Department of Electronics and Communication Engineering

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<u>Academic Year: 2024-25</u>

Project Based Learning Report

on

Heartbeat Transducer

Submitted in the partial fulfillment of the requirements
For the Project based learning in (**Analog Circuits and Applications**)
in
Electronics & Communication Engineering

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the Project Based Learning report entitled, "**Heartbeat Transducer**" is work done by

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in partial fulfillment of the requirements for the award of credits for Project Based Learning (PBL) in **Analog Circuits and Applications** of Bachelor of Technology Semester III, in Electronics and Communication.

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ABSTRACT

The heartbeat transducer circuit is designed to monitor and measure the electrical activity of the heart, providing real-time data for medical diagnostics and health monitoring. This circuit typically utilizes a combination of electrodes placed on the skin to detect electrical signals produced by heartbeats. These signals are amplified and processed to produce a digital output, which can be visualized on a screen or transmitted to a remote monitoring system. Key components include operational amplifiers, filters to eliminate noise, and microcontrollers for data analysis. This technology is crucial for applications in telemedicine, wearable health devices, and cardiology, enabling continuous monitoring of cardiac health and timely detection of abnormalities.

INTRODUCTION

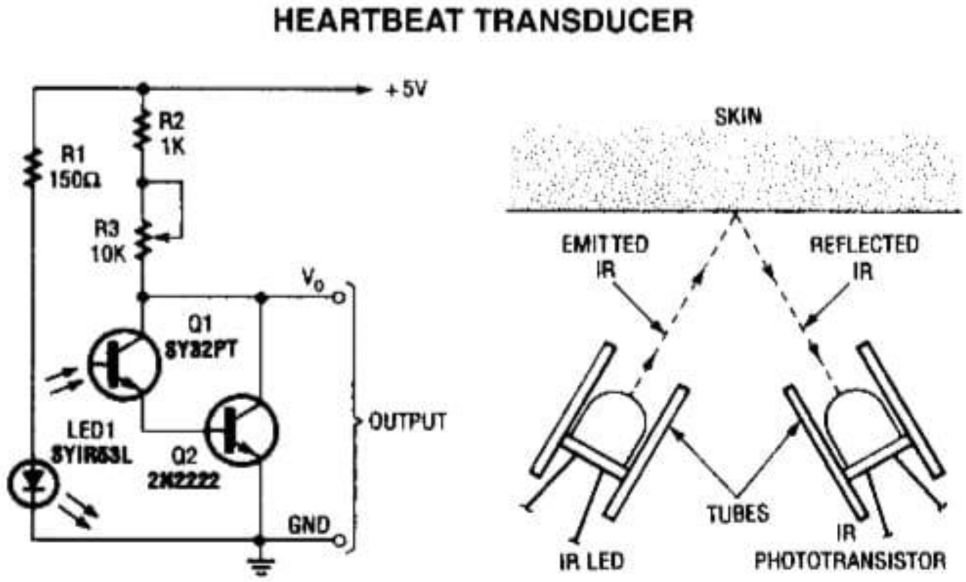
Heartbeat transducers are vital devices in the field of medical technology, designed to measure and convert the mechanical activity of the heart into electrical signals. This transformation allows for real-time monitoring of cardiac function, aiding in the diagnosis and management of various cardiovascular conditions. By providing precise measurements of heart activity, these transducers play a critical role in both clinical and home healthcare settings.

