Surface Electromyography In Healthcare Solution

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Abstract

With miniaturization and technical advancements in electronics and communications field, we are now in a position to safely monitor, diagnose and treat various intricate ailments in patients with relative ease. This has made complex surgeries simple, easy and efficient. Wireless communications have enabled development of monitoring devices that can be made available for general use by individuals/patients and caregivers. New methods for short-range wireless communications not encumbered by radio spectrum restrictions (e.g., ultra-wideband) will enable applications of wireless monitoring without interference in ambulatory subjects, in home care, and in hospitals. Wireless biomonitoring, first used in human beings for featal heart-rate monitoring has now become a technology for remote sensing of patients' activity, blood pulse pressure, oxygen saturation, internal pressures, orthopedic device loading, and gastrointestinal endoscopy. Biotelemetry provides a wireless link between the subject and the remote site where the recording, signal processing, and displaying functions are performed. Rather than using a traditional radio transceiver, which can only broadcast over a limited range, now-a-days the readily available cell phones are used to transmit biological data by creating a link between the subject and a computer receiving the signal via a landline phone. Wireless telemetry of bioelectric signals, specifically neural recordings, is desirable in many research and clinical applications. These include, but are not limited to telemetry and recording of neural activity in laboratory animals, telemetry of EEG, telemetry of short-term implanted electrode arrays for epilepsy medical diagnosis, functional electrical stimulation (FES) systems, and implantable neuroprosthetic devices for sensory and command control. This study will focus on Wireless telemetry in general and also details of Wireless biotelemetry.

Index Terms— Healthcare model, Paralysis, Surface electromyography, wireless engineering.

1.0 Introduction To the system

The main goal of this study was to design and implement a wirelessly transmitted activity monitor. This design was to record heart rate as well as blood pressure. This data would be used to determine a person's physical capabilities using a "job match" method. This method would then analyze a person's heart rate and blood pressure during different physical activities to determine whether or not they are capable of performing the duties required of an occupation. As a person increases in age, their heart may not be able to support the same physical activities it could when he or she were younger. The primary users of this device, occupational therapists, will check the measurements against a reference to determine the candidate's suitability for the position. It can also be used to evaluate recovery from injury, or even the validity of claims of on-site injuries in the workplace. This method and device would result in an entirely new approach to workman's compensation, and drastically cut down on false claims.

Given the wireless nature of the device and its capability to interface with the majority of PC's on the market, networking it to a hospital or EMT service for high-risk patients in the home is also an added benefit. There are many people who suffer from heart diseases and high blood pressure. There have been multiple cases where one of these individuals has a heart attack and no one can get to them fast enough to resuscitate them. The wireless activity monitor, in part, is designed to give these individuals a better chance of survival by monitoring their heart rate and blood pressure and transmitting the data wirelessly to a local computer. If a person's heart rate or blood pressure shows abnormal activity a hospital can be notified immediately over the Internet and a paramedic can be dispatched to the person's house. Being a light weight package and oriented on the body in a way as to not interfere with job tasks, daily activities, or test procedures, this will become a highly valuable evaluation tool when dealing with physical activity. The design goals for this project were to acquire heart rate and blood pressure readings from a wrist mounted cuff, transmit those readings wirelessly to a local computer, access those readings remotely over a network using a different computer, and display those readings in an intuitive display.

1.1 Definition of Wireless Biotelemetry

Biotelemetry is defined as a means of transmitting biomedical or physiological data from a remote location (e.g., astronauts in space) to a location that has the capability to interpret the data and affect decision making (e.g. ground controllers at Mission Control Center). Biotelemetry is a vital constituent in the field of medical sciences. It entails remote measurement of biological parameters. Mode of transmission of physiological data from point of generation to the point of reception can take many forms. Use of wires to transmit data may be eliminated by wireless technology. Biotelemetry, using wireless diagnosis, can monitor electronically the symptoms and movements of patients. This development has opened up avenues for medical diagnosis and treatment. It enables monitoring of activity levels in patients suffering from heart trouble, asthma, pain, Alzheimer's disease, mood disorders, cardiovascular problems, accidents, etc.

