ECE 445 Senior Design Project Proposals

Human-Machine Interface (H.M.I.) enabled by Epidermal Electronics System (E.E.S.)

Spring 2013

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Introduction

1. The purpose of Project

The purpose of this project is to design an epidermal electronics system (EES) and apply this concept for human-machine interface (HMI). The micro/nanotechnology development has access to many types of motion sensors such as Nintendo Wii game controller. However, users still need to hold the controller physically with their hands in order to control any machine or video game. This project would allow those people with neurological and muscular disorders to control machines without having to physically access them. Moreover, we can use it for handling critical risk materials such as scientific studying field. It would make it easier to conduct EMG tests without the hassle of all the bulky equipment. Here, our team wishes to address this issue by directly mounting the electronic system onto skin epidermis, such that human motions can be directly translated into a controlling system.

2. Objectives

A. Goals

i. Fabricate & Design the EES for conformal lamination onto the human skin.

ii. Develop the electronic circuits to control the system.

iii. Test the EES for HMI (quad-rotor control using EMG from the skin).

iv. Evaluate and analyze the electrophysiological signals

B. Benefits

i. Mobile and equally accurate EMG readings when compared to formal EMG equipment reading.

ii. Stretchable, meandering structures naturally follow the soft, curvilinear skin morphology without the use of conductive gels that can cause side effects on the skin.

iii. Conformal lamination of the EES on the skin gives high-quality electrophysiological signals for long time (a week) without adhesives and/or tapes.

C. Features

i. Skin-like material (ultrathin, lightweight, and low modulus).

ii. EES that has the matching mechanics to the skin epidermis.

iii. Signal processing circuits.

Design

1. Block Diagrams.

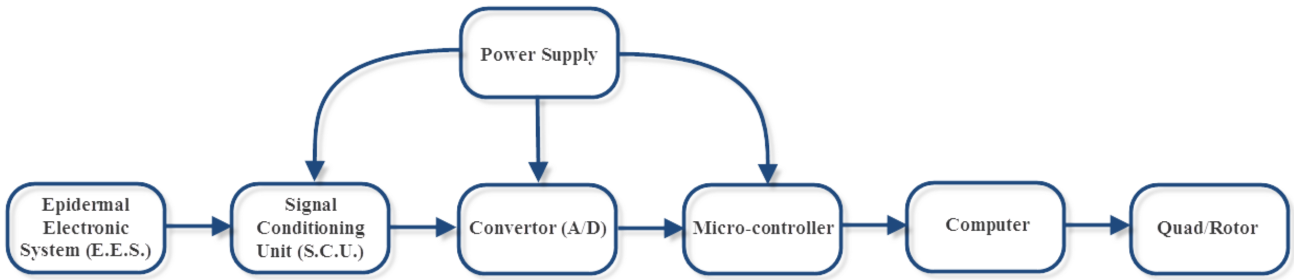

Figure 1. Overall Block Diagram

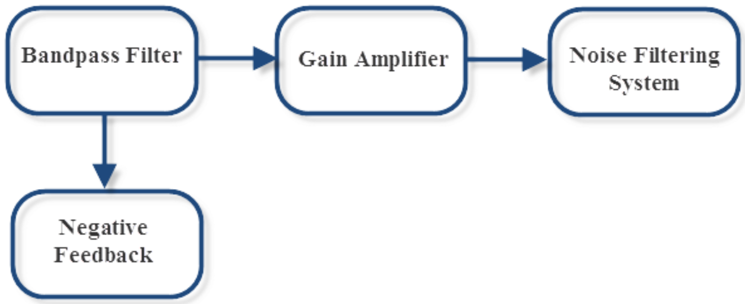

Figure 2. S.C.U. Block Diagram

2. Descriptions

A. Power Supply: We are still on deciding between using power source from the wall or our own battery. But basically, power supply will power up the most of our device except EES.

B. Epidermal Electronic System: The EMG sensor will include three electrodes, each in a form of a filamentary serpentine (FS) mesh with exposed metal that contacts the skin directly, for measurement (MEA), ground (GND), and reference (REF).

C. Signal Conditioning Unit: This unit will receive signals from EES, detect certain amplitude, and amplify the signal. This Unit must contain band pass filter, gain amplifier, and noise filter system.

D. Convertor (A/D): It is essential for the received signal to be converted to digital in order for it to be analyzed. This unit will convert the received analog signal (bio-potentials) from the skin and convert it to a digital signal that is then be analyzed by the microcontroller.

E. Micro-controller: The regulation of the received signal will be done with the microcontroller. It will compare the received signal and with the assistance of predefined programming the necessary action is brought about.

F. Computer: The commands will go through the computer in order to control machine wirelessly. For now, we are planning to use quad-rotor as our machine.

Requirements & Verification

1. **Requirements**

    A. Power Supply: The power supply is the main power source for all the components in our system. It will range from 5- 10 volts and adequately power all the parts of our system.

    B. Epidermal Electronic System: The device must be ultrathin in order to have respected stretch ability and flexibility. We need to use right materials not only to make this device, but also use a proper way to transfer the device from a substrate to skin. Therefore, the device will have a total thickness of around 1 micrometer, gold (Au), done with fabrication process. The fabrication process will be performed on a silicon wafer as a substrate. A double transfer process involving a water soluble tape releases the resulting device from the wafer to allow integration on the skin. It will transfer to a water soluble sheet of polyvinyl alcohol (PVA). Application of water washes this sheet away after mounting on the skin (forearm), to leave only the EES. Additional layers of spray-on bandage can be applied directly on top of the EES to improve the robustness of integration.

