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Thyroid Detection using Electrical Impedance Tomography

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Abstract— **Electrical Impedance Tomography refers to medical imaging technique in which an image of the impedance of a part of the body is created from surface electrical measurements. In this method, conducting electrodes are attached to the concerned body part of the subject and small alternating currents or voltages are applied to some or all of the electrodes. The resulting electrical potentials are then measured. The process may be repeated for various different configurations of applied current or voltage. This technique is rapid, safe, portable and inexpensive, and so is ideal for non-invasive medical imaging. The present work aims at developing a thyroid detector using Electrical Impedance Tomography. The paper focuses on explaining the making of the thyroid detector using the EIT technique.**

Keywords— ***Electrical Impedance Tomography, thyroid detection***

I. Introduction

According to a projection from various studies on thyroid disease, it has been estimated that about 42 million people in India suffer from thyroid diseases [1]. Electrical Impedance Tomography (EIT) is a newly emerging technology with a wide scope for medical applications. It is a non-invasive type of medical imaging in which the electrical impedance of a part of the body is calculated and plotted from surface electrode measurements and used to create a tomographic image of that part. Different biological tissues have different electrical conductivity. The majority of EIT systems apply small alternating currents at a single frequency, however, some EIT systems use multiple frequencies to better differentiate between normal and suspected abnormal tissue within the same organ (multi-frequency EIT or electrical impedance spectroscopy). Typically, conducting surface electrodes are attached to the skin around the body part being examined. Small alternating currents are applied to some or all of the electrodes, the resulting equi-potentials are recorded from the other electrodes. This process will then be repeated for various different electrode configurations and finally result in a two-dimensional tomogram according to the image reconstruction algorithms incorporated. [2]

II. Existing Methods

In the current scenario, levels of hormones secreted by the thyroid gland in the bloodstream and the structure of the gland are the parameters used while checking for abnormalities in the gland. Thyroid hormones and TSH are measured through blood tests. Blood tests are also conducted to identify antibodies against thyroid tissue such as titers of anti-thyroglobulin, anti-thyroid peroxidase, or TSH receptor stimulating antibodies. If thyroid nodules are detected or enlargement is found, imaging tests are used. Ultrasound can visualize the consistency of the tissue within the gland and can often reveal cysts or calcifications.

One of the common methods to evaluate the function of thyroid nodules is to use radioactive iodine during thyroid scans. Since the thyroid is the only location in the body that takes up iodine, the entire radioactive iodine is consumed by it. This uptake of radioactive iodine by normal thyroid tissue is seen in the imaging test. A sample of cells or tissue is removed from the thyroid gland for examination and diagnosis by fine needle aspiration and biopsy. These techniques are painful, expensive and even harmful above a certain limit. Therefore, this work aims at developing a technique using EIT which is rapid, safe, portable and inexpensive, and so is ideal for non-invasive continuous imaging.

III. Block Diagram of Proposed Design

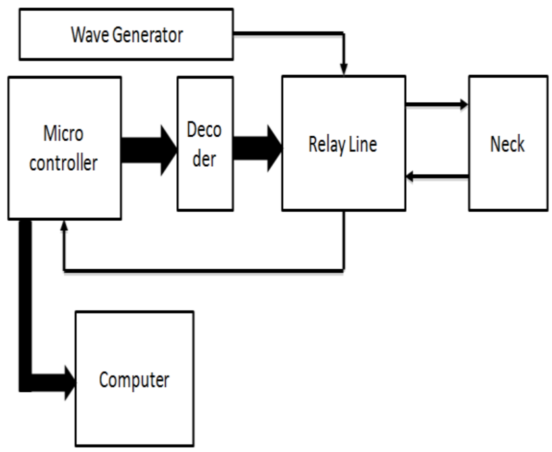

Fig. 1 Block Diagram

A. Explanation of each block

Microcontroller- The microcontroller works as the central hub controlling almost every aspect of this work. The microcontroller used here is the Arduino UNO. The program code is executed by the microcontroller. The square wave used, is also generated by the microcontroller. The microcontroller controls the select lines of the decoder, thus controlling the activation of the electrode pairs. The microcontroller also analyzes the signal coming back from the body.