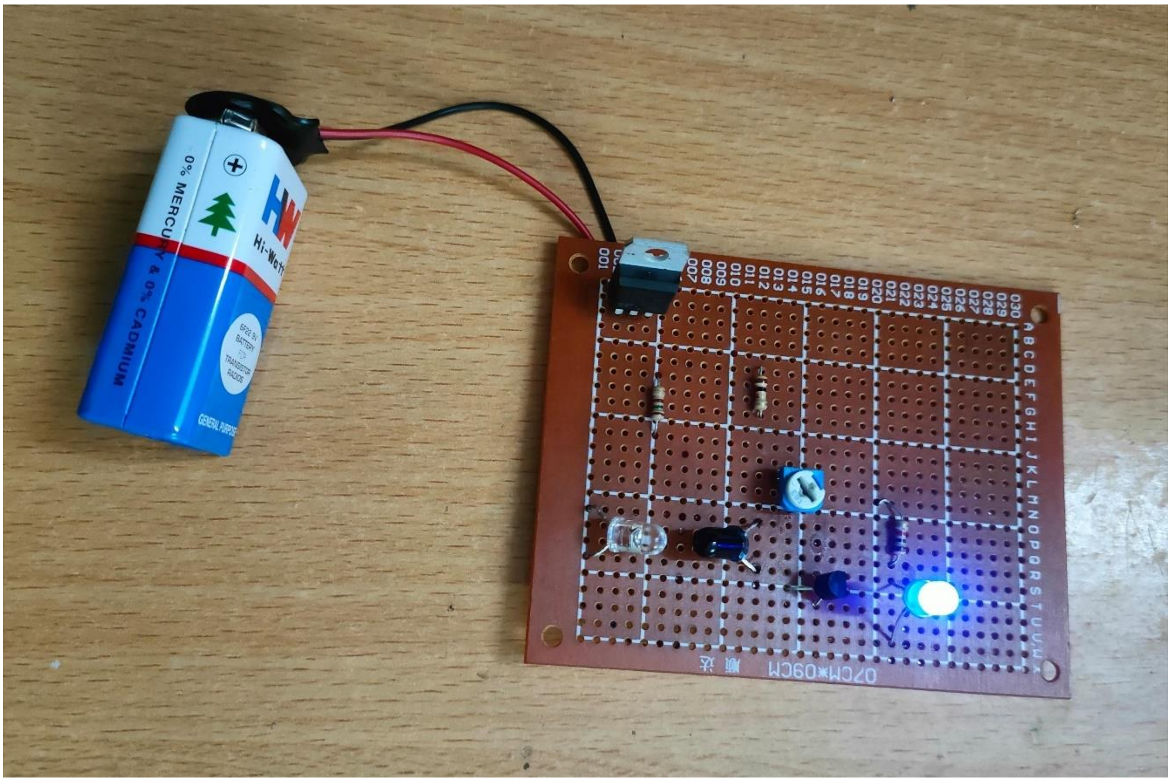
At their core, heartbeat transducers operate on various principles, with the most common being piezoelectric and optical sensing technologies. Piezoelectric sensors, for example, generate an electrical charge in response to mechanical stress, which occurs as the heart beats. These sensors are often incorporated into electrocardiogram (ECG) devices that record the electrical signals produced by heart muscle contractions. Alternatively, optical sensors utilize light to detect changes in blood flow and volume, providing valuable data on heart rate and rhythm.

The significance of heartbeat transducers extends beyond simple monitoring. They enable healthcare professionals to detect arrhythmias, assess heart rate variability, and evaluate the overall cardiovascular health of patients. Furthermore, advancements in technology have led to the development of portable and wearable devices, such as smartwatches and fitness trackers, which integrate heartbeat transducers for continuous monitoring. This accessibility empowers individuals to track their heart health in real time, promoting proactive management and early detection of potential issues.

In addition to clinical applications, heartbeat transducers contribute to research in cardiology. They facilitate the collection of large datasets for studying heart diseases, understanding physiological responses, and developing innovative treatment methods. As technology continues to evolve, the accuracy and capabilities of these transducers are expected to improve, leading to enhanced patient outcomes and further advancements in cardiovascular care.

CIRCUIT DIAGRAM OF HEARTBEAT TRNSDUCER





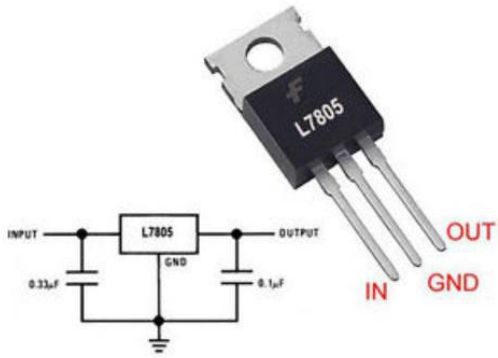
HARDWARE CIRCUIT

HARDWARE COMPONENTS AND SPECIFICATIONS

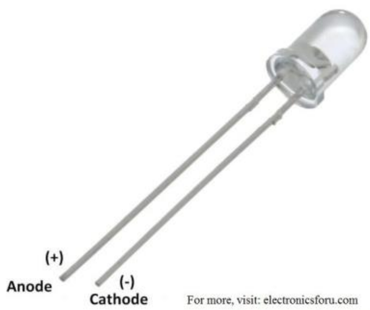
The circuit diagram shown above illustrates a simple heartbeat transducer constructed using an infrared LED and an infrared phototransistor. The key components and their functions are:

Battery & Battery Connector: The 9V battery is an extremely common battery that was first used in transistor radios. It features a rectangular prism shape that utilizes a pair of snap connectors which are located at the top of the battery. It acts as a voltage source in a circuit.

LM7805: The LM7805 is a voltage regulator that outputs +5 volts. Like most other regulators in the market, it is a three-pin IC; input pin for accepting incoming DC voltage, ground pin for establishing ground for the regulator, and output pin that supplies the positive 5 volts.



Infrared LED: Emits infrared light, which is invisible to the human eye.



