Politecnico di Milano - Department of Electronics, Information and Bioengineering

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AOS Microcontroller Project

[Light Sensor & ADC Interfacing]

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Contents

1 Introduction

The goal of the project work was to implement a peripheral driver for the STM32f407 microcontroller. The implemented driver enables the use of the analog-to-digital converter (ADC). The microcontroller which contains the analog-to-digital converter is located on a development board (STM32 F4 Discovery kit) shown in figure 1. This development board contains components that can be interfaced with the microcontroller.

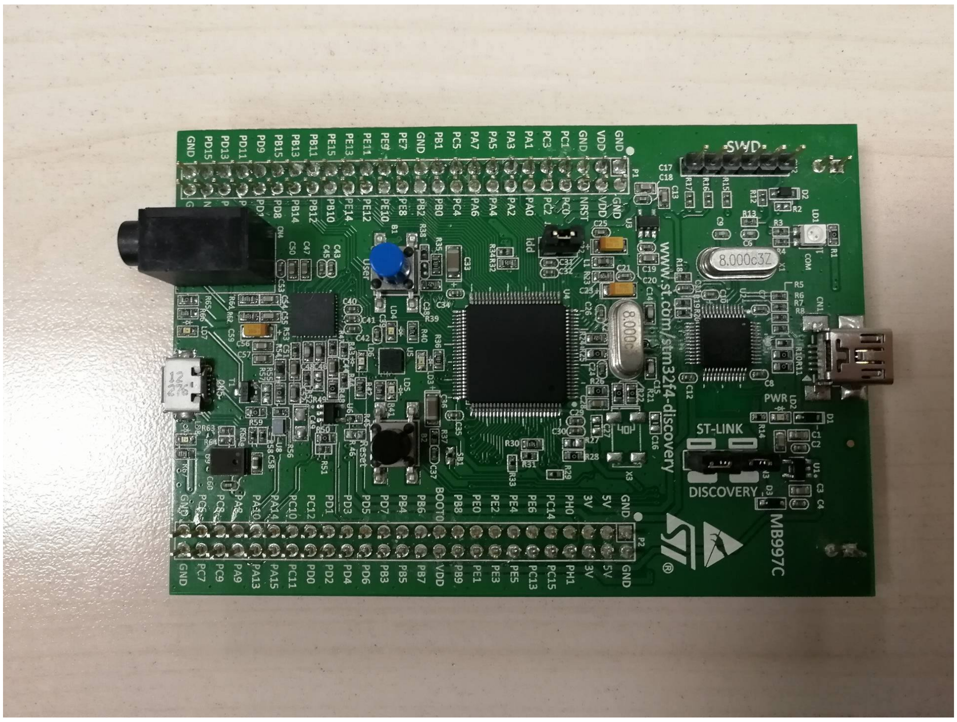

Figure 1: Discovery Board

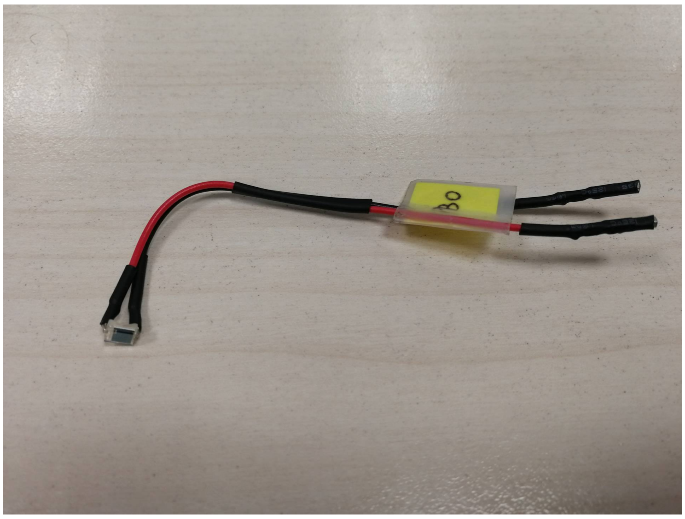

Figure 2: Photodiode

In this work the push buttons and LEDs were utilized. An external photodiode shown in figure 2 was connected to the development board connection pins. These components were used to make a simple user reaction game.

2 Design and implementation

2.1 Game logic

The idea of the implemented game was to test the reaction time of a player. This game can be played by a defined number of players. The reaction time of a player is evaluated by indicating a start signal and after this signal the player has to cover the photodiode as fast as possible. The game logic is illustrated in figure 3.

