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EMG MONITORING SYSTEM

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ABSTRACT

The first recognized embedded system is the Apollo Guidance Computer (AGC) developed by MIT lab. AGC was designed on 4K words of ROM & 256 words of RAM. The clock frequency of first microchip used in AGC was 1.024 MHz.. The computing unit of AGC consists of 11 instructions and 16 bit word logic. 5 It used 5000 ICs. The UI of AGC is known DSKY (display/keyboard) which resembles a calculator type keypad with array of numerals. The first mass-produced embedded system was guidance computer for the Minuteman-I missile in 1961. n the year 1971 Intel introduced the world's first microprocessor chip called the 4004, was designed for use in business calculators. It was produced by the Japanese company Busicom.

KEYWORDS: *Apollo Guidance Computer, MIT Lab*

INTRODUCTION

The Embedded System and the General purpose computer are at two extremes. The embedded system is designed to perform a specific task whereas as per definition the general purpose computer is meant for general use. It can be used for playing games, watching movies, creating software, work on documents or spreadsheets etc. Following are certain specific points of difference between embedded systems and general purpose computers Criteria General Purpose Computer Embedded system Contents It is combination of generic hardware and a general purpose OS for executing a variety of applications. It is combination of special purpose hardware and embedded OS for executing specific set of applications Operating System It contains general purpose operating system. It may or may not contain operating system. Alterations Applications are alterable by the user. Applications are non-alterable by the user. Key factor Performance" is key factor.

The application areas and the products in the embedded domain are countless.

- Consumer Electronics: Camcorders, Cameras.
- Household appliances: Washing machine, Refrigerator.
- Automotive industry: Anti-lock breaking system(ABS), engine control.
- Home automation & security systems: Air conditioners, sprinklers, fire alarms.
- Telecom: Cellular phones, telephone switches.
- Computer peripherals: Printers, scanners.

- Computer networking systems: Network routers and switches. 8. Healthcare: EEG, ECG machines.
- Banking & Retail: Automatic teller machines, point of sales.
- 10.Card Readers: Barcode, smart card readers

DATA COLLECTION/STORAGE/REPRESENTATION

Embedded system designed for the purpose of data collection performs acquisition of data from the external world. Data collection is usually done for storage, analysis, manipulation and transmission. Data can be analog or digital. Embedded systems with analog data capturing techniques collect data directly in the form of analog signal whereas embedded systems with digital data collection mechanism converts the analog signal to the digital signal using analog to digital converters. If the data is digital it can be directly captured by digital embedded system. A digital camera is a typical example of an embedded System with data collection/storage/representation of data. Images are captured and the captured image may be stored within the memory of the camera. The captured image can also be presented to the user through a graphic LCD unit.

Data Communication

Embedded data communication systems are deployed in applications from complex satellite communication to simple home networking systems. The transmission of data is achieved either by a wire-line medium or by a wire-less medium. Data can either be transmitted by analog means or by digital means. Wireless modules-Bluetooth, Wi-Fi. Wire-line modules-USB, TCP/IP. Network hubs, routers, switches are examples of dedicated data transmission embedded systems.

Data Signal Processing

Embedded systems with signal processing functionalities are employed in applications demanding signal processing like speech coding, audio video codec, transmission applications etc. A digital hearing aid is a typical example of an embedded system employing data processing. Digital hearing aid improves the hearing capacity of hearing impaired person

Monitoring

All embedded products coming under the medical domain are with monitoring functions. Electro cardiogram machine is intended to do the monitoring of the heartbeat of a patient but it cannot impose control over the heartbeat. Other examples with monitoring function are digital CRO, digital multi-meters, and logic analyzers.

Control

A system with control functionality contains both sensors and actuators. 9Sensors are connected to the input port for capturing the changes in environmental variable and the actuators connected to the output port are controlled according to the changes in the input variable. Air conditioner system used to control the room temperature to a specified limit is a typical example for CONTROL purpose.

Application Specific User Interface

Buttons, switches, keypad, lights, bells, display units etc are application specific user interfaces. Mobile phone is an example of application specific user interface. In mobile phone the user interface is provided through the keypad, system speaker, vibration alert etc.

ELEMENTS OF EMBEDDED SYSTEM

As defined earlier, an embedded system is a combination of 3 things:

Hardware, Software, Mechanical Components And it is supposed to do one specific task only

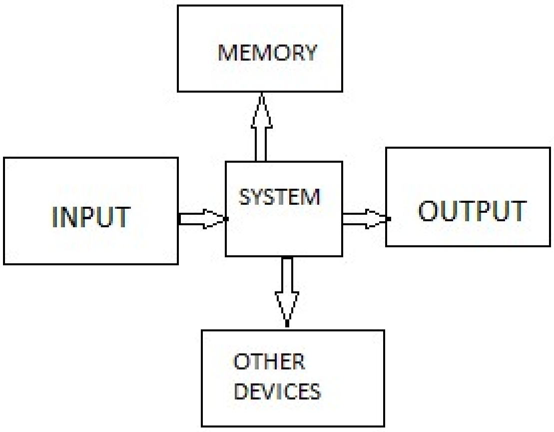

Figure 1: Elements of Embedded System.

