University of Wisconsin-Madison
ECE 453: Embedded Microprocessor System Design
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Design Proposal: Electric Skateboard

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Executive Summary

Our team will engineer a fully-functional electric skateboard controlled via a handheld remote. The project will consist of three modules: a remote control module that uses the PSoC6-BLE microcontroller unit to control the speed of the skateboard, a skateboard module that contains another PSoC6-BLE microcontroller connecting the remote module to the skateboard module via BLE, and a phone module that displays the current speed of the skateboard on a phone application from BLE communication with the skateboard module.

The remote control will house a rotary encoder to control speed. The remote module will communicate with the skateboard through an electronic speed controller to regulate how fast the skateboard will travel. The remote module will communicate speed changes from the input device to the skateboard module, and those changes will be reflected on the mobile phone application. The remote module will act as the server device, since the microcontroller unit serves the data to the skateboard module.

Project Description

Design Objectives

- ➢ To allow the user to control the acceleration and deceleration of the skateboard with a rotary encoder dial
- ➢ To allow the user to safely operate the skateboard by inputting a maximum speed that the board will not exceed
- ➢ To allow the user a safe experience by enabling a safety trigger that will decelerate the skateboard if the user loses control of the remote and releases pressure on the trigger
- ➢ To allow the user to view important metrics including the battery life of the skateboard and the current speed of the board via a mobile application

Measure of Success

The measures of success ensure that the design objectives are achieved when the following happens:

- ➢ Interaction between the modules via BLE allows the speed of the skateboard to change when the rotary encoder dial is turned
- ➢ The speed of the skateboard is viewable for the user to see when they are accessing the mobile application
- ➢ A maximum speed is set on the mobile application and is not exceeded by the skateboard

Design Plan

Remote Module

The remote module will be a 3D printed handheld controller unit that has a rotary encoder to control speed. It will also have a 3D printed trigger attached to a pressure sensor to detect whether the user is holding the controller, and releasing it will make the skateboard gradually come to a stop. The controller will have LEDs to show the current battery percentage of the skateboard. There will also be a start button to turn on the controller and pair the BLE of the PSoC6 remote module controller to the BLE of the PSoC6 skateboard module automatically. The dial wheel of the rotary encoder is used to set the speed to a constant number and only changes when rotating the dial. The acceleration is fixed and around 2 - 2.5 m/s^2.

The PSoC6-BLE microcontroller will have three main tasks: BLE communication, speed control, and presence detection. The remote module will wait for input from the rotary encoder so that the skateboard can start moving; however, acceleration can only start when the pressure sensor indicates the user's hand is present. The data from the encoder will be sent to the skateboard module from BLE.

Skateboard Module

A PSoC 6 MCU will communicate with the remote module to receive speed input. An ESC will drive a 6374 brushless DC motor, and we will use a 36V 10000mA battery to supply power to both MCU and motor. A buck converter will be used to split the battery source between the PSoC6 and the motor. The motor will drive the wheels with pulleys and belts. A mounting bracket will affix the motor to the rear truck and deck.

The skateboard module will utilize the same BLE communication to transmit data between both the remote module and the mobile application module. The main task of the skateboard module will be to receive data from the remote module and transmit it to the ESC, translating and smoothing input values if necessary.

Mobile Application Module

The mobile application module is a simple mobile application that receives data via bluetooth from the skateboard module to allow end users to define a maximum speed for safety. The app will also be able to present information to the user, including the current speed of the board and battery percentage. This app will be available to users who have access to a smartphone device.

Project Features and Team Roles

Each project feature's color indicates which team member is responsible for the specified task. Although each task has one allocated team member that is responsible for completion of that task, all team members will be familiar with every project feature so we can integrate the features seamlessly and help one another if needed. Each team member has tasks with a specified color as indicated by:

Aritra Chakraborty
Liam Hupfer
Jarvis Jia
Leah Kreiter

Stretch goals indicate goals that are not required design goals, but we would like to implement them if time allows. These goals will be colored orange.

- ➢ Skateboard module hardware assembly
  - Fasten wheels, trucks, motor, and pulleys onto skateboard deck
  - Attach battery, ESC, and MCU
  - Stretch goal: software-configurable LED's to reflect battery life embedded onto the board
    - Red LED: battery <= 20%
    - Green LED: battery > 20%
  - We estimate that this will take 5 hours to complete based the accessibility of DIY electric skateboard guides
- ➢ PCB Design of the Skateboard Module
  - PCB design including brushless DC motor, battery source, electronic speed controller, and PSoC6-BLE microcontroller
  - We estimate this to take about 10 hours on Kicad, as we need to research how to connect ESC to the MCU and figure out how to connect to different GPIO pins.
- ➢ Remote module hardware assembly
  - 3D print housing, modeling, and assembly of the remote module hardware
  - We estimate this to take about 20 hours based on our limited experience with 3D printing
- ➢ PCB Design for the Remote Module

- PCB design includes rotary encoder, pressure sensor, power switch, battery source, and PSoc6-BLE microcontroller
- We estimate this to take about 10 hours on Kicad, as we need to determine how to connect the components to the microcontroller unit

➢ Remote Module software implementation

- Set up rotary encoder to control speed acceleration and deceleration
- Set up trigger so it acts as a safety precaution - when trigger is engaged user can adjust speed, else skateboard automatically begins to decelerate by reducing power
- Set up BLE communication on PSoC6 so that it can communicate with the skateboard module
- Set up power switch for controller
- Stretch goal: software-configurable LED's to reflect battery life embedded into the remote controller
  - Red LED: battery <= 20%
  - Green LED: battery > 20%
- We estimate this to take about 15 hours, assuming we can use example code from the HAL and configure it correctly with the PSoC6 microcontroller

