Smart Pill Dispenser Using FreeRTOS

Akash
Department of Electrical and Electronics Engineering
Amrita School of Engineering
Coimbatore, India

Akshara
Department of Electrical and Electronics Engineering
Amrita School of Engineering
Coimbatore, India

M G Keerthana
Department of Electrical and Electronics Engineering
Amrita School of Engineering
Coimbatore, India

Muthu Krishnan
Department of Electrical and Electronics Engineering
Amrita School of Engineering
Coimbatore, India

J Saraan
Department of Electrical and Electronics Engineering
Amrita School of Engineering
Coimbatore, India

Dr. V. C. Dinesh (Guide)
Department of Electrical and Electronics Engineering
Amrita School of Engineering
Coimbatore, India

Abstract—Today modern world managing medical schedules is more challenging when it is come to elders especially and chronically ill patients. Traditional pill management can lead to lose some doses, wrong intake or sometimes overtake doses which may lead to other serious problems. To overcome these challenges, our project is designed and implemented of smart pill dispenser system using FreeRTOS for efficient real time critical time scheduling tasks. Our model aims to automate the pill dispensing by giving timely notifications, dispensing the medicines on right time, and maintaining accurate scheduling ensuring the patients safety. Our project combines LCD display interfacing with i2c, buzzer, servo motor, and heart beat sensor using ESP32. FreeRTOS enables smooth real time multi task scheduling such as dosage timing, pill dispensing, patient alerts and heart beat monitoring. During scheduled time, the ESP32 activates the servomotor to release the medicine which inturn triggers the buzzer to notice to the patient and relevant details display on the LCD display. In addition to this, the heartbeat sensor monitors the patients pulse continuously, which provides safety in critical cases. This project smart pill dispenser is a healthcare automation, which offers portable and user friendly device for home and in hospitals. The combination of FreeRTOS which make the dispenser to perform precise multitasking and timing, critical for handling healthcare related problems in real time. In future, this project can be further build using IoT connectivity, cloud based modelling, and remote health monitoring which make this model can adapt to advance smart healthcare applications.

Index Terms—Smart Pill Dispenser, FreeRTOS, Real-Time Scheduling, ESP32, Healthcare Automation, Pill Dispensing System, Heartbeat Monitoring, Multitasking in Embedded Systems

I. INTRODUCTION

In this fast moving world and changing lifestyle, it is difficult to follow medication schedules, when it comes to elders especially and who have chronically illness and memory loss patients has more risk including factors in this scenarios. If any one miss the dose or medicine to take on right time or else intake more dosage instead of normal doctor prescribed dosage which may lead to serious health issues and some critical conditions it may lead patients to coma and even death can also occur which is unpredictable conditions. To overcome this critical cases, the healthcare industry is shifting to automation instead doing manually. Smart healthcare monitoring devices will be the best solutions for this and also to improve medication adherence, which ensures timely intake, and reduce the risk.

Our project is smart pill dispenser with ESP32 microcontroller and interfacing the controller with FreeRTOS. This model ensures dispensing the medicine and also monitoring the patients. The model has essential components such as buzzer, LCD display, servomotor, and heartbeat sensor. With the help of FreeRTOS, we can able to perform multiple real time tasks like time critical management and patient alert notifications on right time. The dispenser is programmed with specific time in which specific dosage should be taken. For example, BP tablet on 10:00am with 350mg dosage. When the scheduled time arrives, the medicine it dispensed automatically and display relevant details on the LCD display.

In addition to this, this model ensures patients safety and monitors heartbeat rate continuously using heartbeat sensor. This specifications allows to detect the abnormal conditions at the earliest. This also provides critical details to care takers and healthcare professionals or doctors. The smart pill dispenser not only ensures accurate medication delivery but also this can extended in future with combining additional features to it. In future, this model can be done wirelessly communication device in remote locations which include artificial intelligence (AI) and machine learning (ML) and IoT

concepts to improve the accuracy. This can be useful for both home and clinical environments which promotes independent state of living and better healthcare benefits.