Embedded systems are basically designed to regulate a physical variable (such Microwave Oven) or to manipulate the state of some devices by sending some signals to the actuators or devices connected to the output port system (such as temperature in Air Conditioner), in response to the input signal provided by the end users or sensors which are connected to the input ports. • Hence the embedded systems can be viewed as a reactive system. • Examples of common user interface input devices are keyboards, push button, switches, etc. • The memory of the system is responsible for holding the code (control algorithm and other important configuration details). • An embedded system without code (i.e. the control algorithm) implemented memory has all the peripherals but is not capable of making decisions depending on the situational as well as real world changes. • Memory for implementing the code may be present on the processor or may be implemented as a separate chip interfacing the processor In a controller based embedded system, the controller may contain internal memory for storing code • Such controllers are called Micro-controllers with on-chip ROM, eg. Atmel AT89C51. 12

OBJECTIVE OF PROJECT

Electromyography (EMG) is defined as the study of the muscular function through the analysis of the generated electric signals during muscular contractions. The potential difference obtained in the fibres can be registered in the surface of the human body through surface electrodes due to the biological tissues conducting properties. Our project studies the muscular activity as an input in order to control applications.

Outline of the Report

The project is divided into five chapters.the first chapter deals with the overview and the objectives of the project. the second chapter dealing with the block diagram and operation of the project theories followed by the introductory concept of the hardware components in the third chapter.likewise fourth chapter is devoted to the software applications chapter five deal with epilogue containing further modifications and improvements, applications, improvements problems faced and limitations.

SYSTEM DESIGN & PROTOTYPE

We have focussed on the project to study muscular activity as an input to control machines.

Working Principle

EMG refers to electromyography. It is used to sense the movement of muscles. The sensor is interfaced with the microcontroller through signal conditioning unit. Signal conditioning unit is an variable potentiometer. The output obtained from the Sensors are analog. Analog values are converted into digital values with help of inbuilt ADCs. Based on muscle movements controller obtains the signal and pass the signal to the receiver (device) section by using Zigbee. In device section the Zigbee receives the control signal from the control section. Based on the received information devices are controlled by actuating the electronic switch (Relay). Status of the controller can be displayed in LCDs.

Control Section

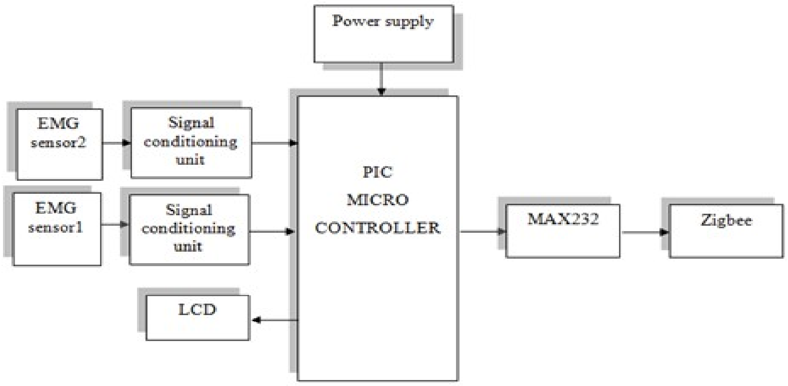

Figure 2

Device Section

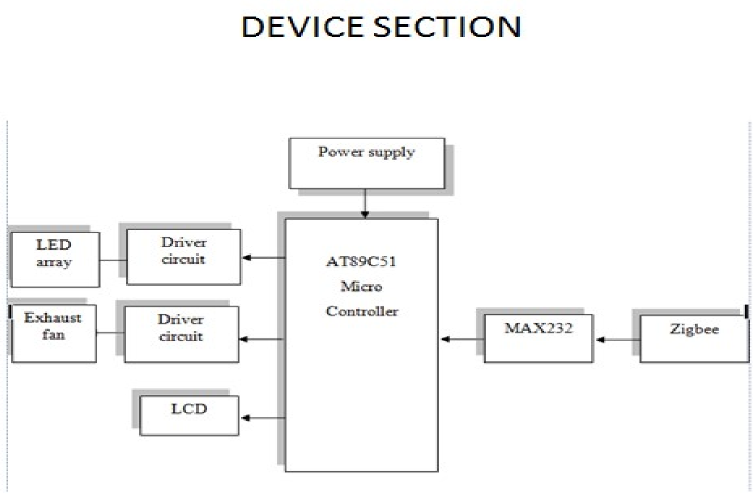

Figure 3: Device Section.

EMG Portable Device

Electromyography device collects samples at a 1000Hz sampling rate in 5 independent channels. It has a 110dB CMRR amplifier and a band pass filter between 25 and 500 Hz with gain 1000. It is a relatively small device that can be carried in a belt or pocket. It is a portable device which communicates by a bluetooth interface within a 100 meters range. To collect the signals we use surface differential electrodes.

