

Human-Computer Interface of Low-Cost Abductor Digiti Minimi Monitoring System Using sEMG

Vivekanandan S, Lokesh Kumar C, and Devanand M
VIT University/ School of Electrical Engineering, Vellore, India
Email: svivekanandan@vit.ac.in

D S Emmanuel
VIT University/School of Electronics Engineering, Vellore, India

Abstract—The affordability of the medical diagnostics is going high over time. To overcome this scenario people are looking for inexpensive, reliable and effective healthcare technologies that are user-friendly and could be used in home without physicians help. This paper focuses on the design and development of low cost *Abductor digiti minimi* (ADM) muscle monitoring system using surface electromyography (sEMG) that detects the electrical pulses from muscle and transmitted wirelessly. Telemedicine is one of the rapidly developing field's nowadays; hence remote monitoring plays a vital role in faster diagnosis by which continuous monitoring is carried out using ZigBee – wireless technique. The EMG data obtained in the receiver end is analyzed using MATLAB software.

Index Terms—Telemedicine, Zigbee, MATLAB

I. INTRODUCTION

Of late, biomedical engineering research is focusing on the development of affordable healthcare equipment that are reliable, portable and easily available in the market. As per the literature conducted, the muscle abnormalities are increasing at a rapid rate over a period of time [1]. With increase in cost of medical diagnostics, there arises a need for affordable equipment. One such equipment is Electromyograph (EMG), as it is least available and of high cost in Indian market. The lack of physicians and the need for medical help in remote places has increased its growth. In Telemedicine, networking plays an important role which acts as a bridge between the doctor and a remote patient. This paper deals with implementation on ZigBee technique in EMG, which detects and records the electrical signals during muscles contractions. The EMG examination has greater sensitivity and specificity for investigating the location and distribution of the neural pathways that act as the mode of nerve fibers involved [2]. Muscle membrane generates an electrical potential of 50 μ V to 30mV depending on the muscle type and conditions during the observation process. The usable

energy of the signal is limited to the 0 to 500 Hz frequency range, with the dominant energy being in the 50-150 Hz range.

There are many muscle groups in human body, among them ADM muscle in palm as shown in Fig. 1, plays an important role in our day to day activities [3]. ADM is a skeletal muscle that arises from the pisiform bone, the pisohamate ligament and the flexor retinaculum and present on the ulnar border of the palm and it helps in pulling the little finger away from rest of the fingers in hand and also helps in grasping large objects with outspread fingers.



Figure 1. Abductor Digiti Minimi muscle.

There are many manufacturers of EMG of which some of the notable companies are Natus, Gymna, Contec and Laborie [4]. The overall EMG signal acquisition product prices ranges between USD 3,000 and 10,000 approximately. In general a data acquisition system (DAQ) is used to carry out this work, which is of high cost. This system uses a PIC16F877A microcontroller that has an inbuilt analog to digital conversion and then the data is transmitted serially through ZigBee to the remote place. The received data is analyzed using MATLAB, which is a programming language that allows the user to monitor and control the parameters more easily.

Manuscript received May 5, 2015; revised July 5, 2015.

II. SYSTEM DESIGN

The block diagram shown in Fig. 2 depicts the working model of developed system. The electrical pulses from the muscle are sensed by the electrodes and the voltage

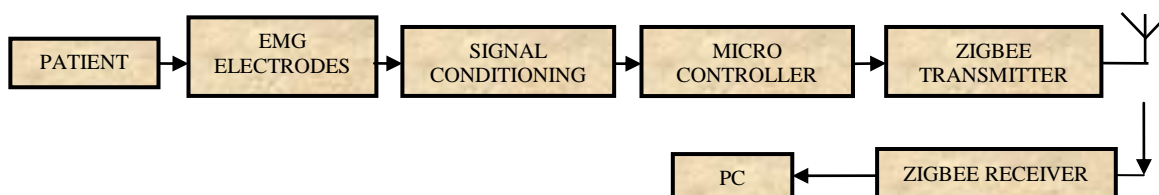


Figure 2. System block diagram.

difference of detected signal is amplified with the help of Instrumentation amplifier. The noise in the amplified signal is filtered using a band pass filter then converted to digital and transmitted through ZigBee via microcontroller.