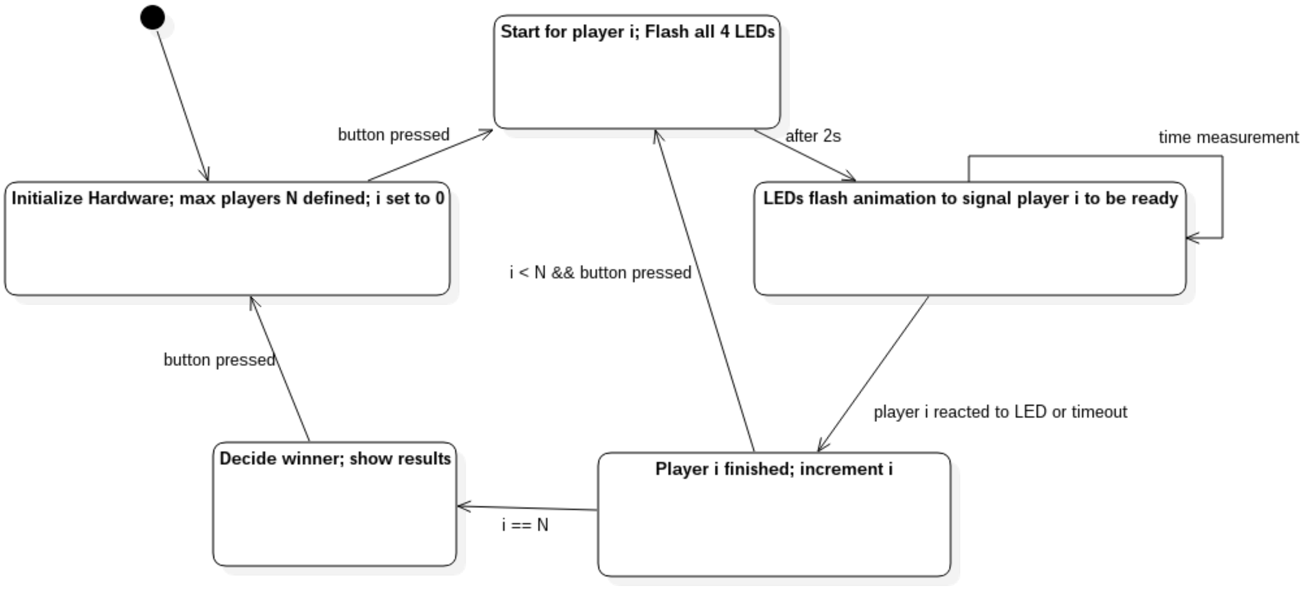
Start for player i; Flash all 4 LEDs
button pressed
after 2s
time measurement
Initialize Hardware; max players N defined; i set to 0
LEDs flash animation to signal player i to be ready
i < N && button pressed
button pressed
player i reacted to LED or timeout
Decide winner; show results
Player i finished; increment i
i == N

Figure 3: Game logic diagram

As illustrated in figure 3 the game is started after the hardware initialization has been completed. This is done when the power of the board is turned on and the board's push button has been pressed. Information about the game status and corresponding instructions are printed on a serial monitor. These instructions are shown in chapter 3.

After the push button has been pressed it is the first player's turn and all of the user programmable LEDs start to flash rapidly for a short duration and then turn off. This is an indication to the player to get ready to get ready. After this the LEDs start to light up in a clockwise orientation one by one. Once the fourth LED has lighten up, the player has to cover the photodiode as quickly as possible. Player reaction time is measured from the fourth LED lighting up and to the point when the photodiode has been covered.

Then another player starts their turn by pressing the push button and has to interact in the same manner as the player before. This cycle is repeated until all of the players have had their turn. The reaction times are finally displayed and the player who had the lowest reaction time wins the game. A new game can be started by pressing the push button.

2.2 Peripheral drivers

For simplicity a design choice for this microcontroller project was to avoid the use of threads. Every game logic procedure is executed in a sequential order and only interrupts allow to break this cycle and trigger events concurrently.

In this project, interrupts are used by timers to toggle LEDs and for button detection. For the analog watchdog polling is utilized. This approach allows to sense if the user tries to cheat by covering the photodiode before the fourth LED start to flash. As an alternative to this it would be also possible to realize the watchdog with interrupts and toggle the LEDs with sleep delays.

The Miosix operating system ([1]) is included in the project workspace and is mainly used for a simplified accessing of the STM32F4 peripheral addresses by calling provided register names. Also the *Timer* class for measuring time and the *Random Number Generator* are exploited.

2.2.1 ADC

The control of the analog-to-digital converter builds the core of the project. A simple photodiode is connected to the board and introduces an analog input voltage level depending on the ambient light intensity. The voltage has to be detected and read out as a digital signal in defined time intervals. Since the actual values are not important for this project, there is no data processing necessary. The values simply have to be compared to a threshold voltage and if they exceed this threshold, further action should be initiated. The analog watchdog provided by the microcontroller is used to execute this comparison.

