

Oesophageal Electronic Stethoscope

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Abstract— The aim of this paper is to monitor the heartbeat frequently, without using the stethoscope on the patient's chest repeatedly. This will ease the anaesthetist and will also provide heart beats heard by the surgeon, assistant surgeon, scrubbers and technician. Monitoring of heartbeats frequently by placing the stethoscope on the chest of the patient may burden the anaesthetist during long surgical procedures [1]. We have designed a Trans oesophageal electronic stethoscope which can be inserted in to the patient oesophagus and helps in monitoring the sounds of the heart as well as the lungs by telemetry. The paper envisages the design, fabrication and testing of a Trans oesophageal electronic stethoscope which can be inserted in to the patient oesophagus and taking the sounds of the heart as well as the lungs by telemetry to a monitor. For the purpose of experimentation, the General Mobile Radio Service (GMRS) circuit is used which includes transmission and reception in both the circuits.

Keywords- Oesophageal Stethoscope, GMRS, Heart rate

I. INTRODUCTION

The human being is vulnerable to diseases and disorders. The diagnosis is done by clinical examination with confirmation by biochemistry and pathological tests. The disorder is most likely due to organ decay or malfunctioning due to unknown reasons. The surgical correction is most likely the cure for such disorders. In both the above cases the surgical intervention or minor procedure requires the patient to be under anesthesia. During anesthesia the patient's level of consciousness and pain thresholds are taken beyond the sensory capabilities of the brain. The duration of anesthesia depends upon the duration of surgical procedure, weight of the patient, gender, age and his/her nutritional habits [2]. Though the patient is under anesthesia, his/her vital signs are continuously monitored to keep the brain and the other subsystems alive but without pain perception [3]. In many surgical procedures involving the limbs, the brain and abdomen and below abdomen, the anaesthetist monitors the

vital signs and heartbeat by placing a stethoscope on the chest of the patient frequently. The heart beats, the breathing as well as the blood pressure (BP) indicates that the patient is alive; it also indicates that there are no complications in weaning off the patient from anesthesia [4]. Monitoring of heartbeats frequently by placing the stethoscope on the chest of the patient may burden the anaesthetist during long surgical procedures. The above project envisages the design, fabrication and testing of a Trans oesophageal electronic stethoscope which can be inserted into the patient oesophagus and taking the sounds of the heart as well as the lungs by telemetry to a monitor. This will ease the anaesthetist from using the stethoscope on the patient's chest repeatedly. In addition to the anaesthetist, the heart beats can also be heard by surgeon, assistant surgeon, scrubbers and technician [5].

II. MONITORING OF HEART RATE UNDER ANAESTHESIA

A. Measurement

Monitoring essentially means indicating controllable variables. Monitoring also means something that reminds or gives warning [6]. The measuring instruments used during the course of surgery can do the following three things:

- They measure
- They display or record the information
- They give an alarm if the measured variable moves outside the defined limits.

B. Manual method

Using stethoscope the heart sounds generated with in the body can be heard. It consists of a chest piece, tubings, ear tube and earpieces.

- **Chest piece:** It is the cup shaped part at the end of the tubing. The diaphragm is present inside the chest piece with a thin plastic covering. The diaphragm vibrates to high pitch sounds.
- **Tubings:** The tubing transmits the sound from the chest piece to the earpieces.
- **Earpieces:** Earpieces fit into the ears. They are made up of soft rubber, which gives comfort to the user and prevents outside sounds entering inside.



Figure 1. Stethoscope

C. C. Proposed Method

The Trans oesophageal electronic stethoscope is inserted in to the patient’s oesophagus [7]. The sounds of the heart as well as that of the lungs of the patient are taken. By using a transmitter and receiver circuit the sounds are telemetered. This will ease the anesthetist from using the stethoscope on the patient’s chest repeatedly.



Figure 2. Oesophageal Stethoscope Used Manually



Figure 3. Oesophageal Stethoscope inserted in a patient

III. OESOPHAGEAL STETHOSCOPE

A. Block Diagram with Features

The block diagram is as shown in Figure 4.

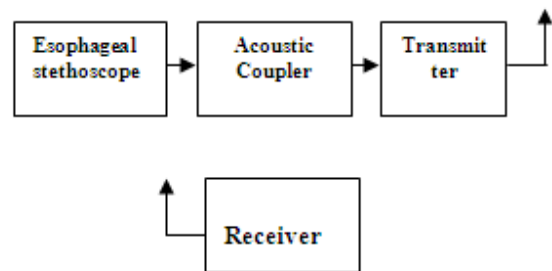


Figure 4. General Block Diagram

- It is used to monitor the cardiac sounds via the esophagus. This method is reliable and very efficient. It is suitable particularly for pediatric and neurosurgical procedures.
- The thin walled cuff provides an extra sensitive membrane for accurate transmission of cardiac sounds.
- This device will easily fit in to a standard stethoscope or electronic monitoring equipment for maximum flexibility of use.
- Distance markings are provided from the mid cuff position to help in the accurate placement of the cuff in the esophagus.
- This device is manufactured from smooth, non-toxic, thermo sensitive PVC for trauma-free use.
- Patients of all age groups can be accommodated with respect to size ranges
- The one which is used in our work is 18f in size.