A. Electrodes

The placement of Electrodes plays a vital role in acquisition of the signal. The primary sensing element used in the system is a non-invasive button like electrode made of Ag. – Ag.cl of 10 mm diameter is firmly placed at a point midway between pisiform and ulnar aspect of the fifth metacarpophalangeal joint and another is placed at approximately 2 cm apart on the ADM muscle to obtain the differential voltage [5].

B. Signal Conditioning

The electrical pulses from the muscle are sensed by the electrodes amplified using instrumentation amplifier. In general AD620, INA126 are used in this paper LM324 [6] is chosen as it is of low cost. It consists of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages.

The noise in the signal is filtered using an active filter which improves the performance and predictability [7]. The usable range of EMG signal is in between 50 Hz and 150 Hz, hence to acquire the desired frequency range a second order Butterworth band pass filter is being used as it provides the flattest amplitude response. Both the Low pass filter and High pass filter form a Band pass filter which ultimately allows an EMG signal in between the required frequency range [8].

The analog output obtained from the signal conditioning circuit is given to the microcontroller - PIC16F877A [9] supports USART communication. It requires an external crystal of 10 MHz to trigger the in-built oscillator. The source code will be written in the C language using MPLAB IDE program. The digital output taken from the port of the controller is given to transmit and receive pins of MAX232 for level conversion.

C. ZigBee Module and PC Integration Board

ZigBee is a technological standard, based on the IEEE 802.15.4 standard, which was created specifically for control and sensor networks ideal for the implementation of a wide range of low cost, low power and reliable control and monitoring applications within the private home and industrial environment. The wireless

transmission of data using ZigBee requires one XBee chip as shown in Fig. 3 (a) and a USB development board (Fig. 3 (b)) on the transmission side and one XBee chip and a serial/USB board at the receiving side as given in Fig. 3 (c).

The ZigBee module can transmit data in the range of 30m to 100m. It supports Analog-to-Digital conversion and Digital I/O line passing. Advanced configurations can be implemented using simple AT commands or API. The received data can be viewed in hyper terminal or the terminal window of the X-CTU software. Fig. 3 (d) shows the PC integration board used in the system developed.

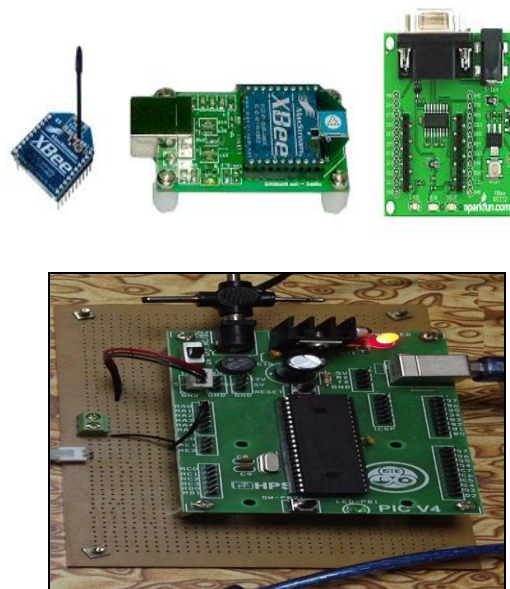


Figure 3. (a) XBee Chip (b) USB Development Board (c) Serial Development Board (d) PC integration board.

D. Software Section

The software used in this paper is MPLAB IDE which is new graphical, integrated debugging toolset for development of embedded applications on Microchip's microcontrollers [10]. To write the code in C language MPLAB C compiler is chosen. The main function of the MPLAB compiler in transmitter side is to convert the

code to a HEX file and then sends to the COM port in digital format (Fig. 4(a)). In receiver side MATLAB compiler is used to write a code to design software that is used to receive the data from the COM port and transmits it wirelessly to display it on computer. Data is acquired to computer from the controller using Silicon lab's IC CP2102 [11].The transmitted information is in ASCII characters and the software receives the data at the COM port and then it does the necessary decoding and the data is displayed in the data section in the software. The Baud Rate, COM port number, Parity, Start Stop bit, handshaking modes and a number of additional features are supported by the system. The Asynchronous mode of data transmission was chosen as there is no need of a serial clock and this effectively extends the range up to which the signals can be transmitted. The flowchart shown in Fig. 4(b) shows the process involved in serial data transmission and reception.