    C. Signal Conditioning Unit: This unit must amplify and noise filters the signals from the EES. After converting analog signal to digital signal, then the microcontroller can detect the signal properly in order to command through the program.

D. Convertor (A/D): This system needs to be designed to convert the analog signal to digital signal with high signal processing rate. Thus, we will search various options to optimize the system.

E. Micro-controller: It is required that the microcontroller interpret the received signal and pass the signal onto the computer to bring about the desired action. This interpreted signal can be used to control a machine and implement the desired motion.

F. Computer: The computer should be able to interpret the signal from the microcontroller and it should ideally send a signal to control the quad rotor. In order to send the signal to the quad rotor, we will use a Wi-Fi Computer EMG Signal Converter .We are not involved with the design and system of the quad rotor. It will be provided to us.

2. **Verification**

A. Power Supply: The power supply should consistently give us a voltage that will sufficiently power our devices. We'll verify this by using a multimeter to gauge the voltage.

B. Epidermal Electronic System (EES): The device will be verified by comparing the signal measured with old type (which conductive gels must be applied) EMG measuring device. If the waveforms match enough, then our EES works properly.

C. Signal Conditioning Unit: Check filtered output signal so that the waveforms are clear enough to make commands beyond the signals. We will use an oscilloscope to check the output signal and determine if this is the desired signal.

D. Analog to Digital Converter: Check the data processing rate and signal-to-noise level of digital signal after converting the analog data.

E. Microcontroller: After the microcontroller has been programmed and connected, we will input a variety of input signals with the assistance of a function generator and observe how the microcontroller responds to the signal.

F. Computer: The computer should process the directions from the microcontroller in the right manner and should control the machine as we desire.

3. Tolerance Analysis

The EES must work to a tight tolerance since accurate EMG signals must be detected compare to formal EMG sensor. If we get far different waveforms from EES, the device is not actually performing as an EMG sensor. With the assistance of an oscilloscope and documented signals from previous EMG tests, we will be able to determine if the waveform from the EES is as accurate as the signals from the EMG tests. As long as the EMG readings are almost the same in terms of signal to noise ratio which is ± 1mV, we shall consider it to be an acceptable reading.

Cost & Schedule

1. Cost Analysis

a. Labor Costs

	$/Hour	Overhead	Total hours	Subtotal ($)
Woosik Lee	50	125	144	18000
Ohjin Kwon	50	125	144	18000
Nithin Reddy	50	125	144	18000
Note : Total hours = 12hous x 12weeks				

b. Parts Costs

Parts	**Cost($)**	**Quantity**	**Total($)**
ADC0804	9	2	18
PIC	5	3	15
12v Battery	12.5	2	25
Resistors (100Ω – 15kΩ)	.8	100	80
Op Amp	5	30	150
Instrument Amp	8	3	24
Universal Filter	15	3	45
PCB board	40	3	120
Capacitors	2.5	20	50
Potentiometers	2.5	10	25
Mask Film	20	2	40
Photo-resist (Two different types)	20	2	40
Polymer (P.I.)	40	2	80
Si wafers	20	4	80
ACF wires	5	1	5
Masks	15	2	30
Total			827

- *We did not include the supported materials & equipment that cannot approximate the cost, such as gold source for E-beam. And all the listed parts are approximated after research online, and all parts that could have different* *values (capacitors, resistors, op amps, etc) are approximately averaged in order to find total costs.. More parts can be added in order to design devices.*

c. Grand Total : Labor Cost, $54000 + Parts Cost, $827 = $54,827 *approximately*

2. Schedule

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<tr><th></th><th>2/6</th><th>2/11</th><th>2/18</th><th>2/25</th></tr>
<tr><td>Woosik Lee</td><td rowspan="3">Update proposal, team discussion</td><td rowspan="2">Design EES, Mock Design Review</td><td rowspan="3">Finalize design of Signal Conditioning Unit (S.C.U.), Order parts of S.C.U. Finish EES</td><td rowspan="3">Design Review, S.C.U. & E.E.S.</td></tr>
<tr><td>Ohjin Kwon</td></tr>
<tr><td>Nithin Reddy</td><td>Design PCB board, Mock Design Review</td></tr>
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<tr><th></th><th>3/4</th><th>3/11</th><th>3/18</th><th>3/25</th></tr>
<tr><td>Woosik Lee</td><td rowspan="3">Modify S.C.U. & E.E.S.</td><td rowspan="3">Test E.E.S. & S.C.U.</td><td rowspan="3">Spring Break</td><td rowspan="3">Programming Microcontroller, Modify S.C.U. & E.E.S.</td></tr>
<tr><td>Ohjin Kwon</td></tr>
<tr><td>Nithin Reddy</td></tr>
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<tr><td>Woosik Lee</td><td rowspan="3">Finalize microcontroller, Test all of parts</td><td rowspan="3">Test all of parts, Additional feedback</td><td rowspan="3">Testing, Tune-up</td><td rowspan="3">Prepare Final Demo, Presentation</td><td rowspan="3">Presentation, Final Paper</td></tr>
<tr><td>Ohjin Kwon</td></tr>
<tr><td>Nithin Reddy</td></tr>
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