There are usually two concerns associated with the use of biotelemetry: the distance over which the signal can be received, and the size of the transmitter package. Often, both of these concerns depend on the power source for the transmitter. Integrated circuits and surface mount technology allow production of very small electronic circuitry in transmitters, making batteries the largest part of the transmitter package.[1] Figure 1 shows the Human implantable system.

1.2 Definition of EMG[1]

"**Electromyography** (EMG) is an experimental technique concerned with the development, recording and analysis of myoelectric signals. Myoelectric signals are formed by physiological variations in the state of muscle fiber membranes."

Neurological EMG, where an artificial muscle response due to external electrical stimulation is analyzed in static conditions, the focus of **Kinesiological EMG** can be described as the study of the neuromuscular activation of muscles within postural tasks, functional movements, work conditions and treatment/training regimes.

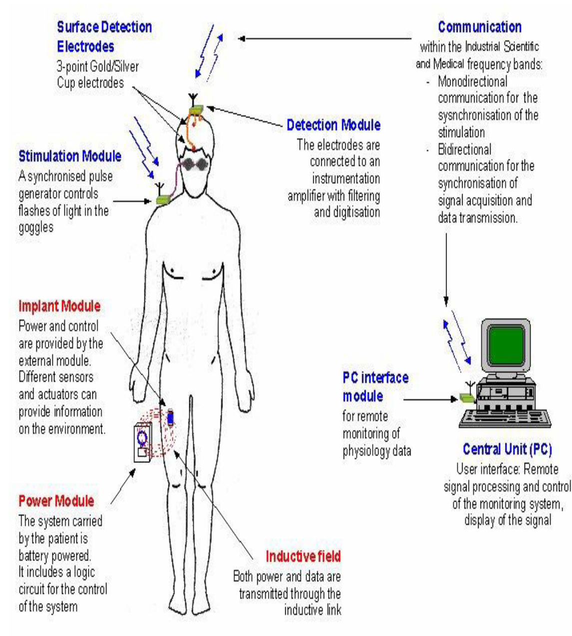


Figure 1 Implantable units

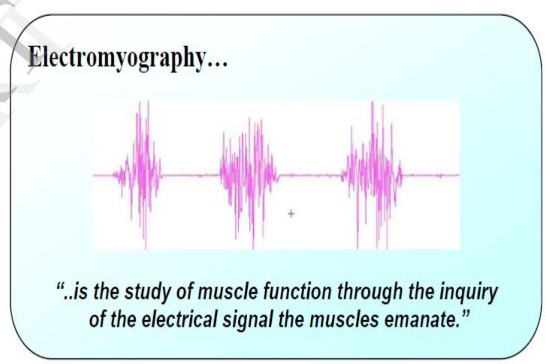


Figure 2 Basmajian & DeLuca: Definition Muscles Alive Unlike the classical

1.3 Definition of Pulse (Heartbeat) rate:[7]

The pulse is a decidedly low tech/high yield and antiquated term still useful at the bedside in an age of computational analysis of cardiac performance. Claudius Galen was perhaps the first physiologist to describe the pulse. The pulse is an expedient tactile method of determination of systolic blood pressure to a trained observer. Diastolic blood pressure is non-palpable and unobservable by tactile methods, occurring between heartbeats.

