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Implementation of Fat Analyzer Using Method of Bioelectrical Impedance Analysis

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ABSTRACT

It is a growing evidence that clearly links body composition with health risks and the growth of certain diseases. From the new researches is been indicated that fat loss, not the weight loss, can extend human long existence or service. By National Institutes of Health, there's no trial data existing to indicate that one method of measuring body fat is better than any other for following overweight and obese patients during medical care given to a patient. In general betterment of results depends on accurately taken measurements and an adequate, scientifically some maintained database. Every measurement method has the quality as well as defined defects. In this context, .most research studies deploy several methods used in combination. For our project, we made the use of the microcontroller in the deigning of a device which would measure body fat percentage of one's body. The motto behind the project is bioelectrical impedance analysis simply BIA. It's a technique that uses a small alternating current flowing between two electrodes attached to skin surface in order to determine impedance. By determining the opposition to the electric current through body tissues, we can estimate the water content of the human body and use it to estimate fat free body mass. The response characteristics of these tissues can provide a good estimation of percentage body fat.

Keywords--- Bioelectrical Impedance Analysis, Body Composition, Body Composition Analysis Models, Fat Analyzer.

I. INTRODUCTION

Human weight is self is not a clear indication of good health as it does not distinguish between pounds that come from body fat and those that come from the mass of the body minus the fat. Carrying too much fat is a condition called obesity, and makes a person at risk for serious medical conditions like heart disease, diabetes and even certain forms of cancer. In fact, obesity contributes to at least half the chronic diseases in society and is based on the food habits and environment. Simple meaning of overweight is an excess of total body weight based upon the population averages for heights and body frame sizes. Athletes and very muscular people may be overweight, but that does not mean they are over fat. By National Institutes of Health, there's no trial data existing to indicate that one method of measuring body fat is better than any other for following overweight and obese patients during medical care given to a patient. In general betterment of results depends on accurately taken measurements and an adequate, scientifically some maintained database. As stated earlier, every measurement method has the quality as well as defined defects. .

In the process of determining Obesity, Height-Weight Tables - were developed by insurance companies to establish recommended weight ranges for men and women. The "desirable" weights were those associated with the lowest mortality among large population studies of insured people. Unfortunately, these studies do not accurately represent a cross-section of the entire American population. Body Mass Index (BMI) - is a simple calculation that determines height to weight ratio. This index correlates a person's physical natural height with the number of deaths in a given area or period, or from a particular cause ratios based on examined studies.

According to the National Institutes of Health and World Health Organization, a BMI or 25-29.9 is indication of overweight and BMI equal to or greater than 30 as obesity. A person with a BMI of 30 is about 30 pounds overweight/Over fat and a BMI of 18 or lower indicates that a person is underweight.

II. BODY COMPOSITION MODELS

The more traditional methods are based on a two-compartment model that simply divides the body into fat and fat-free mass. Such methods are:

A. Calipers(Anthropometry/ Skin fold Measurements)

Using hand-held calipers that exert a standard pressure, the measurement of skin fold thickness could be carried at various body locations (3-7 test sites are common). There is a calculation we have to use for deriving a body fat percentage based on the sum of the measurements. These prediction equations will be different as well as are needed for children and specific ethnic groups (over 3500 equations have been validated). Calipers approach uses underwater weighing as a reference method and is based upon the assumption that the thickness of the under the skin fat reflects a constant proportion of the total body fat (contained in the body cavities), and that the selected sites for the measurement represent the average thickness of the subcutaneous fat.

Skin fold measurements are made by seizing the skin and underlying tissue, shaking it to exclude any muscle and pinching it between the jaws of the caliper. In order to improve the accuracy and reproducibility of the measurements, duplicate readings are often made at each site in the process. Often to save time in large population studies, a single Skin fold site measurement is made to reduce the time involved. It should be a test that can be used only for a rough estimate of obesity.

B. The Dunk Tank (Hydrodensitometry / Underwater Weighing)

This method measures whole body density by determining body volume. To initiate this method, it requires weight of a person outside the tank, then immersing them totally in water and weighing them again. It's been stated that the densities of bone and muscles are higher compared to water, and fat is less dense than water. So a person with more bone and muscle will weigh more in water than a person with less bone and muscle, indicates that they have a higher body density and lower percentage of body fat. The fundamental assumption with this method is "the densities of fat mass and fat-free mass are constant". However, underwater weighing may not be the appropriate reference for everyone. For example, athletes tend to have denser bones and muscles than non-athletes, which may lead to an underestimation of body fat percentage.