Decoder- The decoder is used to select one relay at a time, thus selecting a pair of electrodes at a time. Inputs are given on the select lines of the decoder to do so. The decoder used here is IC74154. It is a 4:16 decoder, however only eight outputs are used.

Relay Line- Relays are used to enable working with alternating current, if required. The relays GS-SH-205T, used here are subminiature power relays.

Neck- This block symbolizes the human neck to which a band of electrodes are attached.

Wave Generator- An external wave generator can be used for this work. However, to make the system more portable, wave signal generation is done using the microcontroller itself. The wave used here is a square wave.

Computer- The microcontroller is connected to the computer. The code is uploaded into the microcontroller through the computer. It also powers the microcontroller. The collected data is sent to the computer for computation and for further analysis.

B. *The Electrode Band*

The thyroid gland is a butterfly or H-shaped organ composed of two lobes joined by a narrow isthmus. The normal thyroid weighs approximately 15 to 25 g, with each lobe 4 to 6 cm in length and 1.3 to 1.8 cm in thickness. The isthmus measures less than 4 to 5 mm [3].

The electrode band is a fabric band, consisting of two sections for the two lobes. Each section consists of 4 pair of electrodes. The horizontal distance between each pair is 1.5 cm and the vertical distance between the electrode in a pair is 1 cm. The distance is kept constant so that the impedance value to be calculated using individual electrode pairs is not affected by change in the distance.

The electrodes used are made up of silver metal as it has the highest conductivity. They are attached to the band with the help of plastic patches which do not interfere with the conductivity of the electrodes. At a time one pair of electrode is selected through which the signal flows, the wave enters the body through the upper electrode travels through the gland and comes out of the lower electrode and goes back to the relay line and thus the circuit is completed.

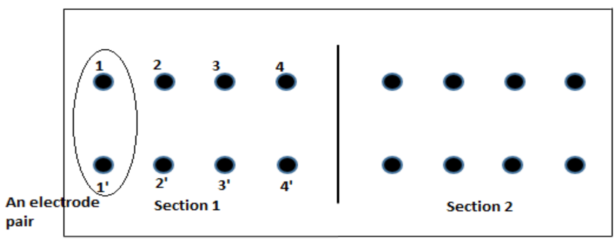

Fig. 2 Electrode band

This work uses fixed topology of electrodes. In this topology there are fixed number of electrodes that is each electrode has a fixed position with respect to its polarity as ground or reference voltage. Electrodes 1, 2, 3 and 4 have fixed supply voltages and electrodes 1', 2', 3', and 4' are fixed grounds.

IV. Circuit Diagram

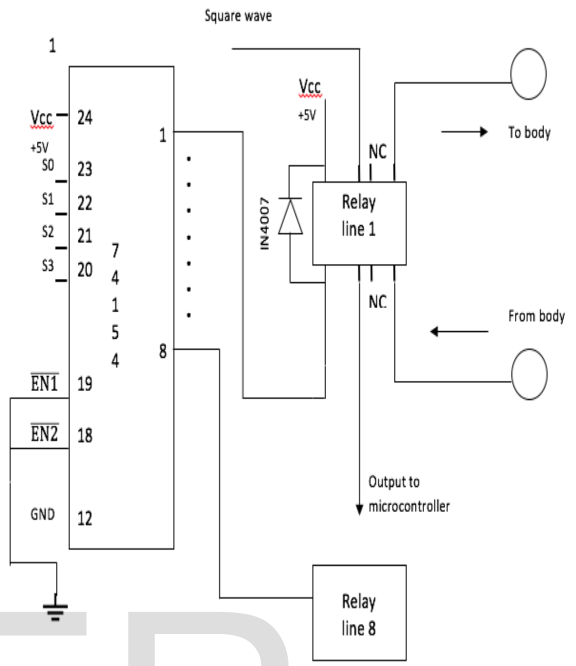

Fig. 3 Circuit diagram

The circuit comprises of the following components-

- Decoder – 74LS154
- Relay – HK 19F
- Diode – IN4007

Decoder: It is used to select the various relay lines which are connected to the body via electrodes. Line selection is done with the help of a microcontroller whose port pins are connected to the select lines of the decoder. By proper programming each relay line will be selected after sufficient delay. This delay is necessary in order to allow time for measurements.