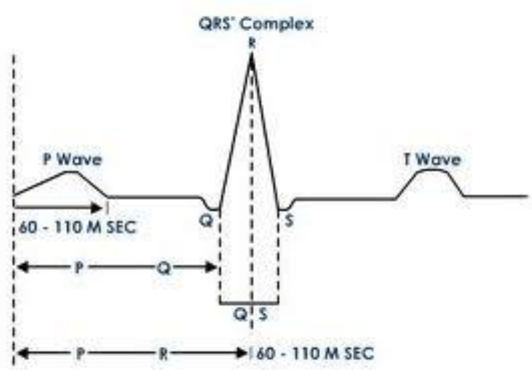


Figure 3 Pulse rate basics

2.0 System design

2.1 Block Diagram:

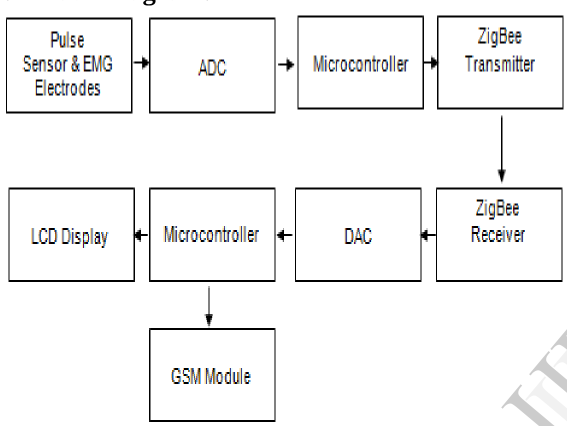


Figure 4 Block Diagram

2.2 EMG amplifier

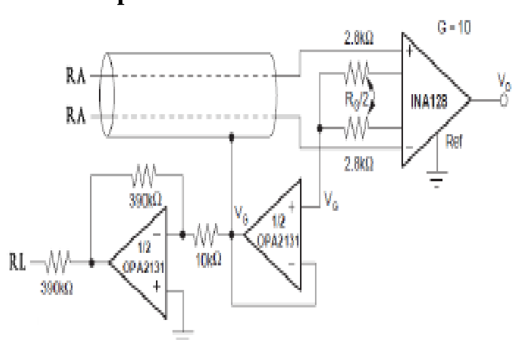


Figure 5 Burr brown amplifier

As explained earlier, EMG signal is so small that computer could not read it. While the amplitude of the signal is between 0 to 10 mill volts (peak-to-peak), the usable frequency of an EMG signal is ranging between 50-150 Hz [1]. At this state, we need a huge gain (about thousand times) to boost the EMG signal without changing phase or frequency of the signal. This amplifier uses a typical differential amplifier circuit, which contains two inputs (positive input and negative input). The differential amplifier circuit subtracts two inputs and amplifiers the difference. To get the right level of the input signal, we need a body reference which works as a feedback from the inputs. Whenever the signal changes due to noise introduced by the body, this body reference will help maintain the correct level of signal.

2.3 Instrumentation Amplifier

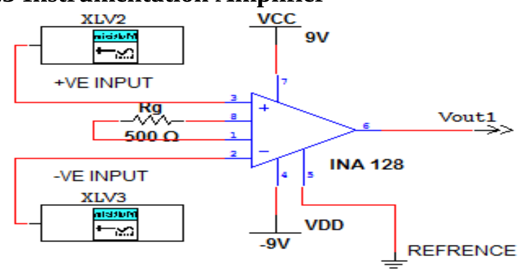


Figure 6 Burr brown using INA128

A suitable operational amplifier (op-amp) for this type of application is the Instrumentation Amplifier. Its versatile 3-op amp design and small size make it ideal for a wide range of applications. This type of op-amp usually provides excellent accuracy because it provides high bandwidth even at high gain. The EMG amplifier used a BURR-BROWN, INA128 chip for the amplifier, as suggested by the application information data sheet of lm 124. The gain of the amplifier can be adjusted by changing the resistor Rg between pin number 1 and 8.

2.3.1 Low pass filter:

When handling pulse trains and signal bursts of EMG signals, it might be favorable to use filters which have negligible over-shoot. When handling pulse trains and signal bursts, it might be favorable to use filter which have negligible over shoot in the step response. A class of filters particularly suitable for this type of signals is the Bessel filter. The phase characteristics of this class of filters exhibit a linear increase with frequency. The group delay, defined as the derivative of the phase with respect to frequency, is hence extremely flat over a wide range of frequencies. Frequency range of EMG signal is between 50-150Hz so 4th order Bessel filter is required for the low pass filtration of 150Hz.