C. Bioelectrical Impedance Analysis (BIA)

Body impedance is measured by passing a small, safe electrical signal through the body, carried by water and fluids. Impedance is more in fat tissue, which contains only 10-20% water, while fat-free mass, which conations 70-75% water, allows the signal to pass much more easily. By using the impedance measurements along with a person's height, weight and body type (gender, age, fitness level), it is possible to calculate the percentage of body fat, fat-free mass, hydration level, and other body composition values. Method of reference for Conventional BIA is underwater weighing and using BIA to estimate a person's body fat assumes that the body is within normal hydration ranges. When a person is dehydrated, the amount of fat tissue can be overestimated. Factors that can affect hydration include not taking enough fluids, drinking too much caffeine or alcohol, exercising or eating just before measuring, certain prescription drugs or diuretics, illness, or a woman's menstrual cycle. Measuring under consistent conditions (proper hydration and same time of day) will yield best results with this method.

D. Tanita BIA

Tanita has developed a simplified version of BIA that uses leg-to-leg bioimpedance analysis. In this system, two footpad electrodes (pressure contact) are combined to the platform of a precision electronic scale. A person's measurements are taken while in a standing position with the electrodes in contact with bare feet. The body fat monitoring system automatically measures the weight and then corresponding impedance. Computer software (a microprocessor) embedded in the developed product uses the measured impedance, the parameters like gender, height, fitness level and in some cases age, (which have been pre-programmed), and the weight to determine body fat percentage based on equation formulas.

E. Near-Infrared Interactance (NIR)

A fiber optic probe is connected to a digital analyzer that indirectly measures the tissue composition (fat and water) at various sites on the body. Based on studies it's been observed that the optical densities are linearly proportional to total body fat situated under the skin. The biceps is the most often used single site for estimating body fat using the NIR method. The NIR light penetrates the tissues and is reflected off the bone back to the detector. Data measured by NIR process is entered into a predefined prediction equation along with person's height, weight, frame size and level of activity to estimate the percent body fat.

III. IMPLEMENTATION OF FAT ANALYZER

Before getting on to the platform of implementation, we have been through study of the methods of fat analysis and more concentrated on Bioelectrical Impedance Analysis. Bioelectrical Impedance Analysis or BIA is considered one of the most reliable and accessible methods of screening body fat. In conventional BIA, a person is weighed, then height, age, gender and weight or other physical characteristics such as body type, physical activity level, ethnicity, etc. are entered in a computer. While the person is lying down, electrodes are attached to various sites of the body and a small electric signal is circulated. Simply explained, BIA measures the impedance or resistance to the signal as it travels through the water that is found in muscle and fat. More the muscle a person has, the more water their body can hold and the greater the amount of water in a person's body, the easier for the current to pass through it. Rudiment for the measure is "the resistance offered to current is proportional to the fat content in the body". BIA is safe and it does not hurt. In fact, the signal used in body fat monitors cannot be felt at all either by an adult or child. BIA actually determines the electrical impedance, or opposition to the flow of an electric current through body tissues which can then be used to calculate an estimate of total body water (TBW). TBW can be used to estimate fat-free body mass and, by difference with body weight, body fat.

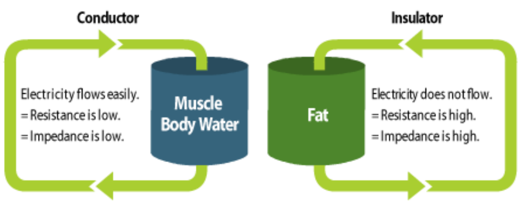


Fig1. Bioelectric Impedance Analysis

For the implementation of the BIA based FAT Analyzer, Fig2. shows the blocks existing in the hardware design. Two electrodes are used to obtain voltage difference between two parts whose one end is connected to transistor which acts as a switching device and the other end is connected to the Channel 1 of ADC 0809.The analog signal voltage which is obtained as the difference voltage by IC LM324 is given to ADC which convert it to digital voltage and gives it to microcontroller AT89C52 which performs the further operation of calculating the body's fat by regression equations which are given below.

Males: *body_fat = 0.0923 * weight + 0.1605 * age – 0.0263 * voltage*
Females: *body_fat = 0.1871 * weight + 0.5800 * age – 0.0920 * voltage*

The user needs to enter his weight and age using the keypad 4*3 whose calculation of body fat is done by MCU AT89C52 which has executable code. Based the user entries and the electrode voltages derived from the user body, the Fat % is displayed on the 2*16 Character LCD Display.