Signal Recording

In order to get useful information concerning the muscular activity it is necessary to carefully analyze some aspects, from technical details at the electrode placement in the surface of the human body to the points where this placement must be done. Several aspects influence the signal quality: skin preparation, electrodes placement position, electrodes fixation, electrodes distance and outside interferences. Basically, the electrodes can monitorize any voluntarily contracted muscle. However, the signal frequencies and amplitudes are somehow different between muscles. We only use surface electrodes as we are studying a wearable daily interface and want to keep users far from pain. The electrodes shouldn't be placed in the motor point where it verifies a damping of the signal low frequency components. Besides the electrodes placement position it is also important to concern the orientation of the electrodes in relation to muscular fibres. The imaginary line that joins the two surfaces must be parallel to the muscular fibres orientation.

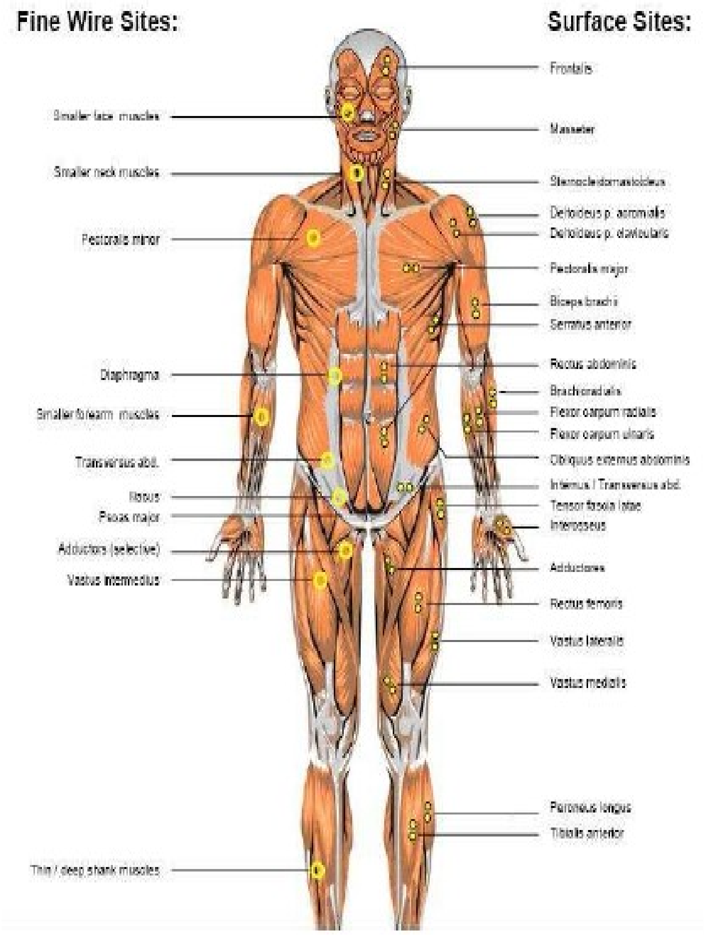

Figure 4: EMG Onset.

Signal Processing

In order to extract useful information from the digitalized signal we need to process it. Our signal processing module is composed by a pre-processing and a smoothing phase.

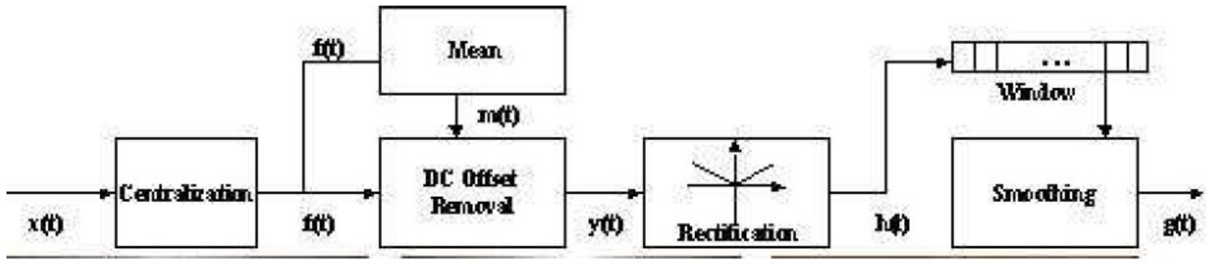

Figure 5: Signal Processing.

The pre-processing is composed by some basic procedures that prepare the signal to be smoothed. The signal received from the electromyography device has a gamma of values between 0 and 4096, having this to be adjusted, since, really, the signal oscillates between negative and positive values. The centralization is a very basic operation and consists of deducting the base value (2048) from the signal. After that, we add the value to the set of received values already acquired and, with the average calculated on these, we calculate and remove the DC offset, normally existent in

EMG signal:

$y(t) = f(t) - m(t)$

Finally, we rectify the sample. The curve rectification is an operation normally used to allow the posterior signal integration, since it transforms a curve with positive and negative values, averaging zero, in a curve of absolute values, all positives. Two forms of rectifying the curve exist: eliminating the negative values (”half-wave rectification”) or adding them to the positives (”full-wave rectification”). The last process is preferable since it keeps all the signal energy:

$h(t) = |y(t)|$

In order to smooth the signal, we carried through an average on a sliding window, keeping in the output the same number of collected samples, but now having in consideration the neighboring” samples:

$g(t) = 1/N \sum w(i)$

where N is the window dimension.