The decoder used is 74LS154 (DIL) which is a 4:16 de-multiplexer i.e. four select lines and sixteen output lines. The de-multiplexer operates on +5V supply and also it uses negative logic for the outputs i.e. a line when selected will remain low, instead of high, while the other outputs are all high, instead of low.

Relay: It is used for switching a line on and off. It activates a line only for a limited duration depending on the delay and then deactivates that line. The circuit uses one relay for activation and deactivation of a line. The relay used is GS-SH-205T which is a subminiature power relay. A single relay package comprises of two individual relay contacts controlled by a single coil. This eliminates the use of two separate relays per line. The relay operates within the range of +5V to +12V. A diode connected across the relay coil prevents any back current from the coil.

Diode: It is used to prevent any back current from the relay coil arising as a result of back emf. The diode is connected in reverse biased mode across the coil of the relay. The diode used is IN4007 which is a basic silicon rectifier

V. Implementation

All the components used in the circuit have been explained in the previous section. The Microcontroller (Arduino) is the center of the entire working. It contains the main execution program. All the control signals are generated by the microcontroller. When the program is executed, the microcontroller sends a signal on the select lines of the Decoder(IC74154). This signal represents a binary number ranging from 0 to 7 since there are 8 relays. Depending on the number sent to the select lines, the respective output line gets activated. There are 8 output lines, each connected to one relay. Depending on the line that is activated, the respective relay gets activated. In short, the microcontroller activates a particular relay through the decoder. The relay is further connected to a pair of electrodes. Only one relay is activated at a time.

The relay used consists of two individual relays within itself. From these two, one is used to send a signal to the electrodes and the other is used to receive a signal from the electrodes. A single frequency square wave is generated by the microcontroller. This frequency signal is given to the inputs of all the relays. This signal cannot go to the electrodes till the relay is activated.

Consider one cycle of operation. The microcontroller sends a signal on the select lines of the decoder. The respective output is selected and the respective relay is activated. This allows the frequency signal at the relay input to travel to the electrodes. The electrodes are in contact with the skin. Each electrode pair works together at a time. One electrode sends the signal and the other receives the signal. The frequency signal travels to the first electrode, passes through the body and then enters the second electrode which brings it back to the relay. This signal is sent back to the microcontroller for storing or processing. The microcontroller is connected to a computer. These signals can be sent to the computer to compute an image or graph using specific software. If a sine wave is used instead of a square wave, the signal is sent to an A/D converter and then sent to the microcontroller.

After one cycle of operation, the next relay is activated and the cycle repeats. There is a delay between each cycle of operation. This delay is given for the time taken for A/D conversion and the processing of data. The direction of signal flow is microcontroller → decoder → relay → electrode → body → electrode → relay → microcontroller → computer.

VI. Results And Discussion

The results can be stated as follows-

The selection of the desired pair of electrodes is done successfully using the decoder and relay line circuit according to the fixed electrodes topology.

The electrode band made is easy to use and adaptable to varying neck size. It neither causes any discomfort nor interferes with the electrical aspects of the components.

In the present work, through the use of Arduino Uno and decoder-relay circuit an electrode pair selector with required delay has been made. The results achieved are appropriate for this version of the circuit. It can successfully activate and deactivate an electrode pair with the desired delay. The electrode band which is safe, easy to use, adaptable, and unaffected by electrical parameters has been made.

VII. Future Scope

In the future this work intends to achieve the following-

- Using a signal generator IC to generate waveforms at high frequency where the frequency can be varied. This is to make the system compact by not having to use a separate function generator which is immobile.
- Using a software which can take the current values from the electrodes, calculate the impedance and plot a tomogram.
- To make the system ready to achieve the values of the electrical parameters as desired according to the recommended and permissible limits of the human body. Get the permission to test the system in vivo.
- Compile the results obtained by using the system on a considerable amount of participants. Check the results obtained by comparing it with the results of a well established method.
- Try to find ways to overcome the shortcomings and disadvantages of the developed system.

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