B. Biomaterial

The Oesophageal stethoscope is made up of PVC for its medical qualities. It is flexible so that it can be easily intubated into the oesophagus and can be manured easily for placing distal end near to the heart or near to the lungs. The PVC is highly insulated for electrical and sound properties. Because of its sound insulating qualities, the sound waves traveling inside the stethoscope are not affected by the external sounds inside the oesophagus [8]. Similarly the external sounds can only vibrate the diaphragm at the distal end, which in turn produces the sound waves inside the stethoscope. The PVC is not affected by temperature, which can vary in the range of 30OC to 40OC, so that there is no elongation or deformity to the stethoscope.

C. Acoustic Coupler and its Design

Acoustics means the physics of sound. A coupler is a device that connects two ends without any loss of energy. The main parameter of the design is to identify the focusing length of the acoustic coupler so that the heart sounds as waves travel without any loss from the esophageal stethoscope to the microphone, which is placed within the coupler. The acoustic coupler is a two-piece Teflon coupling. The microphone is fitted inside the acoustic coupler at the correct acoustical length and the two pieces are tightened using the grub screws. The sound coming from one end of the esophageal stethoscope is focused on to the microphone for high fidelity. The microphone used picks up the heart sounds directly and converts into a voltage signal. Almost airtight environment is provided so that the microphone does not pick up any noise. The design of an acoustic coupler essentially depends on the focusing of sound waves at the proximal end of the stethoscope to that of the microphone-receiving end. Focusing is required so that all sound waves coming from the stethoscope are picked up by the microphone with negligible losses. The acoustic coupler is made up of Teflon. In order to have good focusing the distance between the proximal end of the esophageal stethoscope and the receiving surface of the microphone is around 13 mm. which is the distance between the external ear to the inner drum in a normal adult. This duplication of the nature's high fidelity hearing system is achieved after many trial and errors. The Acoustic Coupler Design is shown in Figures 5-10.

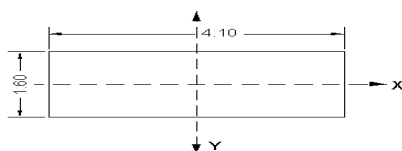


Figure 5. Top View of First Part

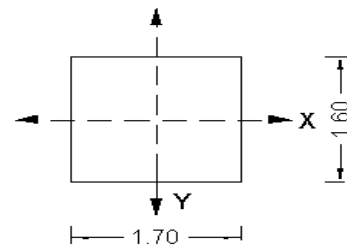


Figure 6. Top View of Second Part

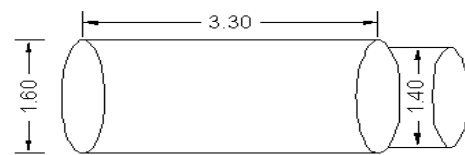


Figure 7. Side View of First Part

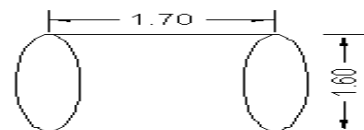


Figure 8. Side View of Second Part

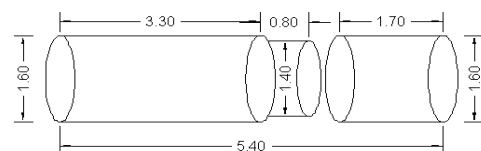


Figure 9. Combination of Two Parts

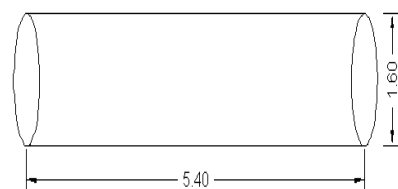


Figure 10. Total Acoustic Coupler

D. Transmitter

Transmission means transfer of intelligence from one place to other through radio waves radiated in the space.

Transmitter antenna radiates electromagnetic waves and a receiver antenna intercepts them.

E. Antenna

The dimensions of antenna and its selection for transmitter and receiver depend on the maximum transfer of power without loss. End fed antenna are used for low frequency communications.

F. Switch Function

The change over from transmit to receive mode is carried through a switch 4 pole away (push to on and release to off type). It is wired such that the receiver mode is always in release to off position.

G. Microphone

A microphone is used to convert sound waves into electrical signals. A condenser microphone is used in the equipment to pick up the heart sound without any noise. There are many different types of microphones that vary in the way they amplify sounds.

H. Battery Source

A 6 volts battery supply is used to operate the GMRS circuit. A 9 volts battery supply is used to operate the relay circuit. Batteries are used in a battery compartment. A rechargeable battery upgrade kit is available to recharge the batteries.