We experimentally observed 50 ms as a fine window dimension value as it keeps the real time impression and smoothes the signal as desired. Upper values improve the signal quality but decrease the response speed

EMG Onset Detection

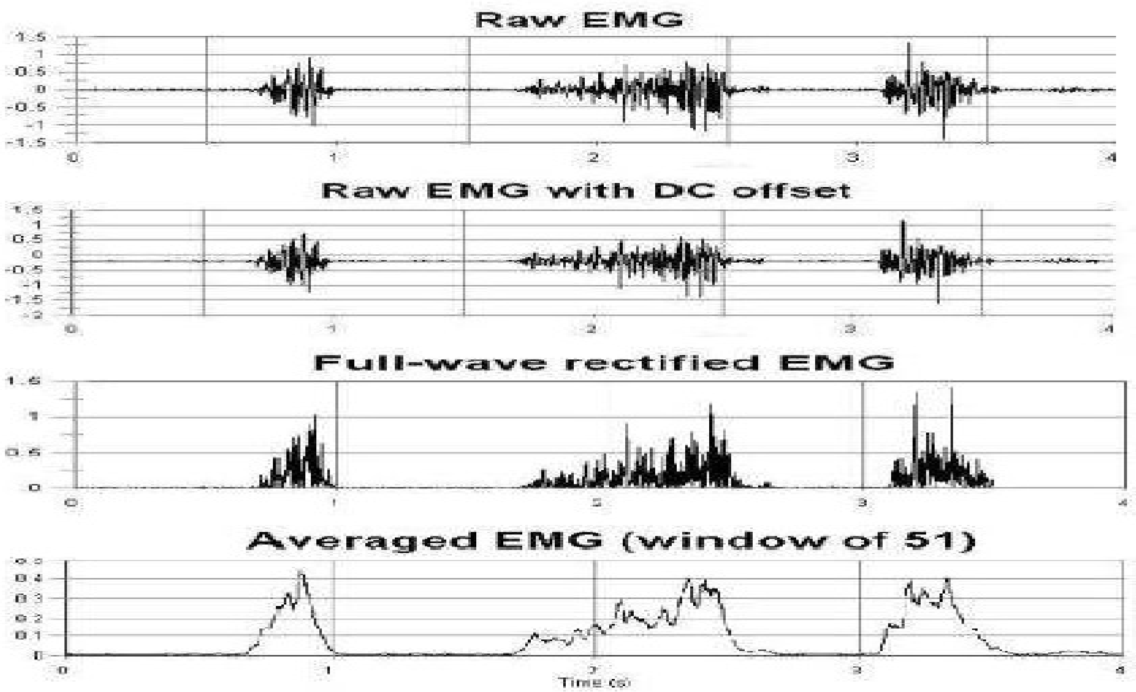

Figure 6: EMG Onset Detection.

INTRODUCTION TO HARDWARE COMPONENTS

PIC MICRO CONTROLLER

Power Supply for PIC 16F877A Microcontroller

This section describes how to generate +5V DC power supply

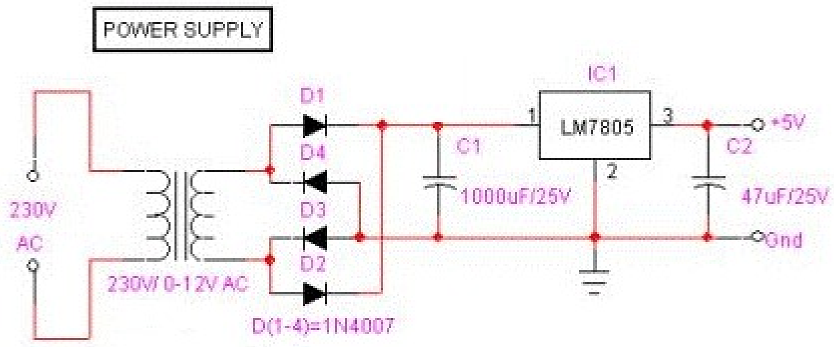

Figure 7: PIC Controller Power Supply.

The power supply section is the important one. It should deliver constant output regulated power supply for successful working of the project. A 0-12V/1 mA transformer is used for this purpose. The primary of this transformer is connected in to main supply through on/off switch& fuse for protecting from overload and short circuit protection. The secondary is connected to the diodes to convert 12V AC to 12V DC voltage. And filtered by the capacitors,Which is further regulated to +5v, by using IC 7805.

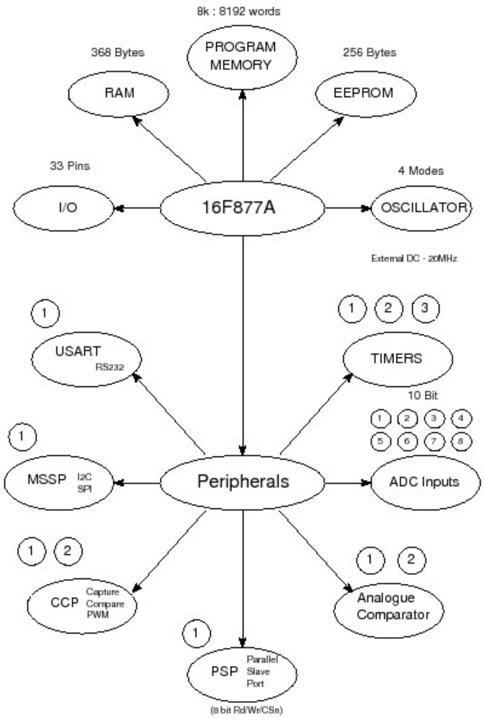

Figure 8: PIC Micro Controller.

