Advanced Sports Timer

Team Number: 63

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1. Introduction

1.1 Objective

The objective of this project is to be able to allow a track coach to monitor the performances of different athletes in a team at the same time. The problem came from the current process of monitoring performances, which requires sprinters and runners break form to pause and look at their times, and have to orally or manually write down their times for the coach to evaluate and consider.

We proposed a solution that could annihilate the different problems encountered in the current process by using a design similar to a stopwatch that can be easily and discreetly worn on the multiple fingers or clipped on the sprinters' cloth without impeding their form when running. The device will be able to wirelessly transmit the results to a central hub that will be held by the coach and easily viewable.

1.2 Background

This project was brought forth by a track coach in Rhode Island who was unhappy with current Stopwatch timers currently on the market. Our solution would not only remove the burden of reaching across their bodies to start and stop the timer, which can cause inaccurate times because of the change in gait, but also allow the reporting of this data to happen without the interruption of practice. This could help runners all over the country get more accurate times and help coaches interpret the data more efficiently. There are many stop watches currently on the market, not all of them have the number of modes that we are looking to implement (such as lap interval timer, countdown timer, interval exercise timer, etc), and none of them allow for the transmission of the data wirelessly to a phone or tablet where the data can be viewed graphically.

1.3 High-Level Requirements list

In order to solve the problem of being able to keep track of multiple athlete's times the first characteristic that must be exhibited is a small size. The device needs to be small enough and comfortable enough to be used by a single person while they are running. We plan to make a 3 to 4-finger sized ring for the athlete to wear and be able to control the stop, start, and reset of his timer.

The next high-level requirements is that the sports timer needs to be able to wirelessly transmit data to a receiver at a quick enough rate such that there is no data loss or interference. We plan to first store the data, using flash memory since it's fast and reliable, before sending it in order to preserve data just in case the data gets lost or corrupted during transmission. The data will be able to be accessed and viewed in graphical form.

The last, and possibly the most important, characteristic is that the device must be able to track the time and be able to communicate with a screen. This would include the different modes that we want to implement on the device. In order to track time, we will be using a real time clock (RTC) chip in order to keep track of all our timing issues. The RTC chip is what will keep the time count consistent and accurate. If the RTC was not used then keeping track or measuring time while be difficult and may possibly lead to false data.

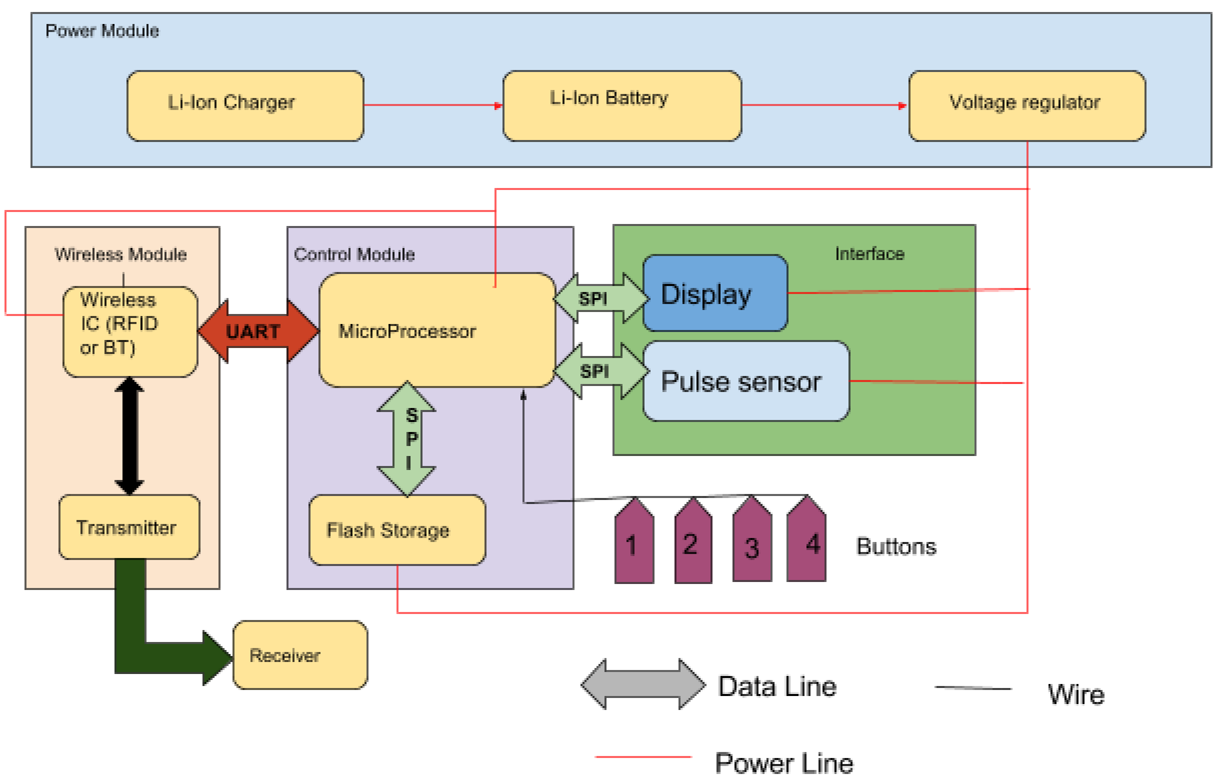
Overall this would summarize what we need from the device:

