**ECE 445**

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**Project Proposal**

# Conductive Fabric Gesture-Controlled Sleeve

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# Table of Contents

# 1 Introduction

## 1.1 Motivation for Design

Cyclists encounter many distractions as they travel. Between using their arms to indicate turns and navigating, riders must also focus their attention on the road to ensure their safety. This has created a need for a wearable solution that enables connectivity on the go and optimizes the rider experience, while preventing against the possibility of an accident.

## 1.2 Project Description

Our project will integrate gesture control into a fabric sleeve that can be worn by bicyclists. Inspired by Project Jacquard, a commuter jacket designed by Google and Levi's that keeps riders connected while on the move, this sleeve will be equipped with a capacitive touch sensor system designed on fabric using conductive thread. The sleeve will be responsible for detecting simple gestures, which in turn will be routed through an RF module to a receiver capable of perform certain actions depending on the gesture pattern. For the purposes of this project, the external interface will be an LED array setup that will represent the potential use cases of this conductive sleeve technology.

This product can be potentially used by bikers to control simple functions on their smartphones. Given the wide scope of potential applications, the end goal for this project will be to demonstrate the touch sensing capabilities of the wrist band. As such, we will be using a 2D array of multi-colored LEDs for demonstration.

## 1.3 High-Level Requirements

- The sleeve, located on the arm, will be able to wirelessly communicate with the LED array display.
- This product will be able to detect four different hand gestures on the sleeve: swipe up, swipe down, single tap, and double tap.
- The product will implement a tilt sensor to create a sensitivity limit to detect if the sleeve
- The LED array will be used to demonstrate the sensitivity of the gesture-control and tilt sensors on the sleeve.

# 2 Design

## 2.1 Block Diagram

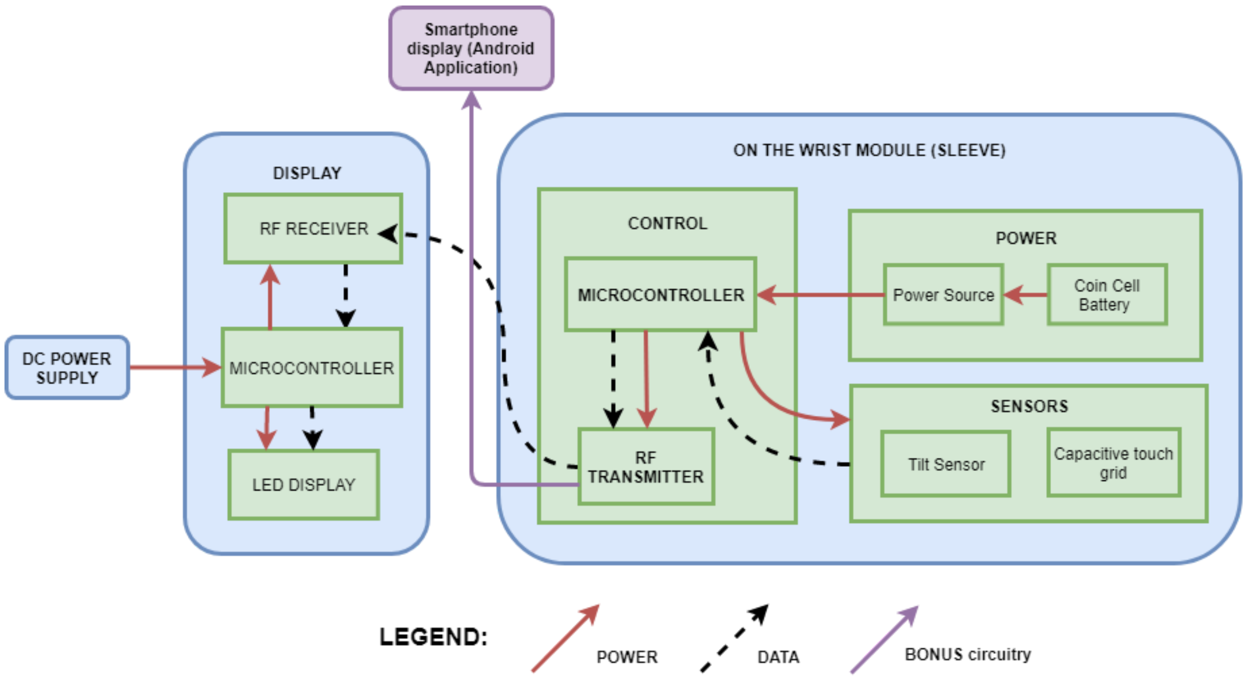


Figure 1. Block diagram of system design

## 2.2 Functional Overview

At a high-level, the system will function as follows. The capacitive touch grid will be created using conductive thread woven on fabric. There are a two ways the user can interact with the sleeve and provide the system inputs. The user can interact with the touch grid located on the wrist by performing four predetermined gestures that correspond to different actions. The signal will be read by the microcontroller located on the wrist. There will be four baseline gestures the user can make to interact with the sleeve. Next, the microcontroller will send the signal using a RF transmitter located on the wrist to the RF receiver. When the RF receiver receives the signal, the signal will be sent to the second microcontroller to illuminate the LED display accordingly.

## 2.3 Description of Blocks

**2.3.1 Conductive Thread Capacitive Touch Grid**
This capacitive touch will be used to detect the gestures made by the biker on the sleeve. It will consist of a conductive thread pattern and will be powered by the microcontroller. It will be capable of detecting four gestures - swipe up, swipe down, single tap and double tap. The capacitive grid will be made of conductive thread weaved into straight lines oblique to sleeve and will be connected directly to the microcontroller.