Special Microcontroller Features

- Flash Memory: 14.3 Kbytes (8192 words)
- Data SRAM: 368 bytes
- Data EEPROM: 256 bytes
- Self-reprogrammable under software control
- In-Circuit Serial Programming via two pins (5V)
- Watchdog Timer with on-chip RC oscillator
- Programmable code protection
- Power-saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug via two pins

EMG Sensors

Electromyography (**EMG**) is a technique for evaluating and recording the electrical activity produced by skeletal muscles.EMG is performed using an instrument called an **electromyograph**, to produce a record called an **electromyogram**.

An electromyograph detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated.

The signals can be analyzed to detect medical abnormalities, activation level, or recruitment order or to analyze the biomechanics of human or animal movement.

EMG Features

- Single Differential and Double Differential models
- No gel or skin preparation necessary
- Can be affixed to skin or used as a probe
- Convenient adhesive skin interfaces
- Slim profile for unobstructed usage

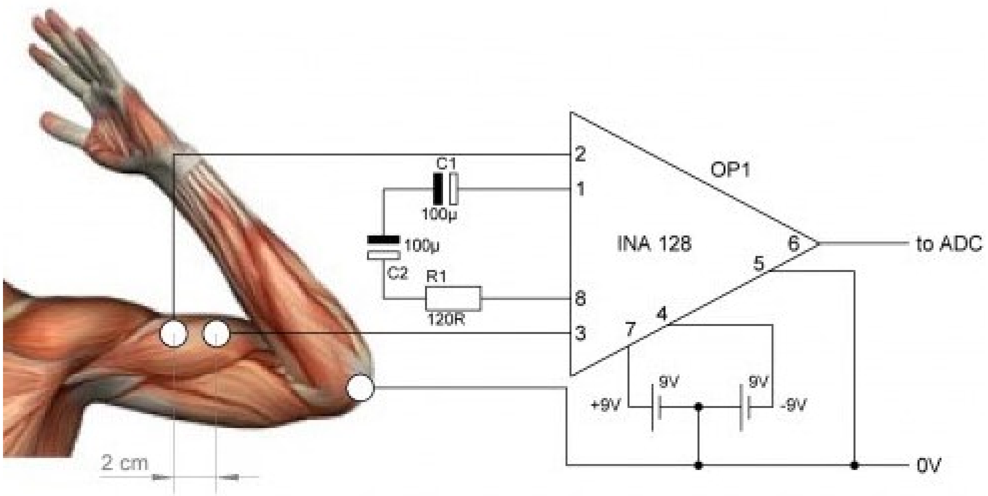

Figure 9: EMG Circuit.

Electrodes and its Classification

An electrode is an electrical conductor used to make contact with a non metallic part of a circuit. Electrodes can be broadly classified into two categories namely,

- Invasive type
- Non Invasive type

Invasive electrodes are inserted into the muscle directly piercing the skin. The EMG signal acquired is highly localized and devoid of most of the noises attributed to the EMG signals. There are two types of invasive electrodes that are commercially available. They are Fine wire type and Needle type [17,18].

For HCI applications, invasive techniques are not practically feasible.

Non invasive electrodes are mainly in the form of surface electrodes. These electrodes are placed on the surface of the skin and the signals are taken from there. These electrodes require a conducting gel to be applied on the surface of the skin so as to assist in the conduction of the signal from the muscles to the electrode. Generally they are pre-gelled silver / silver chloride electrodes and are disposable and are cheaper than other electrodes.

Signal Conditioning Unit

The signal conditioning block is very critical in a data acquisition system. It must be capable of amplifying the signal in order to increase the power of the signal and filter out the noise present in the signal [38]. The signals obtained from the body are of very low amplitude and power. They contain noise which can degrade the quality of the signal. The Analog-to-Digital

Converter (ADC) is generally equipped with sample-and-hold circuitry and converts the analog samples into digital values. The digital data is then sent to the computer through various ports such as parallel port, serial port, USB or through sophisticated, high speed interfaces such as PCI, GPIB etc.

Generally, all computers are equipped with sound cards which enable connectivity to microphones and speakers. The sound cards contain high speed, and high resolution Digitalto-Analog Converters (DACs) and ADCs which can also be used as an interface to send analog signals into the computer. In our project, we make use of the sound card that is present in the computer to send the myo-signals after conditioning.

- Sensors that convert physical parameters to electrical signals.
- Signal conditioning circuitry to condition and to convert sensor signals into a form that can be converted to digital values.

Acquisition Hardware consisting of Analog-to-digital converters, which convert the conditioned sensor signals to digital values.

MAX 232

The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply RS 232 voltage levels from a single 5v supply. Each receiver converts RS-232 to 5v TTL/CMOS levels. Each driver converts TLL/CMOS input levels into EIA-232 levels. The P3_0 (RX) and P3_1 (TX) pin of controller is connected to the max 232 driver and the TX and RX pin of max 232 is connected to the GSM modem or PC.