2.2.2 Push button

2.2.3 LEDs & Timer

Since the toggling of the LEDs is realized with interrupts, the LED management explicitely includes a hardware timer. The *Led* class knows three different operating modes: At the beginning of a game round all four LEDs flash rapidly, after that the number of blinking LEDs increase from 1 to 3 and finally after a random time interval also the fourth LED becomes active. For all these three modes only one timer (TIM3) needs to be utilized because the blinking procedures happen sequentially.

For every sequence the function *startLedTimer()* is called with a different time interval which sets the prescaler of the timer. Also the new LED mode is passed with the function. With the given mode every time the timer generates an overflow interrupt, the corresponding IRQ handler knows in which way the LEDs should be toggled.

2.2.4 Serial

2.2.5 Connections

[2]

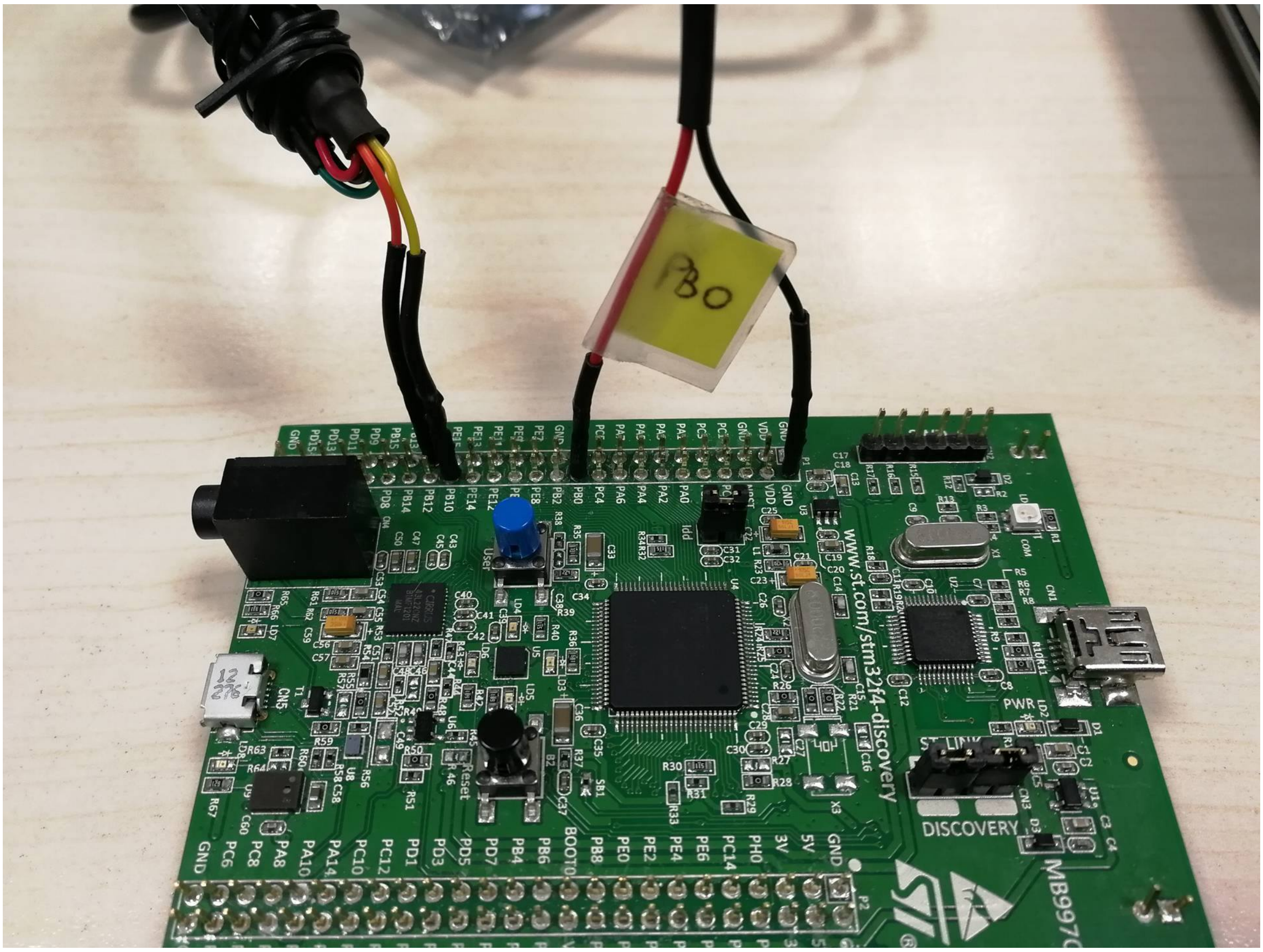

Figure 4: Connections

3 Experimental evaluation

3.1 Experimental setup

3.2 Results

4 Conclusions

References

[1] Federico Terraneo. Miosix operating system. Website. https://miosix.org/index.html.

[2] STMicroelectronics. Reference Manual RM0090 for STM32F407. 2017.