1. **Introduction**

Problem

For college students, industry professionals, and people from all walks of life, alarms or other methods of waking up on time have become essential. Sleep is an essential need that no one wants to give up, yet there are numerous demands in our lives that take us away from the comfort of our beds. To stay on top of their schedules, people resort to various methods of alarms- setting many alarms all two or three minutes apart, downloading an app that forces them to take a picture, or using a smartwatch alarm. However, many times the human body automatically adjusts to the routine of a regular alarm, allowing people to snooze or turn off alarms in their sleep, turn off their phone, or get used to the vibration of a smartwatch alarm.

Solution

To solve this problem and force users to wake up to turn off their alarm, we wish to make an alarm clock with four different challenges using simple sensors (load cell, gyroscope, temperature, pedometer) to turn it off with the clock randomly picking which challenge needs to be completed every morning. Randomly picking between four different challenges every morning keeps the user on their toes, with minimal effort required from the user to set the alarm by having everything in one succinct device.

Visual Aid

Figure 1: Example image describing our solution generated using Google Gemini

As shown in Figure 1, we intend our design to be a sensor deck above the clock. Our sensor deck will wake up when the selected time is reached and pick a challenge for the user to complete. After completion of the challenge, the sensor deck sends a signal to the alarm to stop ringing or making noise.

High-level Requirements

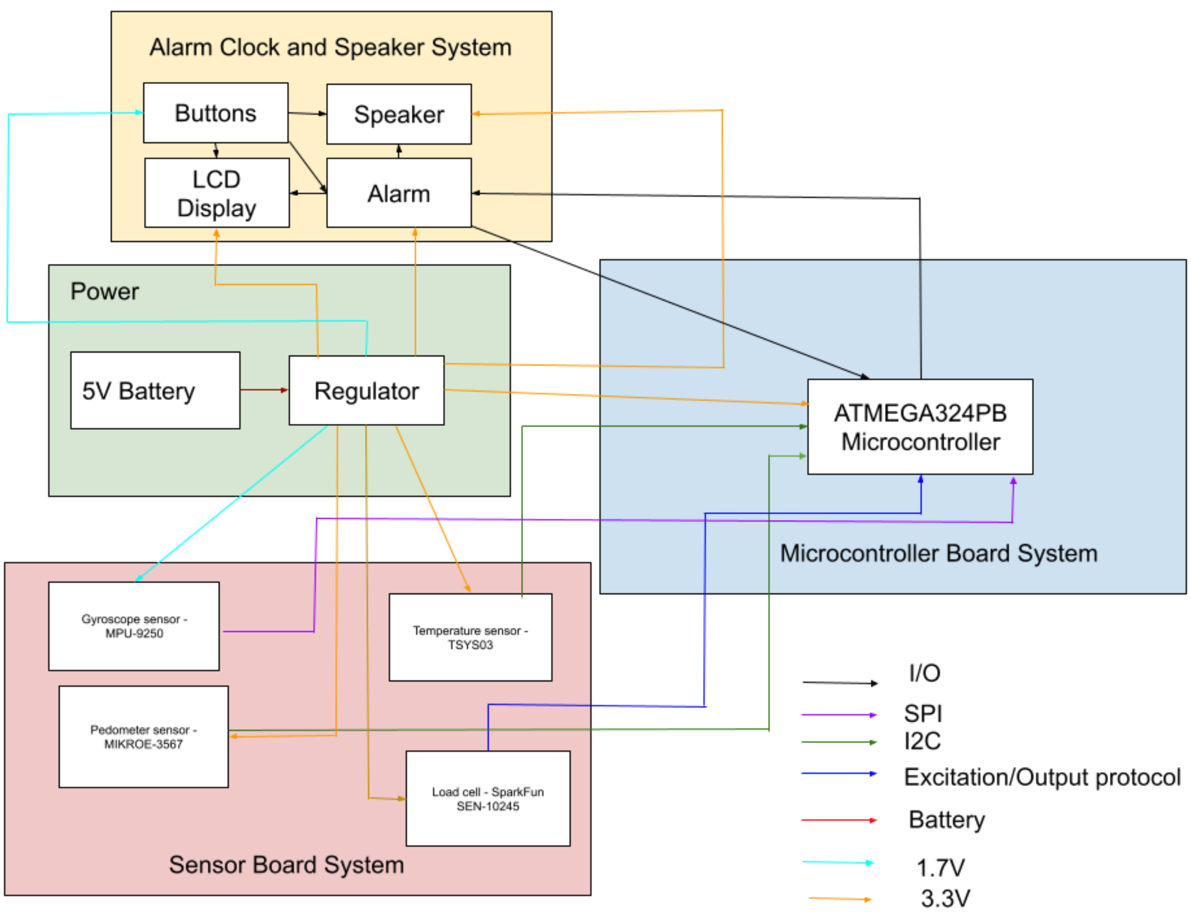
Challenge subsystem wakes up and decides which challenge to complete within five seconds of the wake-up time, and then stops ringing as soon as challenge is completed or within ten minutes, whichever comes first.

