Chapter 9
Toward Applications of EMG and Preliminary Study in the Next Design of Compact Integrated Bio-Signal Recording System

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ABSTRACT

Electromygraph or EMG is a device used to measure and record muscle signal. The developments of microelectronics allow the design and realization of such a device with current off-shelf components. The authors developed system consists of multi-channel analog circuitry and is microcontroller based to facilitate connectivity with a computer or laptop as a recording platform. From this developed system, the authors further improve the system by referring to the previous result. One of the improvements is the user controllable gain of each channel. However, beyond the improvement to the system, the use it in an acupuncture experiment for recording muscle signal during the acupuncture process. This paper also explores the possibility of implementing muscle signal as a control for an assistive system and integrating it for an integrated bio-signal recording system.

INTRODUCTION

Electromygraph or EMG is a device used to measure and record muscle signal (Moritani, Stegeman, & Merletti, 2004; Farina, Stegeman, & Merletti, 2004). The developments of micro-electronics enable us to design and realize such device with the current off-shelf components. We have shown in our previous work (Aridarma et al., 2009) that such system is feasible to be realized. Our developed system consists of multi-channel analog circuitry and also microcontroller based to facilitate connectivity with computer or laptop as a recording platform.

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Our previous design has open several possibility of further study utilizing EMG. Two of the possible applications of EMG that currently interest us are measurement of muscle signal during acupuncture process and utilizing measured surface EMG signal as an input to an assistive system. Beside applications, we also study the possibility of integrating the EMG into a compact bio-signal recording system. The grand design of this system is to be able to detect and record bio-signal in general, whether it is EMG, ECG, EEG, or EOG. Our system is not perfect; we still have many things to be improved.

SYSTEM DESIGN

The aim of this design is a low cost microcontroller based EMG system, which can record and store EMG signals. The system itself will consist of two main parts, hardware and software. The hardware part will be responsible to detect, digitize, and transmit the muscle signal to computer. The software part will be responsible for recording and displaying the digital data. We divide the prototype requirements into three groups. They are usage requirements, hardware requirements (Day), (De Lucca, 2003), and software requirements (Van Bemmel & Musen, 1997). Example of usage requirements are portability and safety. Hardware requirements are derived from the characteristic of muscle signal, it frequency, amplitudes, and signal noises that may detected during measurement.

Figure 1 is the simplified block diagram of the system. The two blocks, hardware and PC is connected by using serial RS232 protocol.

The hardware part consists of two sub-parts: analog and digital. The signal amplification is done by using cascaded amplifier, with instrumentation op-amp as the first amplifier (Merletti & Hermens, 2004). We choose MAX4194 for this purpose, because it enable us to further uses the common signal as a feedback to reduce noise signal that may interfere during measurement (Mancini, 2002). This step is simply done by reading the signal from the from between two resistors that control MAX4194 gain. If we use MAX4196 or MAX4195, these resistors are located inside the IC. For the next stage amplification we choose TL072 op-amps for all op-amps other than instrumentation op-amps. We set the gain of instrumentation amplifier to 26. This includes the op-amps used in the filter. We set the filter so it will have unity gain (Bramble, 2002), although during testing, the gain is not as uniform as we expected.

Signal filtering will remove unwanted frequency. In this design we develop a band pass filter with the 4th order Butterworth-Salley Key topology. The band pass frequency is 20Hz to 400Hz. These setups are repeated for each channel. We decided not to put a 50Hz notch filter in these setups because 50Hz frequency is considered as one of the frequency where muscle signal can be strongly detected.

Since in this design we include 4 channels requirement, we need to further average the common signal from these 4 channels before we can use it as a feedback (Ott, 1976) to minimize noise. This technique is shown by Siriprayoonsak (2005). However we found that in our system, we are unable to use electrodes as the electrode for this feedback signal, so we use aluminum foil instead (Figure 2).

Digital parts of the hardware consist of microcontroller, Serial to USB module and opto-isolator (Hauck, 2006). We choose ATMEGA32 from Atmel for the microcontroller. ATMEGA32 has an internal ADC so we do not have to use external ADC (Wardhana, 2006). In developing the firmware for the microcontroller, we use C language combined with the embedded ASM in speed critical part of the firmware (Joni & Raharjo, 2006). For communication we use FT232 for communication, because it offers full 1Mbps speed. This speed is faster than standard RS232 to USB converter, which only offers 115200bps.