II. LITERATURE SURVEY

1) **Title:** Design and Implementation of Automatic Medicine Dispensing Machine
   Author: K. R. Nataraj, C. S. B. Sagar and S. R. Shruthi
   Published in: 2nd IEEE International Conference on Recent Trends in Electronics, Information and Communication Technology (RTEICT), 2017.
   Methodology: In this paper, the authors proposed a microcontroller-based design for automatically dispensing pills according to predefined schedules. The system incorporates an RTC module for maintaining accurate timing, an LCD display for visual notifications, a buzzer for audio alerts, and a servomotor for operating the pill compartments. The model is equipped with multiple compartments designed to store different types of medicines, enabling it to dispense the correct dose at the scheduled time [1].

2) **Title:** An IoT based smart medicine dispenser model for healthcare
   Author: S. K. Singh, R. Gupta, and R. Kumar
   Published in: 2022 IEEE world conference on applied intelligence and computing (AIC) in the year 17 – 19 June 2022 in sonbhadra, india.
   Methodology: In this paper, the author used IoT based medicine dispenser to improve health care monitoring which is used to ensure timely and accurate pill intake for the patients when it comes to especially elders and chronically ill. This model operate from the inputs given by the cloud based application instructions and dispense the correct dosage of the medicine at the correct scheduled time and also triggers alert message through the buzzer and give a alarm to the patient. It also involves IoT protocols for data communcations [2].

3) **Title:** IoT – based wireless patient monitor using ESP32 microcontroller
   Author: Mujeeb Rahman .K .K, Rayan Zidan, Besher hasan and Ibrahim alsarraj
   Published in: 2023 24th International Arab Conference on Information Technology (ACIT), December 2023.
   Methodology: In this paper, the author used wireless patient monitoring model with ESP32 microcontroller as the primary processing and communicating segment. This system continuously monitor heart rate, body temperature, and oxygen saturation using biomedical sensors interfacing with ESP32. The input from the sensors is transmitted wirelessly through wifi to cloud platform. This will be useful for healthcare professional authorities to take a brief detailed information [3].

4) **Title:** Smart pill dispenser and IoT: Advancements in medication administration
   Author: Pallavi Tiwari and Ramakrishnan raman
   Published in: 2024 International conference on emerg-ing systems and intelligent computing (ESIC) on 09 – 10 february 2024
   Methodology: In this paper, author used IoT based smart pill dispenser for improving medication management especially for elders. He integrated with ESP32 with rtc module. Patient medicine should take on time. When this time arrives, patient is alerted through cloud connected mobile to get real time notifications [4].

5) **Title:** Design of a smart medical box for automatic pill dispensing and health monitoring
   Author: Zara nasir, Amina asif and Muhammad nawaz
   Published in: 2nd international conference on emerging trends in electronic and telecommunication engineering in 15 – 16 march 2023.
   Methodology: In this paper, author modelled smart medical box to automate pill dispensing while simultaneously monitoring the critical health parameter. Here, this model combines sensors to track the heart rate and body temperature which is interfaced with microcontroller the dispensing mechanism. The user set the timer before itself and when that time arrives medical box dispenses the pill according to medicine dosage which is set by the user [5].

6) **Title:** Embedded solutions for IoT based automated drug infusion device
   Author: Chiang liang kok, Zheng yuan loo and Jian ping chai
   Published in: 20th International SoC Design Conference (ISOCC) held on 25 – 28 October 2023 Jeju, korea
   Methodology: In this paper, author showed the embedded IoT based automated drug infusion model aiming at delivering accurate doses of medicines to patients under time sensitive and time critical conditions. It involves flow rate, pressure and monitoring patient vital parts. This system transmits the input data wirelessly to cloud based platform. The methodology emphasizes real time data acquisition and closed loop control for safe and efficient drug delivery [6].

7) **Title:** Automated medicine dispenser with personal healthcare monitoring using IoT
   Author: P Chandramohan, Kanagaraj venu samy, and Deepak G
   Published in: 8th International conference on science technology engineering and mathematics on 06 – 07 April 2023.
   Methodology: In this paper, the author used IoT based automated medicine dispenser which combines personal healthcare monitoring functionalities. This ensures correct time correct dosage of medicine is dispensed correctly [7].