The active set of challenge sensors, the pedometer and gyroscope sensors, function as expected by indicating challenge completion within 250 steps walked and at least 2 minutes of shaking which results in an angular rate of 2 +/- 1 rad/s.

The passive set of challenge sensors, the temperature and force sensors, function as expected by indicating challenge completion within 5 +/- 2N of force applied for 3 minutes, and registering at least 2 mins of 37 +/- 3 deg F for 2 minutes.

2. Design

Block Diagram



Subsystem Overview

Subsystem 1 - Alarm clock and speaker

The first part of our solution is the physical alarm clock that we will be modifying to add to our challenges. We wish to use a simple AA-powered alarm clock with a clear LCD display for the user to be able to easily program times in and use power efficiently. To inform the user what challenge is to be completed that morning, pressing the clock's snooze button will play an instruction on a separate speaker that we will add (i.e., "SHAKE CLOCK FOR ONE MINUTE"). This subsystem will send and receive required I/O signals to the Microcontroller subsystem via C. Each individual element of this subsystem will receive power from the regulator within the power supply and management subsystem. The Speaker, Alarm and LCD display will require 3.3v, and the buttons will require 1.7v.

Subsystem 2 - Challenge Deck with sensors

The second part of our solution is our challenge deck with the associated sensors:

1. *Gyroscope sensor* - MPU-9250 with built in gyroscope and accelerometer sensors. The challenge we want to incorporate here is to shake the clock for one minute, and we will use the data from the sensor to verify the shaking of the clock. This sensor will transfer its data via an SPI interface to the Microcontroller Subsystem. A supply voltage of 1.7v will be supplied via the power supply systems through the regulator.
2. *Temperature sensor* - TSYS03 temperature sensor. The challenge we want to incorporate here is to get up and put the clock in the fridge for two minutes while waiting there for the alarm to turn off. We will check to see if the clock holds a temperature below 40 degrees Fahrenheit (avg fridge temp is 37 degrees) for at least one minute, to consider the time it takes for the clock to cool. This sensor will transfer its data via an I2C protocol to the Microcontroller Subsystem. A supply voltage of 3.3v will be supplied via the power supply systems through the regulator.
3. *Pedometer sensor* - MIKROE-3567 pedometer sensor. The challenge we want to incorporate here is to get up and take 250 steps with the alarm clock. This sensor will transfer its data via an Excitation/Output protocol. A supply voltage of 3.3v will be supplied via the power supply systems through the regulator.
4. *Load cell* - SparkFun SEN-10245 load cell. The challenge we want to incorporate here is to apply an even and constant force for three minutes, to make it inconvenient enough time to be unable to do it in your sleep. This sensor will transfer its data via an I2C protocol to the Microcontroller Subsystem. A supply

voltage of 3.3v will be supplied via the power supply systems through the regulator.

Subsystem 3 - Control

To link all the sensors, we will be using an ATMEGA324PB microcontroller. To make the alarm clock stop ringing when the challenge is completed, we will generate the signal that is usually generated by the "stop alarm" button to the alarm. Once the challenge is completed, we will also use the previously mentioned speaker to give the user simple audio feedback that they've completed the challenge, with a "ding" sound. This subsystem will act as the interface between the Alarm Clock and Speaker subsystem and the Sensor subsystem. The microcontroller will receive I/O data via the alarm subsystem. When a challenge is enabled, the microcontroller will receive and interpret the sensor data. If a challenge is active and if the challenge is completed, the microcontroller will send a signal to the Alarm and Speaker subsystem that will turn off the alarm and speaker. The microcontroller. If a challenge is not completed within 10 minutes of the challenge being set, then the microcontroller will send a signal to the Alarm and Speaker subsystem to turn off the alarm and speaker. The microcontroller will determine which challenge to complete via RNG and send this signal back to the alarm and speaker subsystem. These signals and conditions will be in C.

Subsystem 4 - Power supply and management

To power our alarm clock, we will be using a standard pair of AA batteries. This power supply and then the subsequent power regulator, the AZ1117CD-33TRG1, will be used to successfully power the display and alarm as well as the challenge deck with the appropriate step down voltage. The base supply voltage will be 5v. The regulator will send different voltages varying from 1.7v to 3.3v.

