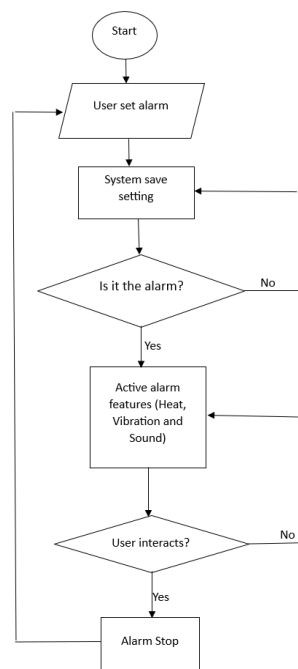
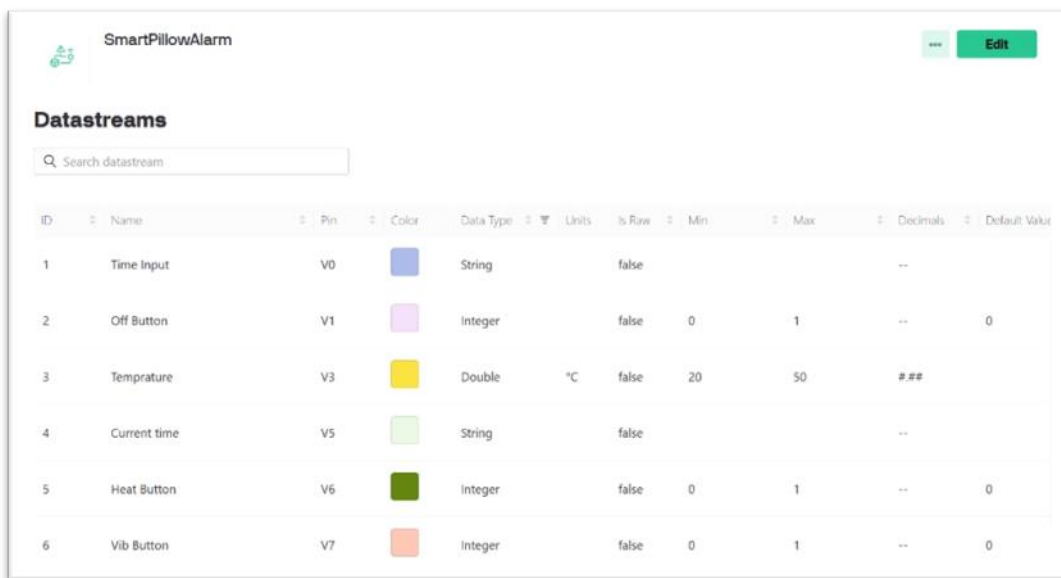


Fig. 3 System Flowchart

The operation process of Smart Pillow Alarm System is diagrammed by the system flowchart shown in Figure 3. The process starts with the user setting an alarm at the system interface for instance the Blynk application which interfaces with the ESP32. It then stores such settings and waits until the required alarm time before being triggered. In our design, when the alarm time is set, all the means of linear heat through the Peltier heater, vibration by the motor, and sound by the buzzer are initiated in such a way that the alarm is effective.

Finally, if the user intakes with the system (for instance by discontinuing this alarm through the application or other inputs), then the alarm is effectively switched off as well. If there is no interaction then it remains active until the user gives a response and so is quite reliable. With regard to the aspect of functionality, this flowchart focuses on ease of use of the system and demonstrates the addition of personalization options to wake to.