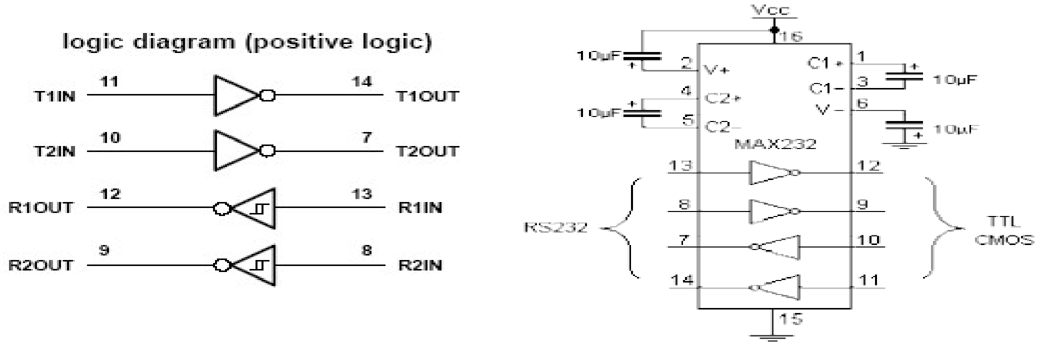

Figure 10: MAX 23.

In this circuit the microcontroller transmitter pin is connected in the MAX232 T2IN pin which converts input 5v TTL/CMOS level to RS232 level. Then T2OUT pin is connected to reviver pin of 9 pin D type serial connector which is directly connected to PC.

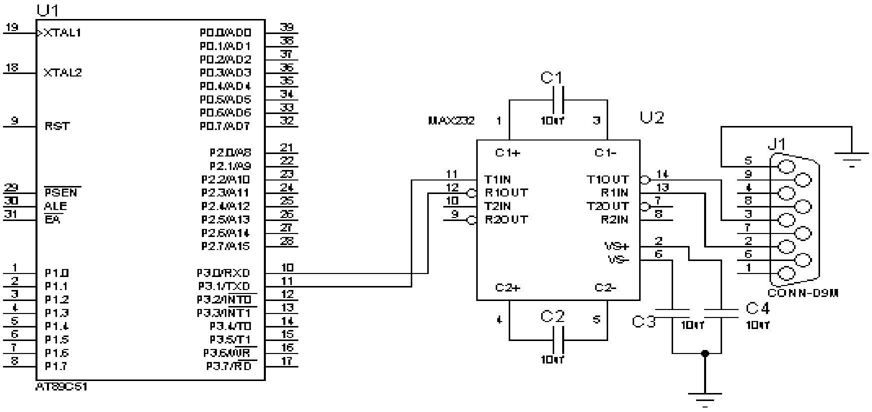

Figure 11: MAX232 Interfaced with PIC16F877A.

Zigbee

ZigBee is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power, wireless sensor networks. The standard takes full advantage of the IEEE 802.15.4 physical radio specification and operates in unlicensed bands worldwide at the following frequencies: 2.400–2.484 GHz, 902-928 MHz and 868.0–868.6 MHz.

- The power levels (down from 5v to 3.3v) to power the zigbee module.
- The communication lines (TX, RX, DIN and DOUT) to the appropriate voltages.

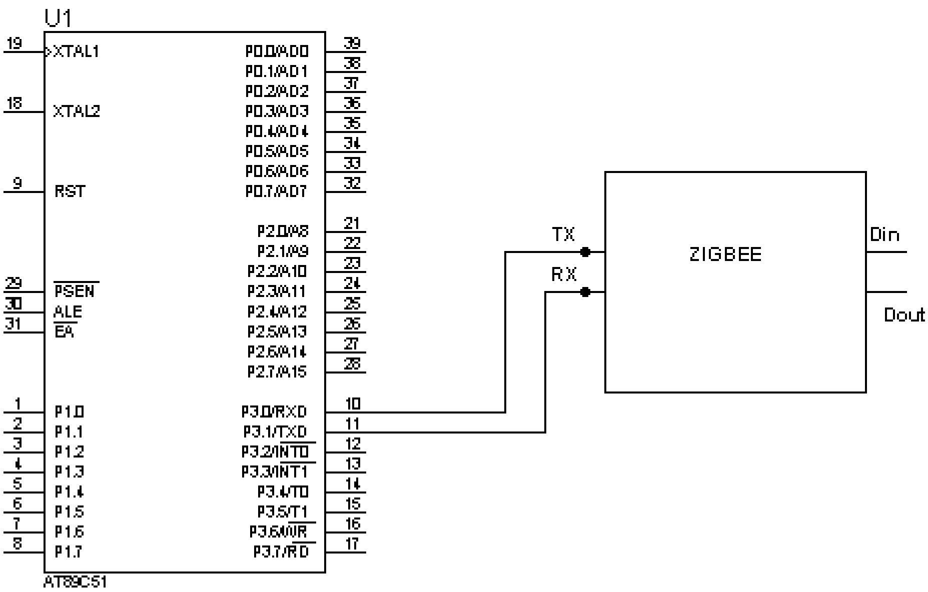

Figure 12: Zigbee Interface.