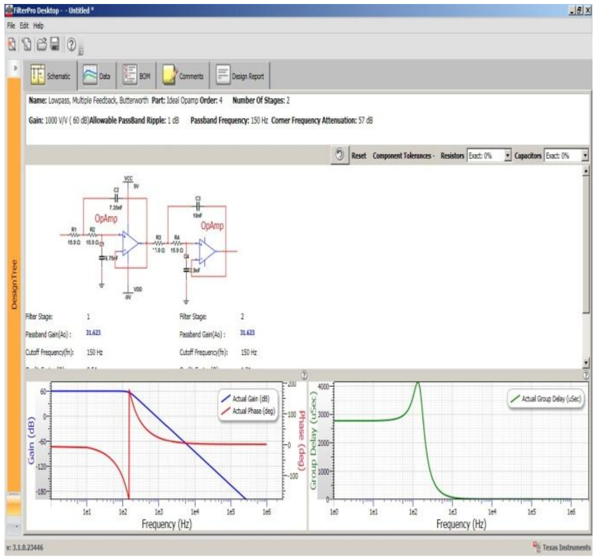


Figure 7 Low Pass filter design in filter pro

4.3.2 High pass filter:

The dominant energy of the EMG signal is located in the 50-150 Hz range, to eliminate the movement artifacts, inherent instability of the signal which ranges between 0 to 15 Hz and the ambient noise arises from the 60 Hz 1st order high pass filtration of 50Hz is required.