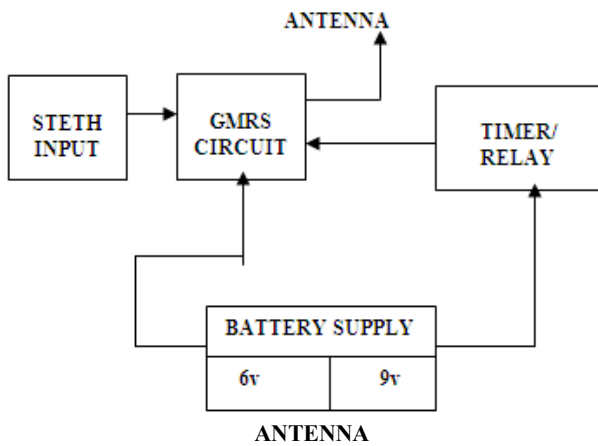


Figure 11. Block Diagram of Transmitter

I. GMRS Circuit

For the purpose of experimentation, the GMRS circuitry is used. This includes the transmission and reception in both the circuits. While the receiver circuit is always kept 'ON' in reception only and the transmission circuit is toggled between transmission and reception for every 60 secs. This switching over is done by a relay with a timer circuit. The transfer time from transmission to reception and vice versa is 20 ms. During transfer time, there may be a noise component heard in the receiver side, which is not critical for the clinical

experimentation. The transmitter is fully battery operated. The GMRS uses 462.56MHz frequency to transmit. An ON/OFF push button is used to turn ON or OFF.

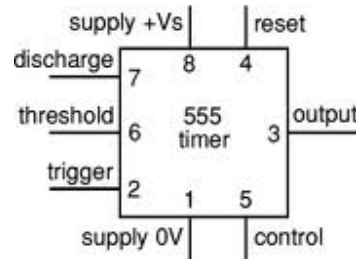


Figure 12. Circuit symbol of 555 timer

The 555 timer is highly stable for generating accurate time delay or oscillation. It can provide time delay from microseconds to hours. It can be used with a supply voltage ranging from +5V to 18V.

J. Receiver

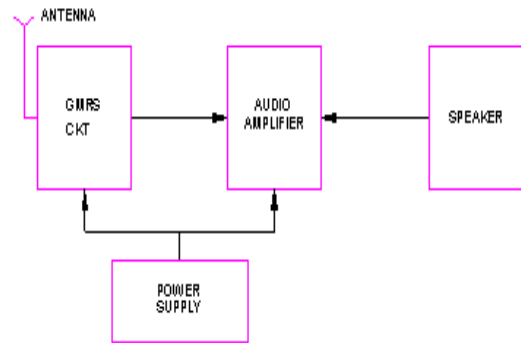


Figure 13. Circuit symbol of 555 timer

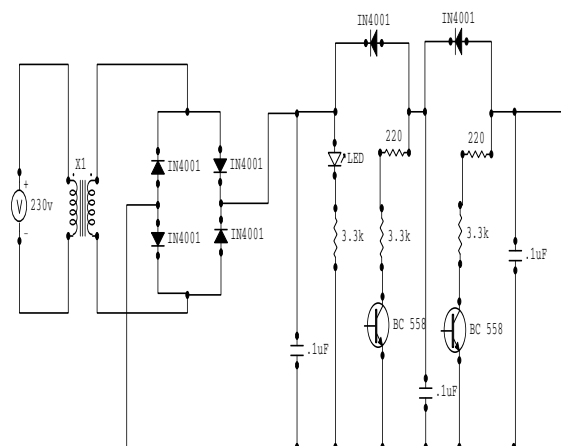


Figure 14. Circuit Diagram of Power Supply

Using the circuit shown in Figure 14, the following voltages at a current limited to one ampere are obtained (3V,

4.5V). The AC main is stepped down by transformer X1 to deliver the secondary output of 18V AC at a maximum current of 1A dependent on the load. The transformer output is rectified by the bridge rectifier comprising diodes D1 through D4, filtered by capacitor C1 and to regulator IC LM317, which is a 3 terminal positive regulator capable of providing 1.2V to 37V at 1.5A current to the load Resistor R3 and R2 are used to produce 3 V at the output, Similarly Resistor R5 and R4 are used to produce 4.5 V at the output. Capacitors. C2 and C3 bypass any ripple in the output. Diodes D5 and D6 are used as the protection diode. Heat sink is used for IC LM 317 to dissipate the heat from it. The LM386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep the external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200. The inputs are ground referenced while the output automatically biases to one-half the supply voltage. The quiescent power drain is only 24 milliwatts when operating from a 6-volt supply, making LM386 ideal for battery operation.

IV. CONCLUSION

For the purpose of experimentation, GMRS circuit is used in our work, which includes transmission and reception in both the circuits. While the receiver circuit is kept on in reception only, the transmission circuit is toggled between transmission and reception for every 60 secs. The transfer time from transmission to reception and vice versa is 20 ms. During this

transfer time, a noise component is heard in the receiver side which is not critical for the clinical experimentation.

ACKNOWLEDGMENT

The authors wish to thank the Chairman and Chairperson of Rajalakshmi Engineering College, Chennai for providing all the facilities required for carrying out this work. They also thank the Principal, Rajalakshmi Engineering College, Chennai and Dr.S.Shobana, Anaesthetist for constant encouragement and guidance.

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