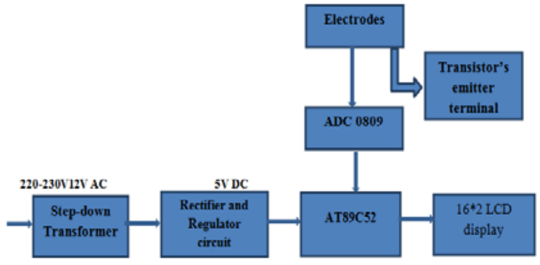


Fig.2 Structure of the hardware implementation

IV. EXPERIMENTAL RESULTS

Step1: Initiate the Hardware by switching it

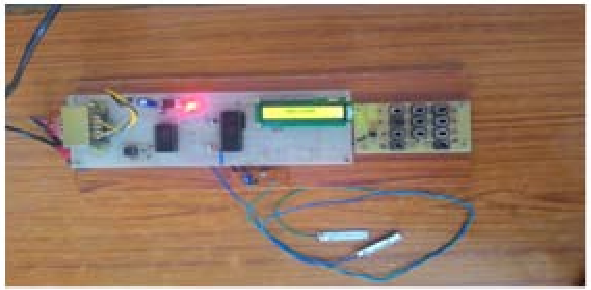
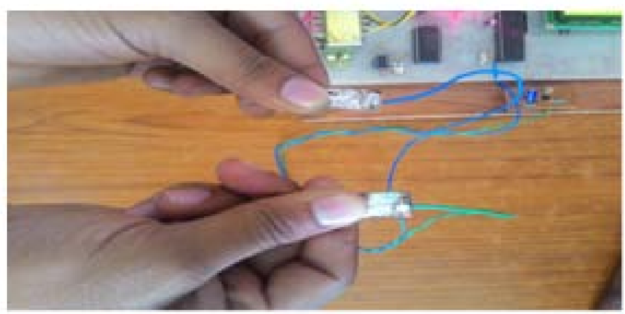


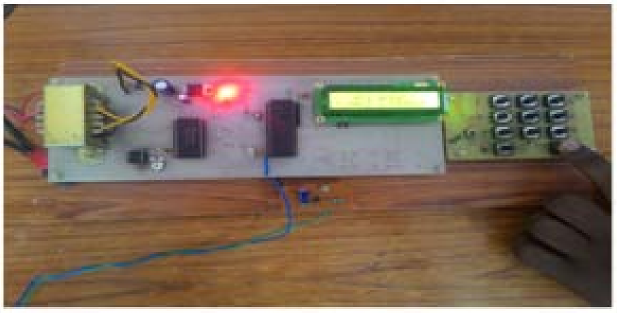
Fig.3 Initial Stage of the hardware once it's switched ON

Step 2: The message "Hold Electrodes" on the 16*2 Character LCD gets displayed.

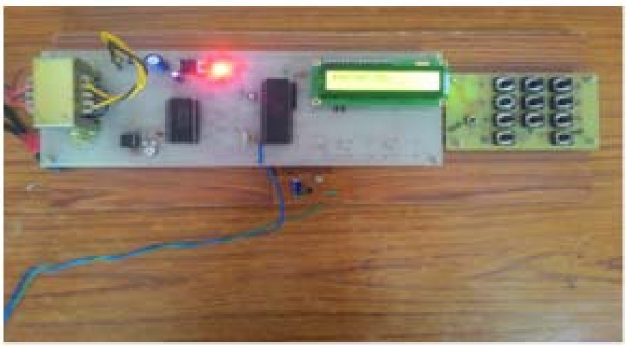
Step 3: On seeing the message "Hold Electrodes" on the LCD display, hold it with two figures of your hand as shown in following picture.



Step 4: Enter the weight and age of the user using 4*3 -keypad in the Kit. Press Go key. After that message "Please enter 1 for MALE or 2 for FEMALE gets displayed" on the display, Enter 1 if the user is 1 or enter 2 if female and press Go key.



Step 5: Fat percentage of the User gets displayed on the LCD screen



V. CONCLUSION

The expectation at the start of the project was that the device would be safe, use a signal of ~10 µA and 50 kHz to determine body impedance, and predict body fat within a 10% error margin. The final circuit, while differing in certain respects from the original design, did achieve the safety and signal goals, while it conditionally achieving the accuracy goal. The device operated at a safe current and did not harm any of our test subjects. Our input signal to the user is approximately 12 µA, which is quite close to our goal of 10 µA, and is still safe to pass through a user's body mass. This project provides many opportunities for future extensions. One extension would be to improve accuracy by implementing multi-frequency bioimpedance analysis.

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