Subsystem Requirements

- Subsystem 1 - Alarm Clock and Speaker System

If no challenge/alarm is active, the clock will behave as a normal digital clock.

The buttons on the clock will allow the user to change the time, as well as set an alarm/challenge.

If an alarm or challenge has been set, and the challenge has been completed, it must stop within 5 seconds of challenge completion.

If the snooze button is pressed the speaker will notify the user which challenge has been chosen.

If an alarm or challenge has been set, and the challenge has not been completed within 10 minutes, it must stop.

· Subsystem 2 - Challenge Deck with sensors

The gyroscope sensor accurately registers shaking (angular rate of 2 +/- 1 rad/s) and is able to interface with the microcontroller to communicate the completion of the 1 minute challenge requirement.

The temperature sensor accurately registers cooling of the clock at the accurate average fridge temperature (37 +/- 3 deg F) and is able to interface with the microcontroller to communicate the completion of the 2 minute challenge requirement.

The pedometer sensor accurately registers steps and is able to interface with the microcontroller to communicate the completion of the 250 +/- 25 step requirement.

The load cell sensor accurately registers the force applied (5 +/- 2N of force) and is able to interface with the microcontroller to communicate the completion of the 3 minute challenge requirement.

· Subsystem 3 - Control

The microcontroller is successfully able to send a signal to the alarm clock that the challenge is completed in order to turn off the alarm within 10 minutes or within challenge completion.

The microcontroller is successfully able to read data from all sensors in order to register completion of the appropriate challenge within 5 seconds of challenge completion.

· Subsystem 4 - Power supply and management

The regulator is successfully able to step the voltage down from 5+/- .3V to 3.3+/-.2V to interface with the challenge deck while also powering the clock.

Tolerance Analysis

Components & Current Draw:

- ATMEGA324PB: 0.25 mA
- TSYS03: 400 μA (0.4 mA)
- SEN-10245: 1.5 mA

- MIKROE-3567: 60 µA (0.06 mA)
- MPU-9250: 0.2 mA
- Typical Digital Alarm: 260 mA

Total Current Draw:

- $I_{out} = 262.41$ mA

Parameters:

- $T_j(MAX) = 150°C$
- $V_{in} = 5V$
- $V_{out} = 3.3V$
- $(\Theta_{jc} + \Theta_{ca}) = 100°C/W$
- $T_a = 38°C$

Junction Temperature Calculation:

Using the formula:
$T_j = I_{out} \times (V_{in} - V_{out}) \times (\Theta_{jc} + \Theta_{ca}) + T_a$

Substitute values:
$T_j = 0.26241 \times (5 - 3.3) \times 100 + 38$

$T_j \approx 82.61°C$

Since $T_j \approx 82.61°C$, it is below $T_j(MAX) = 150°C$.

TSYS03:

Temperature accuracy error = ± 0.5 °C.

Operating Temperature Range (°C) = -40 - 125

MPU-9250:

Gyro Full Scale Range(dps)= ±2000

Accel Full Scale Range(g) = ± 16

MIKROE-3567:

Pedometer error = ±3%

SEN-10245:

Output Sensitivity(mv/v) = 1.0±0.1

3. Ethics and Safety

The main ethical and safety concerns that arise from this project are in the form of disruption of the natural environment for unintended persons, such as companions or roommates of the user. In addition to this, another issue we potentially identified is the possibility of the challenges being excessively strenuous to our users. The IEEE code of ethics states that engineers should not injure others, whether that be mental or physical(IEEE Code of Ethics, Section II no. 9). For the case of disrupting anyone else, we prioritized having our challenges be as minimal time as possible in order to wake the user up but not be exceedingly long. In addition to this, we focused on making our challenges as easily accessible as possible, not involving any form of running or jumping to prevent excessive physical strain on the user and to not exclude or discriminate against those with disabilities(IEEE Code of Ethics, Section II no. 7).

A possible safety concern of placing the alarm clock in a refrigerator involves the use of alkaline batteries in frigid temperatures. A person may ignore or even forget about a ringing alarm clock in the refrigerator since the sound will likely be muffled and sleepiness can impair human judgment and decision making abilities. While refrigerators do not go below freezing temperatures, it is still possible for malfunctions to occur. Alkaline batteries are unsuitable for very low temperatures because the electrolytes may freeze, which can cause leakage or bursts. These batteries contain corrosive substances that are hazardous and can damage eyes and skin.