**2.3.2 Tilt Sensor**
The tilt sensor will be

**2.3.4 Microcontroller**
We expect to use two microcontrollers, one each for the sleeve and LED demo submodules. The microcontroller on the sleeve submodule will handle collecting and processing the input from the capacitive touch sensor. It will determine which gesture the user performed and what action should be performed next. Then, it will provide the output signals to the RF transmitter. A second microcontroller will be used to support the LED display demo. This one will collect the signal from the RF receiver. It will process it to these inputs to determine which LEDs and what color should be displayed, corresponding to the gesture made.

For this project, we have chosen to use the Atmel MEGA328P microcontroller. It supports the generic driver for capacitive touch and has 23 general I/O pins that will be sufficient to communicate all input and output information from the sensors to the RF transmitter.

**2.3.5 RF Module - Receiver/transmitter**
The RF module will establish communication between the two submodules, with the transmitter on the wrist/sleeve module and the receiver on the LED display module. The number of bits this block must be able to handle will depend on the touch grid size. There will also be four signals corresponding to the four gestures the user can make that the transmitter must communicate to the receiver. Those gestures are 1) swipe up, 2) swipe down, 3) single tap, and 4) double tap.

**2.3.6 LED Display**
The LED block will be used to demonstrate the sensitivity of the sleeve and the state associated with the gesture pattern. A 2D array of LEDs will be illuminated accordingly. To show the sleeve's sensitivity, the LEDs will illuminate to display the actual pattern made by the user on the capacitive touch grid. It display will support four different colored LEDs (red, green, blue,

yellow) to indicate the four gesture patterns. This block will receive their inputs from the second microcontroller that is connected to the RF receiver.

### 2.3.7 Power

The power supplies will keep the components running. They will supply power to each component block with the exception of the capacitive touch grid. The power supply for the sleeve module will be small cell batteries and the overall design must be small in the spirit of wearable tech. The ATmega328/P microcontroller that we are considering for our design offers three primary speed grades at different voltage ranges. While we currently remain unsure of the computing speeds and therefore power required for the performance of our sleeve, we expect to finalize specifications only after additional testing of our design components. In general though, we believe these metrics are helpful to start with.

An added potential complexity to our design will be supporting wireless battery charging, although this would require rather intensive RF design that we would only pursue if we have the time to do so. The LED array display will be connected to the wall outlet.

## 2.4 Block Requirements

### 2.4.1 Touch sensor sensitivity

Threshold value of capacitance will be determined based on experimental results, and used to set the sleeve’s touch sensitivity. When a user touches the conductive thread pattern, the dielectric constant of that particular thread will increase. This will change the discharge time of the capacitor and this property will be used to set the threshold value.

As a result, gesture sensitivity requirements will include testing on time (ie to differentiate between a tap or a swipe) and capacitive grid resolution to find the optimal thread pattern. Another important factor to the sensitivity will be the insulating material. Thorough testing will also be conducted on several materials to identify the ideal dielectric constant and EM shielding for capacitive touch.

### 2.4.2 Sleeve Submodule Physical Dimensions

In the spirit of wearables, physical dimension will be an important factor in our projects future marketability. Based on our research of the average adult wrist and forearm sizes, it is expected that the sleeve will be between 22-25 cm in circumference at the wrist and 30-35 cm in circumference at the forearm. We will need to test the responsiveness of different conductive thread capacitive grid patterns and the spacing between the conductive thread lines before finalizing the size of the actual sensor grid for our design.

#### 2.4.3 MCU requirements

Clock speed ranges and power requirements will affect power specifications. These will be dependent on component testing of the sensors. The chosen MCU can support the following clock speeds:

0 - 4MHz @ 1.8 - 5.5V
0 - 10MHz @ 2.7 - 5.5V
0 - 20MHz @ 4.5 - 5.5V

#### 2.4.4 Surface Mount PCB

Physical dimensions continue to be important for this module as it will be on the sleeve submodule.

#### 2.4.5 Power

Based on initial research, off-the-shelf small button batteries can provide up to 3V at 220mAh. Our project will be sensitive to clock speed which is determined by the power provided to the MCU. Depending on initial bench tests, a greater voltage and current may be necessary to achieve higher clock speeds. Other compact batteries we may consider would then include AAA batteries and lithium ion polymer batteries.

## 2.5 Risk Analysis

We believe the biggest risk of our project will be the sensors block. Our design depends on the sensitivity of the capacitive touch sensor and tilt sensor to provide accurate information to the microcontroller. Information from both the touch and tilt sensors will be input signals to the microcontroller to determine the action that should be performed next. In particular, one design challenge for the touch sensor will be to determine the adequate levels of gesture sensitivity. Different users will make swiping or tapping gestures at varying rates, so to avoid false positives, thorough testing must be performed to achieve the optimal pattern design and gesture tolerances. As a result, our project will also be dependent on the microcontroller's clock speed. For both sensors, we will need to be mindful that they are not too sensitive, otherwise the system will perform actions when they are not needed. If they are not sensitive enough, the system will not receive enough data. Another challenge will be implementing low-level code for bluetooth module driver.

## 3 Ethics & Safety

As we continue to work towards finalizing the design of our sleeve, we hope to eliminate the possibility of any electric shock to a potential rider. Given that the bicyclist is interfacing directly with conductive fabric and is also wearing the sleeve, we want to ensure that we incorporate some type of electrical insulating fabric to avoid direct skin to sleeve contact and afford the rider greater protection. One of the ways we hope to minimize this risk and also protect the sleeve from the environment is by applying a water resistant epoxy. While this is a later-stage design consideration, if pursued, we would need to consider the impact of the epoxy on the sensitivity of the conductive thread and ensure that the overall performance of the sleeve is not compromised.

# 4 References

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