2.4 Blynk Database



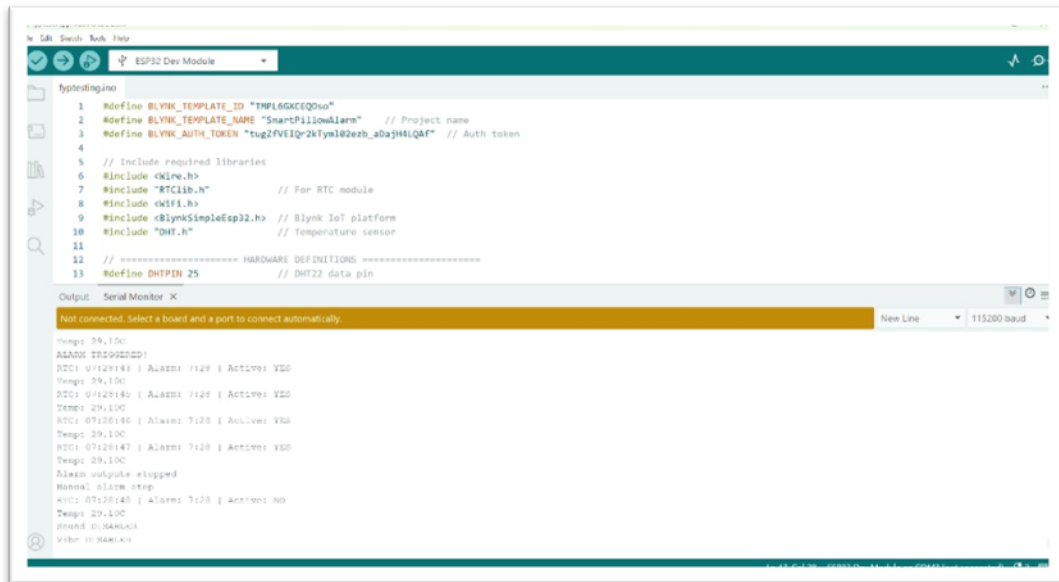
ID	Name	Pin	Color	Data Type	Units	Is Raw	Min	Max	Decimals	Default Value
1	Time Input	V0	Blue	String		false			--	
2	Off Button	V1	Purple	Integer		false	0	1	--	0
3	Temperature	V3	Yellow	Double	°C	false	20	50	##	
4	Current time	V5	Light Green	String		false			--	
5	Heat Button	V6	Dark Green	Integer		false	0	1	--	0
6	Vib Button	V7	Orange	Integer		false	0	1	--	0

Fig. 4 Database on Blynk Website

Figure 4 present the DataStream configuration of SmartPillowAlarm project on the Blynk IoT platform. This configuration establishes the mapping between the virtual pins (V0-V7) and different system functions. This also the communication link to and from the user interface to the ESP32. The different data stream is related with the input or output parameter of the smart alarm system. For example V0 (Time Input) accepts a string value allowing user to set an alarm time, while V1 (Off Button) is a binary control (0 or 1) to turn off a alarm. V3 (Temperature) records the sensor measurement in °C with a range of 20–50°C and two decimal precisions, presumably related to the Peltier module. The V5 (Current time) DataStream will output the current time (clock) as a string we can compare with the alarm.

V6 (Heat Button) and V7 (Vib Button) are also binary control switches for switching on and off the heat module and vibration module, respectively. Each DataStream is colour-coded to contrast and brighten the display of the Blynk dashboard and is shown as false under the "Is Raw" column, this simply means the number values are processed or volumized for display in the dashboard. The min/max attribute on the columns is there to limit silly user input of invalid data (especially on button controls, which are 0 or 1). The entire setup thus enables interactive control and real-time monitoring of the SmartPillowAlarm system through the Blynk interface, connecting the virtual controls to the physical effects in IoT.