8) **Title:** Pillbox: A smart solution for personalized medication scheduling and monitoring
   Author: B Rukmini bhat, M Preethi and Reshma
   Published in: IJRASER ON 17th December, 2024
   Methodology: In this paper, the author used smart IoT enabled pillbox system for personalized care and

real time monitoring. The system used microcontroller based hardware with multiple compartments with various dosage of medicines. It operates on a predefined schedule set by the user or individual through mobile or web based applications. This can be visualized through GUI for easily user interactions [8].

9) **Title:** Pillbox: A smart solution for personalized medication scheduling and monitoring
Author: B Rukmini bhat, M Preethi and Reshma
Published in: IJRASER ON 17th December, 2024
Methodology: In this paper, the author used smart IoT enabled pillbox system for personalized care and real time monitoring. The system used microcontroller based hardware with multiple compartments with various dosage of medicines. It operates on a predefined schedule set by the user or individual through mobile or web based applications. This can be visualized through GUI for easily user interactions [9].

10) **Title:** Smart pill reminder
Author:A. Jagadeeshwaran, H. Shree kumar and Saiyed salim sayeed
Published in: 1st International conference on advances in computing and future communication technologies on 16 − 17 december 2021, meerut, india.
Methodology: In this paper, the author uses smart pill reminder device to take medications on correct time. This system has microcontroller controls the alarm timings and patients and doctors or some other professionals can easily understand the dosage of medicines through LED indicators, and buzzer [10].

III. METHODOLOGY

This methodology shows we are using with FreeRTOS which schedules the task at correct time using real time clock module to indicate correct time medication and monitoring the patients

A. System Overview and Components

Our project aim is to develop a smart pill dispenser using ESP32 microcontroller and the task are scheduled using FreeRTOS. This method involves major hardware like servo motor, hear beat sensor, buzzer and LCD display. The important functionality of our model is to continuously monitor patients heartbeat rate and to dispense the pill according to the scheduled timings and it can also assist for time critical and time sensitive cases like immediate attention and emergency medication when it required. This model has divided into three major tasks to perform in which each of them has separate priority. Highest priority task is heart rate monitoring task. Medium priority task is servomotor rotation task. Lowest priority task is the LCD display when the pill is dispensing. This tasks provides efficient suitable solution for healthcare management and for medication.

B. Task Description and Functionality

The heart rate monitoring task which is highest priority one, used to monitor patients heart rate continuously
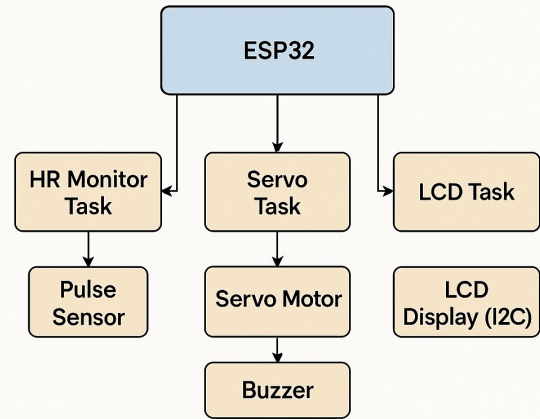

Fig. 1. Task classified based on priority

through heart beat sensor. This task executes in a loop and when emergency or critical cases arrives, like if heart rate is increased above 100bpm. When the emergency cases are occurred, heart rate sensor immediately pause rest of all the tasks, then it will triggers the BP tablet and it is dispensed through servomotor rotating in a certain angle to dispensing the pill. This enables alert the buzzer and notifications in LCD display with an alert messages. This ensure the overriding the regular medication schedule.

C. Scheduled and Emergency Medication Dispensing

- The servomotor which responsible for rotation to dispense the pills. It executes in a medium priority and it is triggered when medication schedule is arrived and critical case from heart rate monitor task.
- When the scheduled time arrives, servomotor rotates and dispense the prescribed medicine.
- If emergency cases arrives, the scheduled process is preempt and the required BP medicine is dispensed.
- After dispensing is over, the system return back to normal condition.
- This process are related to task states such as task dormant, task running, task ready and task waiting. Interrupt service routine executes when interrupt occurs.