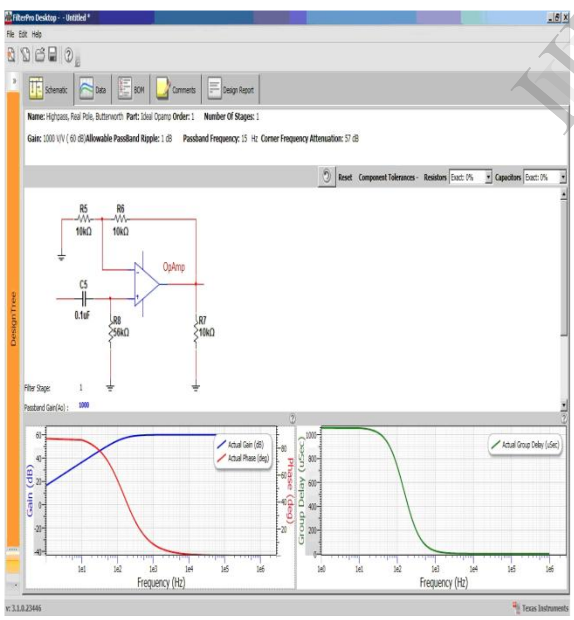


Figure 8 High Pass filter design in filter pro

4.3.3 Pulse monitoring System

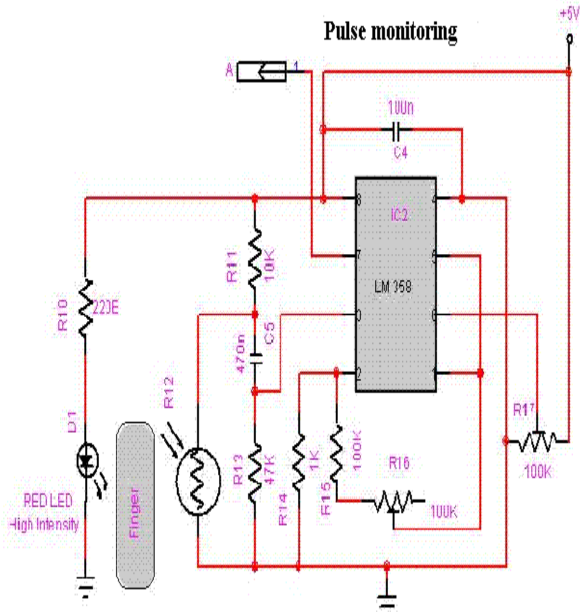
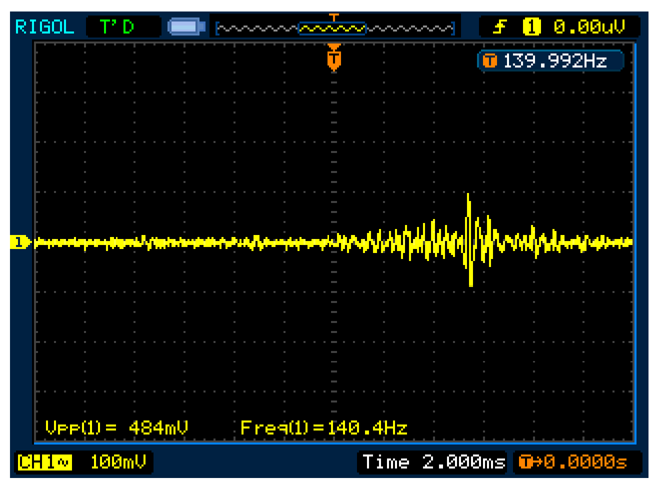


Figure 9 Pulse monitoring system

5.1 Observed signals

Recorded samples from the digital oscilloscope using the developed EMG amplifier device. The samples were recorded in real time from real human hand. The experiment preformed grasping of objects of different sizes and shapes.Vpp = 484mV, Frequency =140.4Hz



5.2 result Suggestions for further advancements

The feasibility of the signals can be improved using suction cup electrodes rather than the Peel-and-stick surface electrode. The use of surface electrode was owing to the unavailability of the suction cup electrode and the cost constraints. Better performance can also be obtained with the help of electrodes with built in preamplifiers. The signals obtained from the body can be converted into digital form and can be further processed digitally using digital processors to carry out various analysis related to the muscular structure as well as their functioning.

The microcontroller incorporated in the project can be used as a base to work upon and develop various functionalities such as emergency braking, obstacle detection and many more. The EMG amplifier, the size of the enclosure should be considered. The electrode extensions should be eliminated. The amplifier should be able to hold electrodes directly on the unit. The amplifier and electrode holders could be placed in the same PCB which has a connector to transfer the output to the microcontroller unit. This amplifier unit would be then placed directly on the hand.

Conclusion & Future work

The WPMG system has been developed and tested that support single channel. The WSEMG amplifier device is designed to amplify EMG signals from muscle groups on the upper forearm. The footprint of the complete system includes electrodes, amplifier, filters, microcontrollers and ZigBee Modems. The EMG amplifier uses skin surface electrodes as input sensors. The amplifier is a battery powered differential instrumental amplifier which raises very weak and noisy EMG signals to a stable level for wireless transmission. The filter is applied to select only the bandwidth of signals that is of interest for the underlying applications. The microcontrollers and ZigBee modems are used for wireless transmission of EMG signals. The major problems in developing the above listed components were to reduce noise, moving artifacts, system grounding and DC bias. Similarly we can see noisy pulse rate signal on the receiver side.All these problems were successfully solved through the following steps:

1. Proper choice of discrete components (resistors, capacitors, and ICs).
2. Proper design of circuitry.
3. Final implementation of the device using PCB technology.
4. Systematic experimentation with the prototype (implemented on a breadboard).
5. Extensive testing of the device after implementation and executing final corrections.

The concerns over the systems are:

1. Size of the system.
2. Distance over which data needs to travel.
3. Cost of the system.

In future I can use some more physiological data like temperature, blood pressure, blood flow and technological data like ECG, EEG and data like to observe the patient completely and analysis the full body parameter using wireless media like ZigBee. So in future doctor can analysis the patient totally from remote location. if we can able to achieve the operation it will open a door in wireless biotelemetry domain to the next level of research.

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