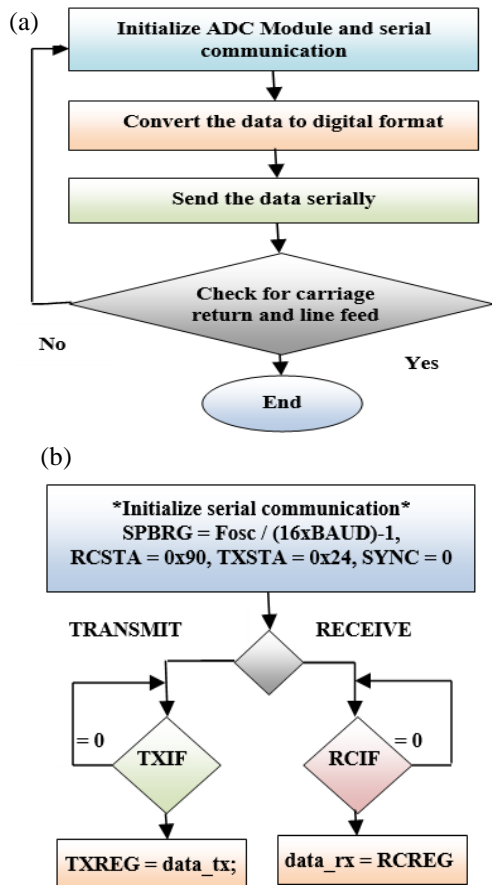


Figure 4. (a) Flow chart for HEX code conversion; (b) Flow chart for depicting serial communication.

III. EXPERIMENTAL SETUP AND RESULT ANALYSIS

The instrument designed (Fig. 5) is used to extract myosignal against strain to study ADM muscle behavior under three different conditions 1. No Load 2. Isometric condition (load of 100 gm is applied at the end of little finger with the help of a spring balance) 3. Isotonic

(Maximum strain) - probably for the first time - is inexpensive.

EMG signal acquired from different subjects is filtered and processed to extract root mean square value and compared with commercially available EMG instrument from Clarity Medicals as indicated in Table I.

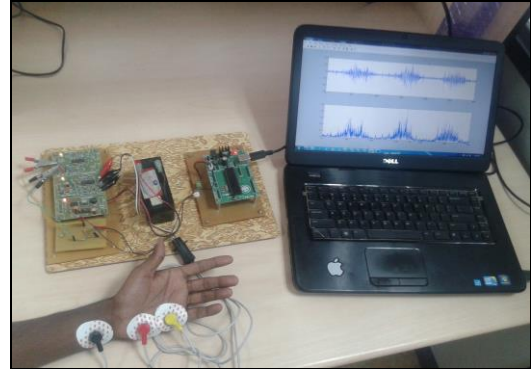


Figure 5. Experimental setup.

TABLE I. COMPARISON RESULTS OF COMMERCIAL WITH PROPOSED EMG

No load		Isometric condition		Isotonic condition	
Commercial EMG	Proposed EMG	Commercial EMG	Proposed EMG	Commercial EMG	Proposed EMG
42.308	39.85	52.983	49.57	111.96	110.5
30.773	31.85	45.866	44.75	87.079	80.45
31.390	26.57	46.870	40.85	96.000	97.57

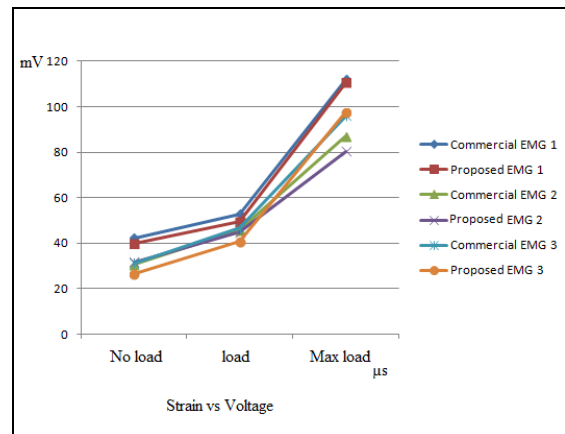


Figure 6. Graphical results of commercial with proposed EMG.

For three different subjects under three different conditions values are taken for several times, average of 10% of deviation is found in the proposed EMG with the commercial one. This error can be sorted by proper signal conditioning circuit. For ease of analysis the data is further represented in the form of a graph as shown in the Fig. 6. The output of the entire system can be viewed on the software that is developed using MATLAB compiler which acquires the data from the COM port and transmits through ZigBee and displays on the PC. The

communication is done using COM port and USB protocol. The final result is as shown in Fig. 7.