The Zigbee module acts as both transmitter and receiver. The Rx and Tx pins of ZIGBEE are connected to Tx and Rx of 8051 microcontroller respectively. The data's from microcontroller is serially transmitted to Zigbee module via UART port. Then Zigbee transmits the data to another Zigbee. The data's from Zigbee transmitted from Dout pin. The Zigbee from other side receives the data via Din pin.

ZigBee/IEEE 802.15.4 - General Characteristics

- Dual PHY (2.4GHz and 868/915 MHz)
- Data rates of 250 kbps (@2.4 GHz), 40 kbps (@ 915 MHz), and 20 kbps (@868 MHz)
- Optimized for low duty-cycle applications (<0.1%)
- CSMA-CA channel access Yields high throughput and low latency for low duty cycle devices like sensors and controls
- Low power (battery life multi-month to years)
- Multiple topologies: star, peer-to-peer, mesh
- Addressing space of up to - 18,450,000,000,000,000,000 devices (64 bit IEEE address) - 65,535 networks
- Optional guaranteed time slot for applications requiring low latency
- Fully hand-shaked protocol for transfer reliability
- Range: 50m typical (5-500m based on environment)

8051 Micro Controller

Microcontroller manufacturers have been competing for a long time for attracting choosy customers and every couple of days a new chip with a higher operating frequency, more memory and upgraded A/D converters appeared on the market.

However, most of them had the same or at least very similar architecture known in the world of microcontrollers as "8051 compatible". What is all this about?

The whole story has its beginnings in the far 80s when Intel launched the first series of microcontrollers called the MCS 051. Even though these microcontrollers had quite modest features in comparison to the new ones, they conquered the world very soon and became a standard for what nowadays is called the microcontroller.

The main reason for their great success and popularity is a skillfully chosen configuration which satisfies different needs of a large number of users allowing at the same time constant expansions (refers to the new types of microcontrollers). Besides, the software has been developed in great extend in the meantime, and it simply was not profitable to change anything in the microcontroller's basic core. This is the reason for having a great number of various microcontrollers which basically are solely upgraded versions of the 8051.

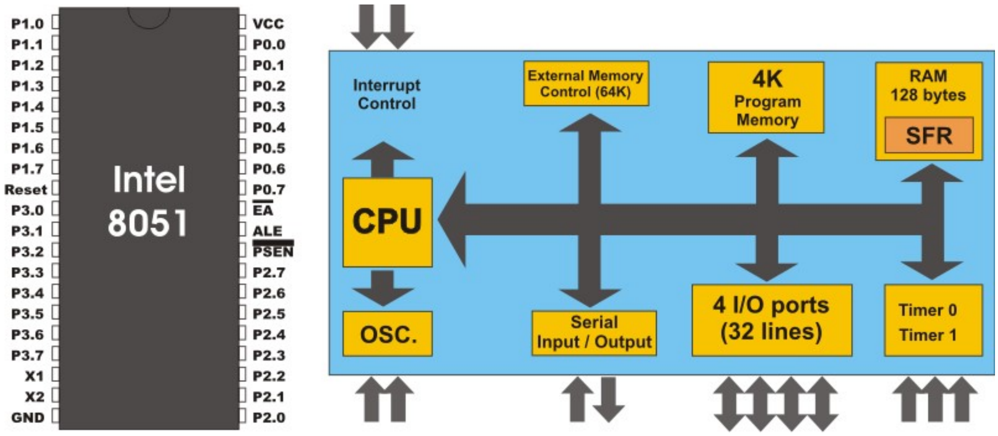

Figure 13: 8051 Micro Controller.

As seen in figure above, the 8051 microcontroller has nothing impressive in appearance:

- 4 Kb of ROM is not much at all.
- 128Kb of RAM (including SFRs) satisfies the user's basic needs.
- 4 ports having in total of 32 input/output lines are in most cases sufficient to make all necessary connections to peripheral environment.

The whole configuration is obviously thought of as to satisfy the needs of most programmers working on development of automation devices. One of its advantages is that nothing is missing and nothing is too much. In other words, it is created exactly in accordance to the average user's taste and needs. Another advantages are RAM organization, the operation of Central Processor Unit (CPU) and ports which completely use all recourses and enable further upgrade.

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- 4 Kb of ROM is not much at all.
- 128Kb of RAM (including SFRs) satisfies the user's basic needs.
- 4 ports having in total of 32 input/output lines are in most cases sufficient to make all necessary connections to peripheral environment.

Driver Circuit

The ULN2003 is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN darling ton pairs that features high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single Darlington pair is 500mA. The darlington pairs may be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED gas discharge), line drivers, and logic buffers.

The ULN2003 has a 2.7kW series base resistor for each Darlington pair for operation directly with TTL or 5V CMOS devices.

FEATURES

- 500mA rated collector current (Single output)
- High-voltage outputs: 50V
- Inputs compatible with various types of logic.
- Relay driver application

The ULN2003 series input resistors selected for operation directly with 5 V TTL or CMOS. These devices will handle numerous interface needs particularly those beyond the capabilities of standard logic buffers. The ULN2003 have series input resistors for operation directly from 6 V to 15 VCMOS or PMOS logic outputs. The ULN 2003 is the standard Darlington arrays. The outputs are capable of sinking 500mA and will withstand at least 50 V in the OFF state. Outputs may be paralleled for higher load current capability. The ULx2823A/LW and ULx2824A/LW will withstand 95 V in the OFF state. These Darlington arrays are furnished in 18-pin dual in-line plastic packages (suffix 'A') or 18-lead small-outline plastic packages (suffix 'LW'). All devices are pinned with outputs opposite inputs to facilitate ease of circuit board layout. Prefix 'ULN' devices are rated for operation over the temperature range of -20C to +85C; prefix 'ULQ' devices are rated for operation to -40C.

