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Implementation of Bioimpedance Instrument Kit in ARM7

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Abstract— Bioimpedance analysis (BIA) is a valuable tool for measuring body composition. Determination of body fat is in relation with the learning of body mass. It plays an important role in the assessment of health and nutrition. AD5933 based IC is used to measure the bioimpedance. This chip can be configured and controlled by an ARM7 microcontroller. User is able to set various frequencies using a keypad. The measured values are displayed on a graphical LCD display. This bioimpedance instrument can also be used for various impedance analysing applications.

Keywords— Bio impedance, body mass index, ARM7, BIA, Embedded, Microcontroller

I INTRODUCTION

Bioimpedance is gaining popularity in the field of biomedical research applications including investigations related to skin hydration, gel performance, body fat content, tissue ischemia, dental decay, food freshness and tree growth. The human body has a number of electrical features. One of the features among them is the impedance. A group of properties which opposes the AC current flow is known as impedance. The way to measure it is not different from the conventional impedance measuring, which consists of supplying a small alternating current signal, and measuring the differences in the voltage, and then the impedance is calculated with the amplitude and phase changes between the original signal and the recorded one. Bio impedance analysis (BIA) is used to detect improper balance in body composition, which allows to detect earlier intervention and prevention. BIA also provides the measurement of body mass and fluid that can be a critical assessment tool for body health. Bioimpedance, which depends on the tissue properties and its geometry shape, is useful to estimate the relative volumes of different tissues or fluids in the body fluid compartments.

II METHODOLOGY

The AD5933 IC is used to measure the bioimpedance . The on board frequency generator generates stimulus signal with known frequency. The red dot electrodes are connected between the input and output ports. The current in response to the impedance is converted into voltage by an impedance amplifier. The output voltage of amplifier is sampled by an on board ADC and the Discrete Fourier Transform is performed by a DSP engine at each frequency. The real and imaginary results from the DSP are processed by the microcontroller. These values are compared with the obtained results from a known precise resistance using the same configuration on the signal path. The actual impedance value can be calculated from the known resistance together with the above measured results. The system is based on a microcontroller, high precision and low power device. Due to the simple structure, it can be made as a portable impedance measurement device, which is used in bioelectrical impedance analysis and material property analysis. The accuracy of 2% is realized through the appropriate design and system calibration. This accuracy is good enough for most of the biomedical impedance measurement applications. The AD5933 generates a small current 800 µA at a fixed frequency 50 KHz which is passed between two electrodes attached to the body and the voltage drop between two electrodes gives the measurement of impedance. Bioimpedance signals from human body are acquired by AD5933 and those signals are analysed using ARM7TDMI. The signals from different parts of the human can be accessed by keypad control. The measured signals are displayed with the help of graphical LCD. User can access the stored data and feed the input according to the patient data like age, weight, height, and other details.

A. MEASURING THE BIOIMPEDANCE

The AD5933 is capable of measuring impedance values by providing the real and imaginary values. The magnitude of the real and imaginary data contents is given by the equation.

$$magnitude = \sqrt{R^2 + I^2}$$

This magnitude value is equal to a scaled value of the actual impedance under test at the known frequency. To determine the actual impedance value, the microcontroller must multiply magnitude with Gain Factor GF. The Gain Factor is measured using a known external impedance connected between Vout and Vin as close as possible to the pins.

$$Gain\ Factor = \frac{\frac{1}{impedance}}{magnitude}$$

The Gain factor is calculated which calibrates the parasitic impedance between Vout and Vin at a given frequency. After measuring the unknown impedance at a known frequency. the measured impedance at the frequency point is calculated using the equation,

$$impedance = \frac{1}{gain\ factor \times magnitude}$$

B.CALCULATING BODY COMPOSITION

TOTAL BODY WATER (TBW)

The form of the equation is based upon Kushner. Deuterium dilution was the control method used to measure total body water.

$$TBW = \left(0.372 \times \frac{Height}{Impedance}\right) + (3.05 \times Sex) + (0.142 \times Weight) \qquad - (0.004 \times age)$$

Where, Height in centimetres, Resistance, Weight in Kg, Sex Male =1 Female = 0, Age in years

FAT FREE MASS (FFM)

$$FFM = TBW \div 0.73$$

FAT MASS (FM)

$$FM = Weight - FFM$$

BODY FAT IN PERCENTAGE

$$Body\ FAT\ \% = \frac{FM}{Weight} \times 100$$

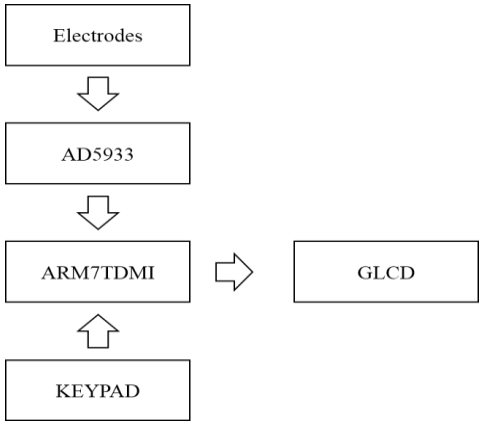
III HARDWARE

A. NXP LPC2148 MICROCONTROLLER

The LPC2148 microcontrollers are based on a 32/16 bit ARM7TDMI-S CPU core that combines the microcontroller with embedded high speed flash memory 512 KB. A 128-bit wide memory interface and accelerator architecture enable 32-bit code execution at the maximum clock frequency, 16-bit Thumb mode reduces code by more than 30 % with minimal performance.

B. AD5933 BIOIMPEDANCE CHIP

The AD5933 is a high precision impedance converter system that combines a frequency generator with a 12-bit, 1 MSPS, Analog-to-Digital converter. The frequency generator allows an external complex impedance to be excited with a known frequency. The signal in response from the impedance is sampled by the on-board ADC and a discrete Fourier transform (DFT) is done by an on-board DSP engine. The DFT algorithm returns a real (R) and imaginary (I) data-word at each output frequency.



Once calibrated, the magnitude of the impedance and relative phase of the impedance at each frequency point along the sweep can be easily calculated. Using the real and imaginary register contents, this calculation is done off chip, which is read from the serial I2C interface. Also a 4x4 Keypad, 128x64 Graphical LCD are used for user access, REDDOT Electrodes are used for better measurement.

IV SOFTWARE

A.KEIL µVision 4

The KEIL µVision 4 IDE is a very powerful Integrated Development Environment that allows us to develop and manage complete embedded application projects.This is a development platform, which have all the features we would expect to find in your everyday working place.

B.FLASH MAGIC

Flash Magic is an application developed by Embedded Systems Academy to allow us to easily access the features of a microcontroller device. With this program, we can erase individual blocks or the entire Flash memory of the microcontroller.

V EXPERIMENTS AND RESULTS

An instrument is designed carefully with all safety criteria and tested with four terminal single frequency with human body. User is able to give the parameters like age, height, weight by accessing 4x4 keypad. 128x64 graphical LCD used display the body impedance and other processed calculation such as total body water, fat mass, fat free mass etc. also control the device. When the user connects the red dot electrodes by right arm-right leg method, the device passes the safe current through the body. The measured values will be displayed after the frequency sweep completed. The processed values will be displayed in the graphical LCD.

Acknowledgement

Designing an instrument for bioimpedance began with a great deal of excitement. However, while programming and implementing this project many unexpected issues came across but were solved successfully. I got the initial idea and was able to successfully complete this project under the guidance of Mr. K. Rajasekaran. This greatly facilitated the design progress and finally helped me to complete a good job.

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