- Have a compact and nondescript housing size, ideally a size of 3”x1”.
- Preserve at least 2KB of data for transmission to the Hub.
- Have a transmitter and receiver that has a bandwidth of at least 2Mb/sec for fast transmission.
- Be able to reliable track the times to within a millisecond of accuracy.

2. Design

Our design is constituted of five modules that are interconnected with power flow and data flow. We have the power module, which is the block that processes power accordingly to the information content at the control interface. We also have the wireless module, the control module and the interface module.

2.1. Block Diagram



2.2. Power Module

The power module is composed of 3 other submodules which are the li-ion charger, the li-ion battery and the voltage regulator.

2.2.1 Li-ion Charger

We will implement a Li-ion charger that will charge a li-ion battery having it main source from wall outlet. The charger will be constituted of a one 115V/9V single-phase transformer, a full-bridge rectifier, a filter and a variable regulator, just to name the main components. The charger will allow a current of about 500 mA. The charger will be able to charge the 9V li-ion battery fully for only 3 to 4 hours.

Requirement 1: *The li-ion charger will be able to provide a voltage close to 9V DC at the output.*

Requirement 2:*It will also be able to continuously provide a current close to 500mA needed to charge the li-ion battery.*

2.2.2 Li-ion Battery

For this part of the power module, we will use a 9V , 1200mAh li-ion battery with snap connectors that will ensure a strong connectivity between the battery and the device. Thus the battery will be able to continuously supply power to all the the different blocks of the devices that need power until discharge or until the device is turned off by the user.

Requirements: The 9V li-ion battery will be able to store enough power needed by the device. It will also be able to operate at its operating temperature range of 253.15K-333.15K.

2.2.3 Voltage Regulator

The voltage regulator submodule will be composed of two buck converters that will have for main purpose to step-down the 9V DC voltage received at their input into respectively 3.6V needed by the control module, and the 5V needed by the display in the interface module.

Requirement 1: *The buck converters will be synchronously controlled with approximately 85% efficiency to reduce losses with a switching frequency of around 250 kHz.*

Requirement 2:*The voltage regulator will also be able to maintain the different voltages needed, (3.6V +/-5% and 5V +/-5%) at their nominal values in order to continuously power the device.*

2.3. Wireless Module

The wireless module is the module responsible to transmit the different informations through radio. It is composed of two mains submodules which are the wireless integrated circuit and the transmitter.

2.3.1 Wireless Integrated Circuit (IC)

The wireless IC will be responsible for taking the data that we feed into it and convert it into analog radiation, to be sent over the air.

Requirement 1: *Our wireless IC must communicate using either RFID or NFC*

2.3.2 Transmitter/ Receiver

The transmitter and receiver pair are responsible for sending over the data. The range will be small, approximately 4 cm - 12 cm. This will easily be within the range of most NFC/RFID chips. The frequency will operate within 10 and 20 MHZ

Requirement 1: *Be able to transmit the data with at least an approximate bandwidth of >=1Mb/sec. The data being sent will be small so there is no use for a bandwidth over 2Mb/sec.*

2.4 Control Module

The control module handles the calculations and necessary data manipulations for the basic stopwatch functionality. The microprocessor will handle the operations then when temporary logging must occur such as when a runner runs a lap but wants to continue running, the microprocessor will write the lap time to flash. Once all time recording is done and the data must be transmitted, the microprocessor will move the data in flash and send it over UART(Universal Asynchronous Receiver/Transmitter) to the wireless IC for transmission.