LCD

Introduction

The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580. In this tutorial, we will discuss about character based LCDs, their interfacing with various microcontrollers, various interfaces (8-bit/4-bit), programming, special stuff and tricks you can do with these simple looking LCDs which can give a new look to your application.

Pin Description

The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most of 80 characters, whereas LCDs supporting more than 80 characters make use of 2 HD44780controllers.

Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (two pins are extra in both for back-light LED connections). Pin description is shown in the table below.

Usually these days you will find single controller LCD modules are used more in the market. So in the tutorial we will discuss more about the single controller LCD, the operation and everything else is same for the double controller too. Lets take a look at the basic information which is there in every LCD.

* DDRAM address given in LCD basics section see Figure 2,3,4

** CGRAM address from 0x00 to 0x3F, 0x00 to 0x07 for char1 and so on.

SOFTWARE REQUIREMENTS

Keil U Vision

Keil Software is the leading vendor for 8/16-bit development tools (ranked at first position in the 2004 Embedded Market Study of the Embedded Systems and EE Times magazine). Keil Software is represented world-wide in more than 40 countries. Since the market introduction in 1988, the Keil C51 Compiler is the de facto industry standard and supports more than 500 current 8051 device variants. Now, Keil Software offers development tools for ARM.

Keil Software makes C compilers, macro assemblers, real-time kernels, debuggers, simulators, integrated environments, and evaluation boards for the 8051, 251, ARM, and XC16x/C16x/ST10 microcontroller families.

Keil Software is pleased to announce simulation support for the Atmel AT91 ARM family of microcontrollers. The Keil µVision Debugger simulates the complete ARM instruction-set as well as the on-chip peripherals for each device in the AT91 ARM/Thumb microcontroller family. The integrated simulator provides complete peripheral simulation. Other new features in the µVision Debugger include:

- An integrated Software Logic Analyzer that measures I/O signals as well as program variables and helps developers create complex signal processing algorithms.
- An Execution Profiler that measures time spent in each function, source line, and assembler instruction. Now developers can find exactly where programs spend the most time.

"Using nothing more than the provided simulation support and debug scripts, developers can create a high-fidelity simulation of their actual target hardware and environment. No extra hardware or test equipment is required. The Logic Analyzer and Execution Profiler will help developers when it comes time to develop and tune signaling algorithms." said Jon Ward, President of Keil Software USA, Inc.

MP LAB

MPLAB X is the latest edition of MPLAB, and is developed on the NetBeans platform. MPLAB and MPLAB X support project management, code editing, debugging and programming of Microchip 8-bit, 16-bit and 32-bit PIC microcontrollers.

MPLAB is designed to work with MPLAB-certified devices such as the MPLAB ICD 3 and MPLAB REAL ICE, for programming and debugging PIC microcontrollers using a personal computer. PICKit programmers are also supported by MPLAB.

MPLAB IDE also serves as a single, unified graphical user interface for additional Microchip and third party software and hardware development tools. Moving between tools is a snap, and upgrading from the free software simulator to hardware debug and programming tools is done in a flash because MPLAB IDE has the same user interface for all tools.

EPILOGUE

Applications

- It can be used in Hospitals
- It can be used in Industries
- It is used to control Home appliances.
- It is widely used in Robotics.

LIMITATIONS

- There are some inherent noise in the electronics components used for the detection and recording of EMG signal.
- Noise due to the skin- electrode interface is reduced by effective skin preparation
- The amplitude of the EMG signal is quasi-random in nature. The frequency components between 0 and 20 Hz are particularly unstable because they are affected by the quasi-random nature of the firing rate of the motor units which, in most conditions, fire in this frequency region.
- Noise from the other process occurring in the body also affect the EMG signals (i.e.) ECG, EOG and respiratory signals also contribute to the noise.
- The leads or the connecting wires from the electrodes carry the signals from the body surface to the signal acquisition board. The raw signal is most susceptible to noise during this transmission

CONCLUSIONS

This presents EMG as a daily wearable interface. It presented a prototype where users can control machines with their muscles. The capability to monitorize any voluntarily contracted muscle gives us the ability to adapt the system. The main goal of the project is to provide tetraplegic individuals the capability to control Machines. In order to accomplish this task we monitorize muscle activity through an electromyographic portable device, process the digital signal and emulate certain events accordingly to the features detected. Being able to detect and to evaluate muscular activity in an individual gives us the possibility to associate it with determined interface commands, thus having the myographic signal as input. The recurrent and increasing electromyography study in medicine related areas led to a great scientific investment to improve the myographic signal acquisition and analysis process. The work, based on gestural recognition with biomechanic and bioelectric sensors, present many motivating results being capable to differentiate gestures through the use of neural networks.

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