D. Task Prioritization in FreeRTOS

- High Priority Task: Heart Rate Monitor Task (Heart Rate Monitoring) - This is continuously checks heart rate. When emergency (HR ¿ 100 bpm), triggers immediate BP tablet dispensing
- Medium Priority Task: ServoTask (Pill Dispensing) - This task executes medication at scheduled intervals and it responds to emergency BP dispensing
- Low Priority Task: LCDTask (Display Updates) - It checks continuously updates pill name on LCD.
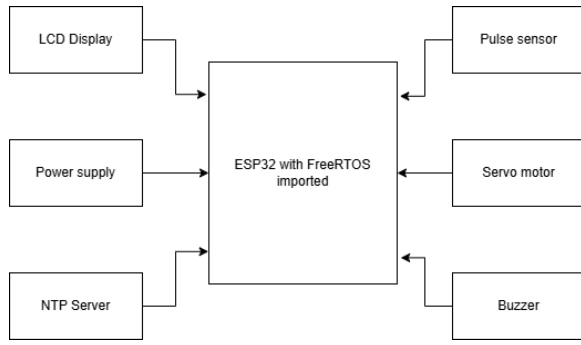
Fig. 2. Block diagram of methodology

E. Task Synchronization and FreeRTOS Preemptive Scheduling

The whole system executes based on FreeRTOS preemptive scheduling to ensure smooth task execution. The tasks are assigned with different priorities to execute in order. When heart rate monitor task arrives, in an emergency conditions interrupt allows to execute immediately. The servomotor task and LCD task are independent where LCD task executes in the background continuously updating the LCD display with current medicine name, status and alert. The system ensures preemptive scheduling. This model suitable for accurate time dispensing and emergency situation handling and making this model more efficient.

IV. RESULTS

This output is from desktop serial monitor used for visualizing

```
⚠ Emergency! Dispensing BP tablet immediately.
Dispensing: BP Tablet
Heart Rate: 100
```

Fig. 3. Serial monitor output.

V. HARDWARE SETUP

This section shows the hardware setup of the whole methodology

```
Dispensing: Diabetes Tab
Heart Rate: 85
Heart Rate: 85
Heart Rate: 85
Heart Rate: 85
Heart Rate: 84
Dispensing: Vitamin Tab
Heart Rate: 85
Heart Rate: 84
Heart Rate: 85
Heart Rate: 84
Dispensing: BP Tablet
Heart Rate: 85
Heart Rate: 84
Heart Rate: 84
Heart Rate: 84
Dispensing: Diabetes Tab
Heart Rate: 84
Heart Rate: 84
```
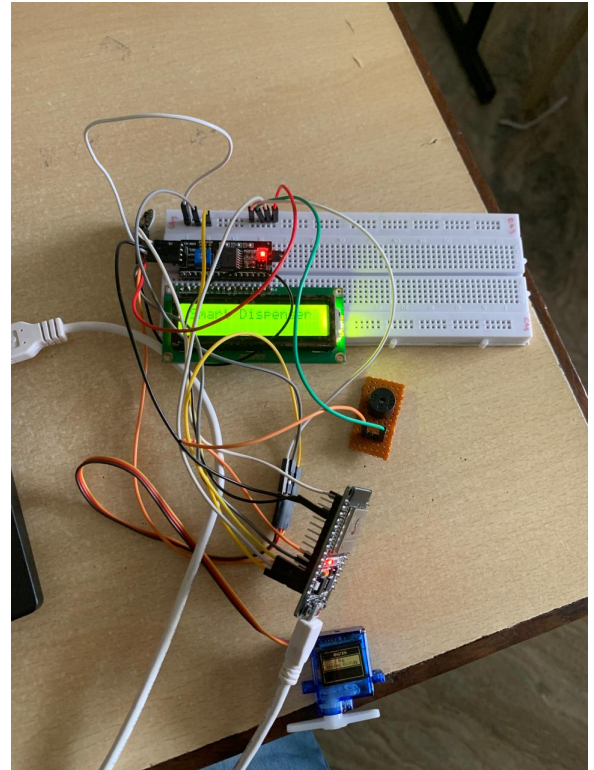
Fig. 4. Serial monitor output.