2.5 Arduino Ide Integration with ESP32



```

1 #define BLYNK_TEMPLATE_ID "TmPL6GKcIQho"
2 #define BLYNK_TEMPLATE_NAME "SmartPillowAlarm" // Project name
3 #define BLYNK_AUTH_TOKEN "sug2FvEIQ-2kTym102ezb_aDa9H4lQdF" // Auth token
4
5 // Include required libraries
6 #include <Wire.h>
7 #include <RTClib.h> // For RTC module
8 #include <WiFi.h>
9 #include <BlynkSimpleEsp32.h> // Blynk IoT platform
10 #include <DHT.h> // temperature sensor
11
12 // ===== HARDWARE DEFINITIONS =====
13 #define DHTPIN 25 // DHT22 data pin
  
```

Output: Serial Monitor X

```

Not connected. Select a board and a port to connect automatically.
Temp: 29.10C
ALARM TRIGGERED!
RTC: 07:20:14 | Alarm: YES | Active: YES
Temp: 29.10C
RTC: 07:20:15 | Alarm: YES | Active: YES
Temp: 29.10C
RTC: 07:20:16 | Alarm: YES | Active: YES
Temp: 29.10C
RTC: 07:20:17 | Alarm: YES | Active: YES
Temp: 29.10C
Alarm module stopped
Normal alarm stop
RTC: 07:20:18 | Alarm: YES | Active: NO
Temp: 29.10C
  
```

Fig. 5 Code running as the output shows

Figure 5 show that the Arduino IDE environment, with a sketch (code) for the SmartPillowAlarm project, targeted at a ESP32 Dev Module. This sketch speaks with IoT Blynk, RTC module, a DHT sensor (temperature and humidity) and output devices such as vibration modules, and heat modules.

At the beginning of the code, Blynk related credentials such as BLYNK_TEMPLATE_ID, BLYNK_TEMPLATE_NAME, and the auth token are declared. These settings will allow the ESP32 establish a secure connection with Blynk cloud. The sketch uses core libraries WiFi (Include the core Libraries) We create an instance of client.h (for network setup), BlynkSimpleEsp32.h (Blynk communication), Wire.h, for I2C communication, and DHT.h (for the temperature*/humidity sensor). DS3231 RTC library is also added so we can keep the time accurate.

The bottom serial monitors show logged info about what the system is doing at any given time. It is displaying the time for the alarm (i.e., 11:45:00), the actual current time from the RTC and state (on or off) of the heat and vibration modules. So those log entries such as Alarm: YES / Heat: ACTIVE YES / Vib: ACTIVE YES indicate that the alarm is going off and both actuators are switched on. Once the alarm time has passed, or the alarm is reset, messages such as "Alarm stopped" are displayed. This is the live output. It will verify that the Blynk app is able to communicate with the sensors, actuators and the ESP32 board.

The Arduino IDE configuration and the serial monitor output confirm altogether that the firmware does properly handle the smart alarm logic, the timed comparisons and controls the output modules when alarm conditions have been set through a Blynk application.

3. Results and Discussion

The development of the Smart Pillow Alarm System is described in this chapter, including the hardware and the software with their integration. It also explains the testing approach carried out to test how well the system would work and get feedback from the participants to confirm that the project requirements would have been met. The main focus here is to demonstrate that a configurable multimodal wake up in form of an alarm clock implementation is feasible.

