Design of a logic circuit for an electronic activity bracelet

Authors

Elena Pascual Corral, Universidad de Salamanca (Spain)
Sergio García Sánchez, Universidad de Salamanca (Spain)
José Manuel Iglesias Pérez, Universidad de Salamanca (Spain)
Raúl Rengel Estévez, Universidad de Salamanca (Spain).

Type of activity

This exercise is applicable in digital electronics, industrial automation, and control systems classes. It relates to SDGs 9 (Industry, innovation and infrastructure) and 3 (Health), which promote stirring a healthy life style through the development of electronic devices.

Recommended educational level

Aimed at students in the final years of secondary education (Baccalaureate) and Higher-Level Vocational Training, especially in areas of electronics, mechatronics, or automation. It is also suitable for university students of Electrical, Electronic, Mechanical, or Industrial Engineering.

Gathering information

Activity sensors —such as accelerometers and pedometers— are standard components in today's widely used smartwatches and fitness trackers. When properly configured, these devices provide valuable insights into the user's lifestyle, such as daily step count or overall activity level. Beyond monitoring, they can also play a key role in promoting healthier habits by actively tracking movement and issuing alerts when prolonged inactivity is detected.
However, it is equally important to respect the user's sleep and rest periods, as adequate rest is just as vital to health as regular physical activity. For this reason, activity monitors designed to encourage movement should integrate both motion

sensors and a time control mechanism that suppresses alerts during designated sleep hours, ensuring that the user's rest remains undisturbed.

Problem statement

An activity wristband is designed to, among other functions, prevent the user from remaining sedentary. To achieve this, the wristband includes a motion sensor that detects if the user has been still for more than 15 minutes (S). In such a case, a vibration alarm (A) will be triggered on the wristband to notify the user to start walking.

However, if the inactivity occurs during the user-defined rest period —in this case, between 23:00 (T_1) and 09:00 (T_2)— the alarm will not be activated, as this time frame is recognized as a resting period.

In summary:

- S = 1 if the user has been still for more than 15 minutes, and 0 otherwise.
- T_1 = 1 if it is later than 23:00, and 0 otherwise.
- T_2 = 1 if it is later than 09:00, and 0 otherwise.

Note that T_1 and T_2 take 00:00 as a reference (for example, at 02:00 $T_1 = 0 = T_2 = 0$, while at 13:00 $T_1 = 0 = T_2 = 1$).

Figure 1. Activity wristband monitoring system. The device alerts the user to start moving after a prolonged period of inactivity, while respecting designated rest periods to avoid unnecessary interruptions. Source: AI generated picture.

How is the user's activity level monitored while respecting rest periods?

We first identify the inputs and outputs to our system. The inputs are the binary signals S, T_1, and T_2, while the output is **the alarm signal *A*** indicating the user that he should start walking or exercising. Since between 23:00 and 09:00 the user is expected to be resting or sleeping -and therefore likely to remain inactive- the alarm should **not disturb** their rest during this period, even if S = 1. However, outside of the rest period (before 23:00 and after 09:00), the alarm should notify the user when they have been inactive for more than 15 minutes. In summary, the alarm should ring (***A* = 1**) when ***S* = 1**, considering the following time span criteria as summarized in the following truth table:

S	Time span	T_1	T_2	A
0	*	*	*	0
1	00:00 – 08:59	0	0	0
1	09:00 – 22:59	0	1	1
1	23:00 – 23:59	1	1	0

Therefore, the objective of this problem is to design a combinational circuit that governs the alarm behaviour according to the pre-set resting timespan, and the level of the activity of the user.

Monitoring and pursuing a conscious awareness of people's activity has been demonstrated to enhance a healthier life-style and prevent very common diseases in the motor, skeletal and cardiac systems. The circuit designed in this exercise is an example of the kind of systems that are commonly seen implemented in activity bracelets and smart watches that pursue these objectives.

In this way, the proposed solution contributes to the Sustainable Development Goals 3 and 9, promoting the applications of the electronics technology to the enhancement of the users' healthy habits.

Let's analyse how to implement this circuit fulfilling the established criteria.

Solution

1. **Truth table:**

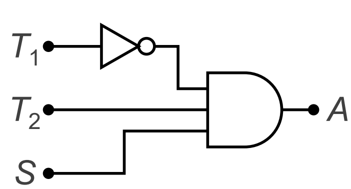
S	***T_1***	***T_2***	***A***	
0	*	*	0	→ High activity. Don't mind the time. Alarm OFF
1	0	0	0	→ Low activity. Earlier than 09:00 and earlier than 23:00. Alarm should not disturb sleep.
1	0	1	1	→ Low activity. Later than 09:00 and earlier than 23:00. Alarm should warn the user to move.
1	1	0	*	→ Low activity. Earlier than 09:00 and later than 23:00. Logically undefined, this situation is not possible (remember T_1 and T_2 take 00:00 as a reference).
1	1	1	0	→ Low activity. Later than 09:00 and 23:00. Alarm should not disturb sleep.

Karnaugh maps to simplify the logic function:

S \ T_1T_2	00	01	11	10
0	0	0	0	0
1	0	1	0	*

$$A = \overline{T_1} \cdot T_2 \cdot S$$

2. **Circuit:**



Conclusion

The designed system enables an activity wristband to effectively monitor the user's activity level and issue a timely alert when prolonged inactivity is detected, encouraging the user to move. At the same time, it respects the user's rest period by suppressing the alarm during the designated hours, ensuring an appropriate balance between activity and rest. This kind of system promotes healthier habits and helps prevent the health risks associated with a sedentary lifestyle, such as cardiovascular diseases or musculoskeletal discomfort, while avoiding unnecessary disturbances during sleep. It demonstrates how digital electronics can be applied to develop personalised, context-aware devices that improve health and quality of life. By supporting healthier behaviours and integrating innovative, user-centred technology, the system contributes directly to the Sustainable Development Goals (SDGs) 3 and 9, promoting good health and well-being and the development of resilient and innovative infrastructures that respond to human needs.

To extend this problem, additional features could be considered, such as:

- Allowing the rest period to be programmed dynamically by the user, rather than fixed between 23:00 and 09:00.
- Adding additional sensors, such as heart rate or ambient light, to better determine when the user is sleeping.
- Implementing an adaptive algorithm that learns the user's habits and adjusts the alert thresholds over time.
- Using a microcontroller-based system instead of purely combinational logic to increase flexibility and enable more complex behaviours.

This exercise encourages students to think critically about how technology can help address real-world health and lifestyle challenges, while also fostering creativity in the design of digital solutions aligned with sustainability goals.