Fig. 5. Hardware setup

VI. CONCLUSION

The smart pill dispenser is an best solution which is designed to overcome the challenges of healthcare management especially for elders and chronically ill patients. By using FreeRTOS for real time multitasking, this model ensures accurate scheduling, continuously monitoring the patients and accurately dispensing the medicine. The integration of lcd display, buzzer, servomotor and heart rate sensor which provides efficiency and ensuring patients safety.

This whole model is used to automate dispensing the medicines to reduce the risk of missing any dosage at right time, wrongly intaken and medicine overdose which is suitable for both home and hospital environments. This model can be enhanced in future advancements also like integrating with IoT applications and cloud-based remote monitoring which increase further patient safety. In conclusion, the smart pill dispenser shows significant advance in the healthcare management, user friendly, portable and improving patients medication.

REFERENCES

[1] M. Penna, D. V. Gowda, J. J. Jijesh, and S. Shivashankar, "Design and implementation of automatic medicine dispensing machine," in *Proc. 2017 2nd IEEE Int. Conf. Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, Bangalore, India, May 2017, pp. 1101–1105, doi: 10.1109/RTEICT.2017.8256941.

[2] C. H. Patil, N. Lightwala, M. Sherdiwala, A. D. Vibhute, S. A. Naik, and S. M. Mali, "An IoT based Smart Medicine Dispenser Model for Healthcare," in *Proc. 2022 IEEE World Conf. Applied Intelligence and Computing (AIC)*, Sonbhadra, India, Jun. 2022, doi: 10.1109/AIC55036.2022.9848934.

[3] M. R. K. K, M. N. M, R. Zidan, I. Alsarraj, and B. Hasan, "IOT-Based Wireless Patient Monitor Using ESP32 Microcontroller," in *Proc. 2022 Int. Conf. Biomedical Engineering, College of Engineering and IT, Ajman University*, Ajman, United Arab Emirates, 2022, doi: [insert DOI here].

[4] P. Tiwari and R. Raman, "Smart Pill Dispensers and IoT: Advancements in Medication Administration," in *Proc. 2024 Int. Conf. Emerging Systems and Intelligent Computing (ESIC)*, Bhubaneswar, India, Feb. 2024, doi: 10.1109/ESIC60604.2024.10481624.

[5] Z. Nasir, A. Asif, M. Nawaz, and M. Ali, "Design of a Smart Medical Box for Automatic Pill Dispensing and Health Monitoring," *Eng. Proc.*, vol. 32, no. 7, 2023, doi: 10.3390/engproc2023032007.

[6] C. L. Kok, Z. Y. Loo, and J. P. Chai, "Embedded Solutions for IoT Based Automated Drug Infusion Device," in *Proc. 2023 20th Int. SoC Design Conf. (ISOCC)*, Jeju, Korea (Republic of), Oct. 2023, pp. 284–287, doi: 10.1109/ISOCC59558.2023.10396203.

[7] P. Chandramohan, K. Venusamy, G. Deepak, M. A. Wazil A.K, and N. R. Um, "Automated Medicine Dispenser with Personal Healthcare Monitoring Using IoT," in *Proc. 2023 Eighth Int. Conf. Sci. Technol. Eng. Math. (ICONSTEM)*, Chennai, India, Apr. 2023, pp. 250–255, doi: 10.1109/ICONSTEM56934.2023.10142832.

[8] R. B. Bhat, M. Preethi, and Reshma, "Pillbox: A Smart Solution for Personalized Medication Scheduling and Monitoring," *Int. J. Recent Adv. Sci. Eng. Technol. (IJRASET)*, vol. 12, no. 12, Dec. 2024, doi: 10.22214/ijraset.2024.65975.

[9] A. Jagadeeshwaran, H. S. Kumar, S. S. Sayeed, and C. A. Vaithilingam, "Smart Pill Reminder," in *Proc. 2021 1st Int. Conf. Advances in Computing and Future Communication Technologies (ICACFCT)*, Meerut, India, Dec. 2021, pp. 1–5, doi: 10.1109/ICACFCT53978.2021.9837341.

[10] M. Ramljak, "Smart home medication reminder system," in *Proc. 2017 25th Int. Conf. Software, Telecommunications and Computer Networks (SoftCOM)*, Split, Croatia, Sep. 2017, pp. 1–5, doi: 10.23919/SOFTCOM.2017.8115585.