3.1 Functionality Test (User Interface)

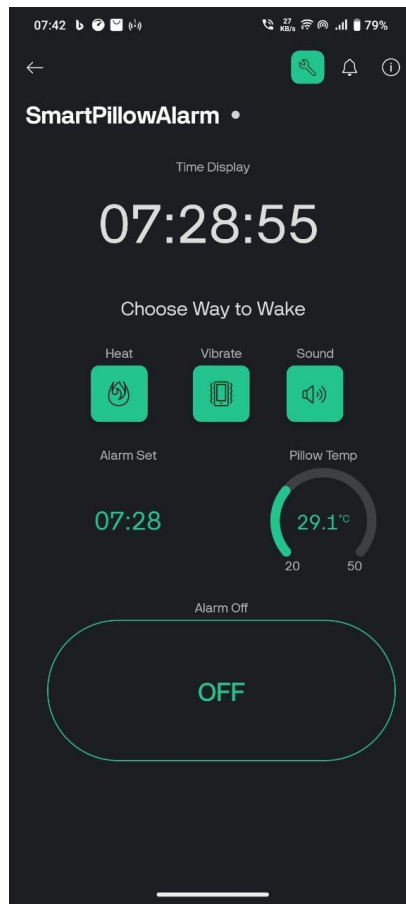


Fig. 6 Blynk App User Interface

Figure 6 shows the user interfaces of the SmartPillowAlarm are depicted in the image at the Blynk mobile application front to end, offering the possibility for users to manipulate their IoT smart alarm system in real-time. At the very top is the time display (in this picture it is showing 07:28:55) – this is essentially the Real-Time Clock (RTC) time value present in the ESP32. Once again, users will find a familiar interface with the ability to check or uncheck the wake-up method options including Heat, Vibrate and Sound. All these options are different pieces of hardware (a Peltier for heat, a vibration motor and buzzer) that we will turn on if the alarm is detected.

The interface also reveals the alarm time set (07:28) and the current pillow temperature (29.1°C), which is sensed by a temperature sensor (DHT22) and rendered via a gauge that ranges from 20°C to 50°C and the big "OFF" button is placed at the bottom for the user to manually turn off the alarm when it goes off. It enables the user to be able to change things or control the system from remote through the Blynk app. All that means it is flexible, comfortable to control, and very easy to be done into integration with the hardware, the control acts as a connector between hardware and software in Blynk IoT dashboard with the virtual pins in it.

3.2 Testing Result

Table 1 Data Collected from Google Form

Sleeper Profile	Preference Combination	Avg. Wake Time (s)
Light	Heat+Vibration+Sound	8.2
Medium	Heat+Vibration+Sound	12.7
Deep	Heat+Vibration+Sound	19.5

Table 1 holds the results of a quantitative test conducted in the form of Google Form, with two groups of participants based on their sleeper profile: Light, Medium, and Deep. To test the time of an average individual participant to respond and awaken when the alarm had tri-modal activated; every one of the participants was

subjected to a complete tri-modal alarm combination consisting of heat (using the Peltier module), vibration (using the motor), and sound (using the buzzer).

The information revealed that participants of all sleeper types reacted faster when the three stimuli were used simultaneously. The wake-up latency varied to 8.2 secs and 19.5 secs in light sleepers due to light sleepers and deep sleepers respectively, affirming the fact that synergistic effect of multimodal stimuli has great impact on alarm responsiveness. Such findings can support the significance of incorporating heat, tactile, and audio stimulus into an IoT-based wake-up framework. Particularly, the fact that the system will even wake up the sleepers who are unwilling to listen to a single-sensory call reminders is an indication of the benefit of the tri-modal design. This empirical finding is confirmative to the purpose of system to increase the reliability in waking up using embedded technology conformable to the needs of the different users.

4. Conclusion

It should be appreciated that the Smart Pillow Alarm System has been realized to provide a novel approach addressing the problems with alarm clocks as described. This is a multi-sensory wake-up system that uses sound, vibration and heat to offer one of the most customizable wake-up experiences of your life. The system's capacity to mix and match sensory inputs is to accommodate a variety of users, such as very light sleepers and those with hearing loss who may not be stimulated by sound-based alarms.

The construction of this system validates the capability of the ESP32 as the central control unit. The control of the Peltier heating pad, vibration motor, and buzzer is controlled by the ESP32 with good precision and wireless response time. The system is also designed to achieve individual customization, the user can customize the heat temperature, vibration intensity, and sound volume by themselves. Instead of waking up grumpy, now I wake up with energy and a good mental state, which definitely makes me better through the day, since a soft wake-up has a great impact on this, 'modded' alarm is also a proof of this with its ability of controlling fading.

In general, the Smart Pillow Alarm System is a major advancement in alarm technology providing a more comfortable, effective, and less stressful method of awakening. Unlike other offerings, it brings a tailored wake-up, promising to start the day on a good foot.

Acknowledgement

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