LED Swim Pacer

ECE 445 Senior Design Proposal

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Table of Contents

I. Introduction

1. Title

LED Swim Pacer

This project is proposed by Coach Howard. He wants a swim pacer unit as a training tool to help improve the performance of his swimmers. This variable speed sequential LED pacer will help pace swimmers allowing them to swim at different speeds set in a predetermined setting.

1.1 Motivation

There are multiple different pacers for running and other sports which helps improve one's performance. A swimming pacer on the other hand helps swimmers improve their swim time. With a strip of LED underwater, the swimmer can follow the LED light and could increase the speed of the LED to improve the swimmer's performance. The waterproof strip and control can be easily set up and it will have a display to show the speed of the pacer. Each of the LED will be connected in series with a shift register to reduce wiring and size of the strip. Ends of the strip will be programmed to be faster to account for when the swimmer pushes off the pool wall. The colors at the end will also be different to alert the swimmer that the end of the pool is near.

2. Objectives

The goal of this project is to design and build a swim pacer using a strip of LED. There will be a main controller controlling several shift registers. The controller will have pre-programmed modes which can be changed easily from the control box.

2.1 Benefits

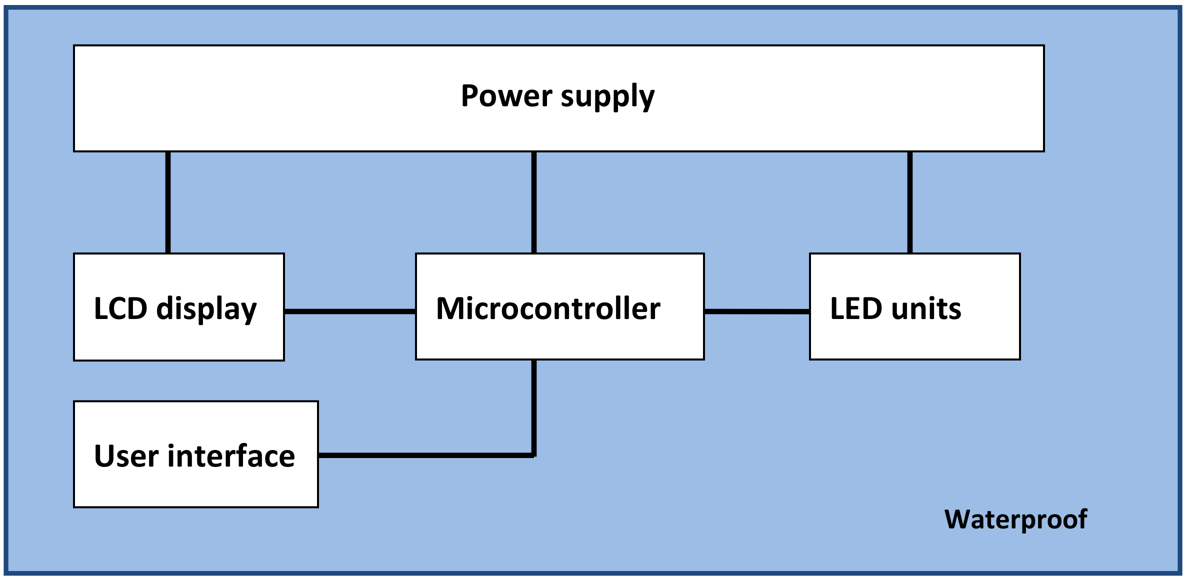
- User-friendly display and controls
- Simple to deploy
- Ability to monitor and improve swimmer's speed

2.2 Features

- Strip of green LEDs with a 50cm separation between each LEDs
- Two ends of the strip will have red LEDs to alert the swimmer
- Variable speed control allowing the end of the LED to be sped up as the lap begins
- Waterproof LED strip and control box
- Low power consumption

II. Design

1. Block Diagram



2. Block Descriptions

Power supply
The unit will be powered by battery so the pacer device is portable and doesn't require electric socket. This allows the unit to be waterproof and reduces the risk of electric shock to the users.

Microcontroller
The microcontroller will process the data from the user interface block and output the data to the LCD block. It will also control the signal that it has to transmit to the LED units. Depending on the mode that the user chooses, it will send out different signal to the LED units. The microcontroller also calculates the speed of the LED strip and displays it on the LCD.

LCD display
The 2×16 LCD display will show the current set up information from the micro controller which includes the time required to swim the 25m and the meters per second that the LED is moving and the mode the program is in. It will have a microcontroller that processes the data to be displayed and it will be connected to the main microcontroller.

User Interface
The user interface will have three waterproof buttons to control the mode and the speed of the pacer.

LED units
LEDs will light up individually with different speed according to the signal from the microcontroller. Several LED will be connected to a shift register to reduce the wiring and reduce the thickness of the strip. The 8 bit shift register will control 8 LED units. Each of the LED unit will contain 2 LED for brightness and in case one breaks down, the other will be its back up.

3. Performance Requirement

- Signal should be accurate to the 100ms
- LEDs should be able to light up when it receives the signal with 0% error
- LCD should be able to display the mode and the speed accurately from the user input
- LED should be bright enough for the swimmer to see and follow
- Device should be 100% waterproof

4. Special Circuit

No special circuit required

III. Verification

1. Testing Procedures

1. LCD display will be tested to make sure it is fully functional and able to display the menu function properly without any error. This means the display code is bug free and could display the intended information. It will have different menu interfaces where the user can choose which mode they want to use. There will also be an interface where the user could control the timing for the 25m swim.