2.4.1 Microprocessor

The microprocessor solutions we are currently considering are either ARM processors or an FPGA based solution. If we go for an FPGA based design, most likely Altera or Xilinx FPGAs, we will most likely be including a processor, either Nios II or MicroBlaze, IP core into our design. The processor will handle the computations and the remaining programmable logic will be used for peripheral connections. We think experimenting with an FPGA might save on space, so as to keep a small overall profile for the wearer.

Requirement 1: *The Microprocessor/FPGA must be able to simultaneously communicate data to the flash and display. The data transmission to flash must happen at least at 1Kb/sec.*
Requirement 2: *Must have a UART interface for communicating with a console.*
Requirement 3: *Must have at least 1MB of RAM for programs to run.*

2.4.2 Flash Storage

The flash memory will be a temporary point in the transmission of the data to the HUB. While the watch is timing the athlete, the flash will contain previous lap times or perhaps whole run times. Once transmission occurs there will be no use for keeping information here so it will be wiped as data is transmitted.

Requirement 1: *Must have at least 5KB of storage size.*
Requirement 2: *Must have Read/Write speeds of at least 1Kb/sec.*

2.5 Interface Module

The interface will be the module that directly interacts with the user, by either reporting data or getting in input and responding to the input. We will implement a simple UI(User Interface) that will allow some interaction with the watch.

2.5.1 Display

The display will be a simple and small 16X2 display that can show the current times for the runners as well as any other information that a stopwatch would be expected to do.

Requirement 1: *Must be small, roughly 96x24 pixels.*
Requirement 2: *Must use approximately 250 milliWatts per hour.*

2.5.2 Buttons

Simple push buttons will allow the user to interact with the different features.

Requirement 1: *Must be able to produce a suitable voltage to drive the GPIOs.*

2.5.3 Pulse Sensor

The pulse sensor we will be using is Digi Key's MAX30100EFD. The sensor has a sampling rate between 50 sps and 1000 sps, so this will be more than sufficient to measure our users heart rate in real time. It operate at a voltage of 2.2V and draws 20mA of current. Its total power dissipation is 44 mWh. The interfacing with the processor will involve reading and writing to a FIFO on the sensor.

Requirement 1: *Must be small enough to be worn on the fingers.*

2.6 Risk Analysis

Risk analysis of our project is the process by which we are able to access the different and possible risks which threaten the achievement of our project objectives [1]. There are several aspects of the design that have a risk related to them. One of them is getting the power needed to to feed the device while being under the weight specification. In fact as mentioned in the previous part, the device will require enough power in order to aliment the module such as the interface module, the wireless module and the control module. The screen display in the interface module requires will require 5 Volts and draw 40 mAh, which give a power consumption of 200 mWh. While, the wireless module will take approximately 50 mWh, and the sensor will require 2.2 Volts and draw 20mAh which gives a power consumed of 44 mWh . It will be difficult to control the switch frequency of the buck converters used and as well as have the weight of the device maintained under the specification. Since the device is mainly for track runner, the weight of the device is very important as it will affect how the athlete performs.

3. Ethics and Safety

Our project seems to be fairly ethical in its natural form. The reason for saying that our project is ethical is because it follows the regulations and rules set by the IEEE code of Ethics [2]. Some things that we would like to point out that may be unethical about our project is if we decided to use code found online and not stating so. We do plan to code everything ourselves from scratch, but if we do use a library that will be beneficial to the project we will make sure to specifically state that we used code that was not ours. The other unethical thing our device may cause is harm to the athlete if we do not design it accordingly. For example, we would not want our device to short or cause any sort of shock to the athlete who is wearing the timer for safety concerns. The University of Illinois specifically states that we have to be careful in harming anything and that we should plan for safe designs [3]. These are some of the ethical challenges we will be facing when working on this project. Other than this, we as engineers from the University of Illinois are certain, and will make sure, this project focuses on assisting colleagues and co-workers, avoids injuring others, and follows the other guidelines set by IEEE.

References

[1] Perry, John 'Project Risk Analysis and Management', 2007. [Online]. Available: http://www.fep.up.pt/disciplinas/PGI914/Ref_topico3/ProjectRAM_APM.pdf. [Accessed: February 2017].

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[3] Engineering Services 'Ethical Guideline', 2017. [Online]. Available: https://courses.engr.illinois.edu/ece445/guidelines/ethical-guidelines.asp. [Accessed: February 2017].

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