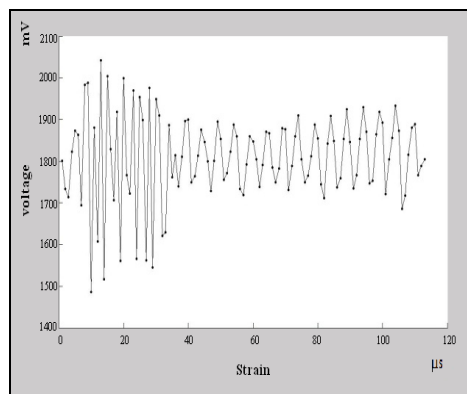


Figure 7. Software output for Strain Vs Voltage

IV. CONCLUSION

The proposed instrument is thus inexpensive, affordable, reliable, easily transportable and accurate when compared it with the commercially available Electromyography instrument. Therefore the goal to develop a low cost EMG system which is beneficial to research group is an advantage for the patient and physiotherapies. This study aims to design the sEMG that can be applied to the ADM muscle, by time and frequency domain analysis; the RMS value of EMG signal can be estimated. The effectiveness of the design was evaluated in the experiment and should be improved.

ACKNOWLEDGMENT

We would like to acknowledge DST-IDP, Government of India (grant no: IDP/MED/4/2012) for their funding to develop this prototype.

REFERENCES

- [1] S. I. M. Salim, "Hardware implementation of surface electromyogram signal processing," *A survey in Control and System Graduate Research Colloquium (ICSGRC)*, Malaysia, 2011, pp. 27-31.
- [2] Larissa, *et al.*, "Electromyography function, disability degree, and pain in leprosy patients undergoing neural mobilization treatment," *Revista da Sociedade Brasileira de Medicina Troical*, vol. 45, no. 3, pp. 357-359, 2012.
- [3] American society of surgery of hand, "Abductor Digiti Minimi" [online]. Available: www.assh.org/Public/HandAnatomy/Muscles/Pages/Abductor-Digiti-minimi.aspx.
- [4] Medical Expo, "TheVirtual Medical Exhibition" [online]. Available: www.medicalexpo.com/cat/intensive-care-monitoring/electromyographs-eng-G-640.html.
- [5] Bio-medical, "EMG Electrodes" [online]. Available: <http://bio-medical.com/products/electrodes/emg-electrodes.html>.
- [6] Texas Instruments, "LM324 low power quad operational amplifiers" [online]. Available: www.datasheetcatalog.org/datasheet/SGSThompsonMicroelectronics/mXuqyx.pdf.

- [7] Electronics-tutorials.ws, "Butterworth Filter" [online]. Available: http://www.electronics-tutorials.ws/filter/filter_8.html.
- [8] T. S. Poo and K. Sundaraj, "Design and development of low cost biceps tendonitis monitoring system using EMG sensor," *International Colloquium on Signal Processing & Its Applications (CSPA)*, 2010, pp. 288-292.
- [9] Microchip, "PIC16F877AMicrocontroller" [online]. Available: ww1.microchip.com/downloads/en/DeviceDoc/39582C.pdf.
- [10] Microchip, "MPLAB IDE user's guide" [online]. Available: <http://ww1.microchip.com/downloads/en/devicedoc/51519a.pdf>.
- [11] Silicon Laboratories, "CP2102" [online]. Available: www.sparkfun.com/data_sheets/IC/cp2102.pdf.



Vivekanandan Sundaram is working as an associate professor in VIT University. This author became a member and faculty advisor of ISA in 2008. He has completed his M. Tech. in process control instrumentation at Faculty of Engineering, Annamalai university, India and his Ph. D. in VIT university, India. His area of research is biomedical signal processing, biosensors and industrial Instrumentation.



Daniel S. Emmanuel is currently working as senior professor in VIT University. His area of research is ultra wide band spectrum and Telecommunication engineering.



Lokesh Kumar Chinthala has completed his bachelor's degree in Electronics and Instrumentation Engineering under the School of Electrical Engineering, VIT University, India. His area of research is Biomedical Instrumentation and Biosensors.



Devanand Manokaran is currently pursuing master's degree in Automation and Control Engineering at Politecnico di Milano, Italy. He formerly completed his bachelor's degree in Electronics and Instrumentation Engineering at Anna University. His area of research is Instrumentation, Industrial Automation and Multivariable process control.