➢ Skateboard Module software implementation

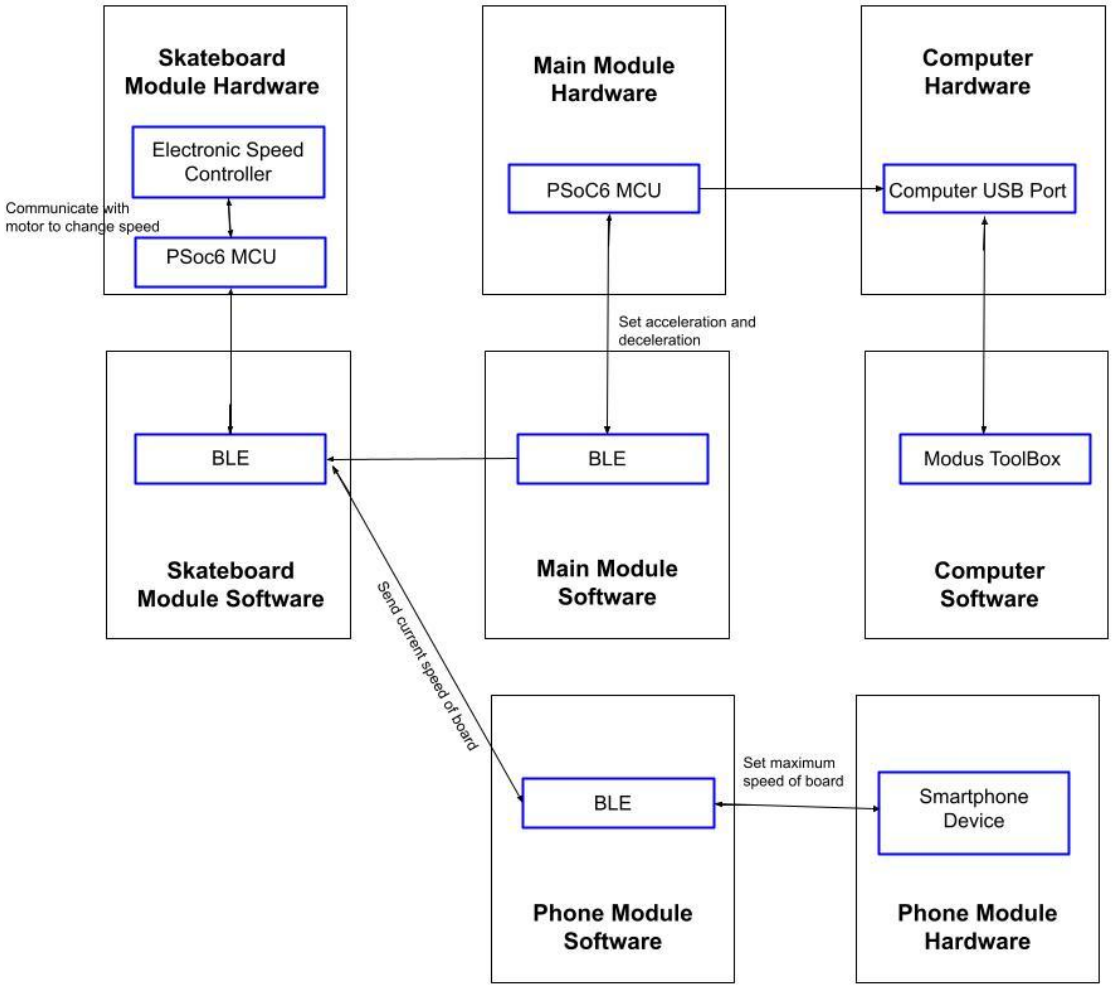
- Set up BLE communication on PSoC6 so that it can communicate with the remote module and phone module
- Configure the ESC to interact with the BLE and motor
- We estimate this to take about 15 hours, assuming we can use example code from the HAL and configure it correctly with the PSoC6 microcontroller

➢ Mobile Application Software Development

- Implement basic user interface for changing operating parameters
  - Maximum speed
  - Stretch goal: acceleration curve
- Implement interface for reporting usage data
  - Current speed, battery level

        - Stretch goal: ride summary - gives the user an average trip speed and total time of the trip
    - We estimate this to take 20 hours in total, as we need to familiarize ourselves with BLE connection between two devices, and outputting the speed of the skateboard to the app

Block Diagram



Cost Estimate

Part	**Model**	**Quantity**	**Cost estimate**
Motor	MBoards 6374 180KV Motor	1	$110
Deck	31.5" X 8" Mini Kicktail Blank Deck (#C31)	1	$35
Trucks	Caliber trucks	1 set of 2	$60
Wheels	90 MM flywheels	1 set of 4	$40
PCB development kit (skateboard MCU)	CY8CPROTO-063-BLE	2	$20
Pulleys and mount	Motor mount and sprocket pulley kit for 6374 motor	1	$40
Skateboard battery	36V 10000mAh	1	$131
Power converter	Buck Converter TLV62569DBVR	1	$15
ESC	Mini FSESC4.20 50A	1	$100
Remote MCU	CYBLE-416045-02	1	$20
Remote battery	AA battery	2	$4
Remote battery holder	36-2461-ND battery holder	2	$8
Rotary encoder	Dial wheel potentiometer	2	$6
Pressure sensor	BPS330-AG005P-3T	1	$20
Switches	JS202011CQN	4	$2
Total			$611