2. The microcontroller is the most important block in this device and it is tested to make sure that it can receive and respond according to user interface function signal. In order to test this we will connect LED at the microcontroller input and output to see if the input LED light up when button is pushed. We can also measure the pacer speed by measuring the time of LED flash rate as the distance between the LEDs are fixed. It is to ensure that the speed of the pacer is same as the one displayed. This test can also ensure that we programmed the slow clock functions correctly.

3. The power supply is also tested to make sure that it has enough power to supply to the microcontroller and the shift registers. Due to the long wiring in the device, we have to make sure that the wire doesn't have too much resistance that might cause the shift register or the LED to malfunction.

4. Signals need to be sent through a long wire for this device, thus, the resistance from the wire becomes quite significant. We will calculate and measure the actual resistance from the wire to avoid the resistance from affecting the performance. We will use different gauge wires for this test to make sure that the ones used will fit this project.

5. After assembly of all the blocks, the whole device is tested for waterproof because all these blocks are intended to work underwater or nearby. Making the device waterproof is one of the priority of this project. We will first test the waterproof ability of the LED strip by placing the LED strip in clear PVC tubing. It will be sealed at both ends and placed under water to make sure it's still functions as intended. Next we will test the waterproof ability of the main control box without components in it to prevent damaging the components if the test fails.

6. The LED strip needs to be at the bottom of the pool however with all the air in the tubing, the strip will float on the water. This test will make sure that there are enough weights on the strip to keep it underwater and aligned in a straight form.

2. Tolerance Analysis

The main microcontroller is the most important block in the device and it has to work 100% in order for the device to function as designed. It has to process the LCD signal, user interface and output signals to the shift registers in the LED units. It will be tested extensively to ensure that it's working as intended.

The microcontroller has to output a clock cycle to the shift register for the LED unit to light up. The world record for 50m freestyle is about 20 seconds. Therefore the LED unit will be tested to run 10 second for the 25m. A stop watch will be used to record the timing of the test to make sure that the device can handle the 2.5m/s speed.

An average child can swim 25m in about 40 seconds. Once again a stop watch will be used to record the timing of the LED strip. The LED light needs to be slow and accurate enough for the 0.625m/s speed. This might be harder to test because the LED strip is in an interval of 0.5m. However, the last LED at the end of the strip will indicate the end of the 40 seconds which has to be accurate to the 100ms.

As stated in the testing procedures we will carefully test the interface between the LCD, user interface and the main microcontroller.

Speed	**Timing(sec)**
Fastest	10s
Slowest	40s

IV. Cost and Schedule

1. Cost Analysis

1.1 Labor

Name	Hourly Rate ($/hr)	Total Hours to complete (hrs)	Total= Hourly Rate*2.5*hours to complete
Jonathan Lee	$32/hr	150 hrs	$12,000
Yi-Liang Chen	$32/hr	150 hrs	$12,000
Total			$24,000

1.2 Parts

Part	Cost ($)	Quantity	Total ($)
1602 LCD display	$13.95	1	$13.95
LED (Green)	$0.28	60	$16.80
LED (Red)	$0.28	40	$11.20
Wire(25 feet)	$2.00	200	$400
Energizer Battery AA	$1.57	4	$6.28
Resister	$0.02	100	$2.00
Tubing	$30	1	$30.00
Silicone Sealant	$6.95	1	$6.95
Microcontroller Arduino UNO board	$21.45	2	$42.90
Shift register 74HC595	$1.50	10	$10.50
Total			$540.58

1.3 Grand Total

Section	Total
Labor	$24,000
Parts	$540.58
Grand Total	$24,540.58

2. Schedule

Week	Task	Member
1/16-1/30	Brain storming for idea Get RFA approved Start working on proposal	Jonathan Lee, Yi-Liang Chen
2/6	Finish proposal Search parts	Jonathan Lee, Yi-Liang Chen
2/13	Detail electrical design schematics Research microcontroller implementation	Yi-Liang Chen
	Sign up for Design review Verification and tolerance analysis	Jonathan Lee
2/20	Complete flow charts and calculations Design review	Yi-Liang Chen
	Simulation, block diagram Design review	Jonathan Lee
2/27	Begin implementing microcontroller	Yi-Liang Chen
	Order parts Implement LCD and user input	Jonathan Lee
3/5	Continue microcontroller programming	Yi-Liang Chen
	Continue LCD and user input	Jonathan Lee
3/12	Prototype of LED strip on breadboard	Yi-Liang Chen
	Implement LED strip	Jonathan Lee
3/19	**Spring Break**	Jonathan Lee, Yi-Liang Chen
3/26	Sign Up for Mock Presentation Program microcontroller	Yi-Liang Chen
	Test LED strip	Jonathan Lee
4/2	Assemble the product	Yi-Liang Chen
	Troubleshoot bugs	Jonathan Lee
4/9	Testing and Debugging	Yi-Liang Chen
	Waterproof test	Jonathan Lee
4/16	Sign up for Demo and Presentation Finish Testing and Debugging Work on final paper	Yi-Liang Chen, Jonathan Lee
4/23	Demo and Presentation Revise Final Report	Jonathan Lee, Yi-Liang Chen
4/30	Finish final report Presentation	Jonathan Lee, Yi-Liang Chen