- Forward current (IF) is 100mA (normal condition) and 300mA (max.)
- 1.5A of surge forward current
- 1.24v to 1.4v of forward voltage
- Temperature for storage and operation varies from -40 to 100 ℃
- Soldering Temperature should not exceed 260 ℃
- Power Dissipation of 150mW at 25℃ (free air temperature) or below
- Spectral bandwidth of 45nm
- Viewing angle is 30 to 40 degrees

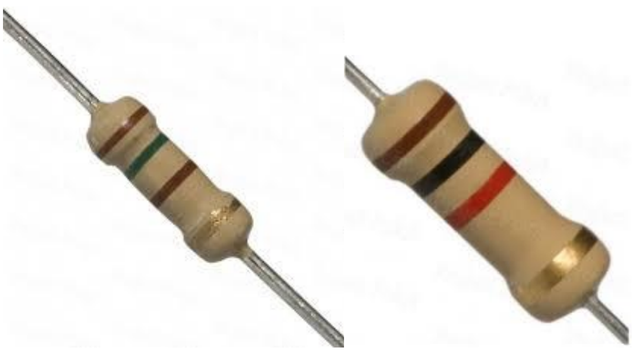
Skin: Acts as a reflective surface for infrared light.

Infrared Phototransistor: Detects the reflected infrared light and converts it into an electrical signal.

- Wavelength Sensitivity (λP): 940nm.
- Open Circuit Voltage: 0.39V.
- Reverse breakdown voltage: 32V.
- Reverse Light current: 40μA.
- Reverse Dark current: 5nA.

Resistors (R1, R2, R3): The resistor is a passive electrical component that creates resistance in the flow of electric current.

- Resistance: 150 Ohms, 1k Ohms



Transistor 2N222 (Q1): Acts as an amplifier to increase the strength of the electrical signal generated by the phototransistor.

Potentiometer (10K ohms): A potentiometer (also pot or electronic pot) is a variable resistor in which a wiper sweeps from one end of the resistive element to the other, resulting in resistance that is proportional to the wiper's position.

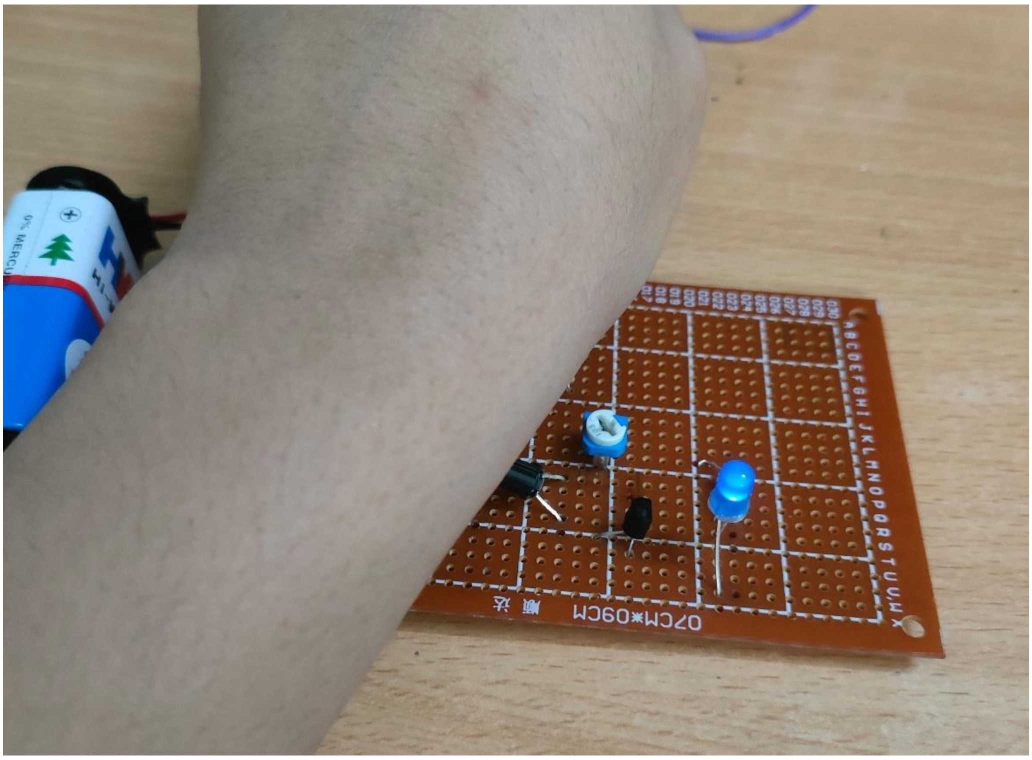
LED (LED1): An LED is a two-lead semiconductor light source, which emits lights when activated. When an appropriate voltage is applied to the LED terminal, then the electrons can recombine with the electron holes within the device and release energy in the form of photons. This effect is known as electroluminescence. The color of the LED is determined by the energy band gap of the semiconductor.

Colour: Blue (made from gallium nitride (GaN))

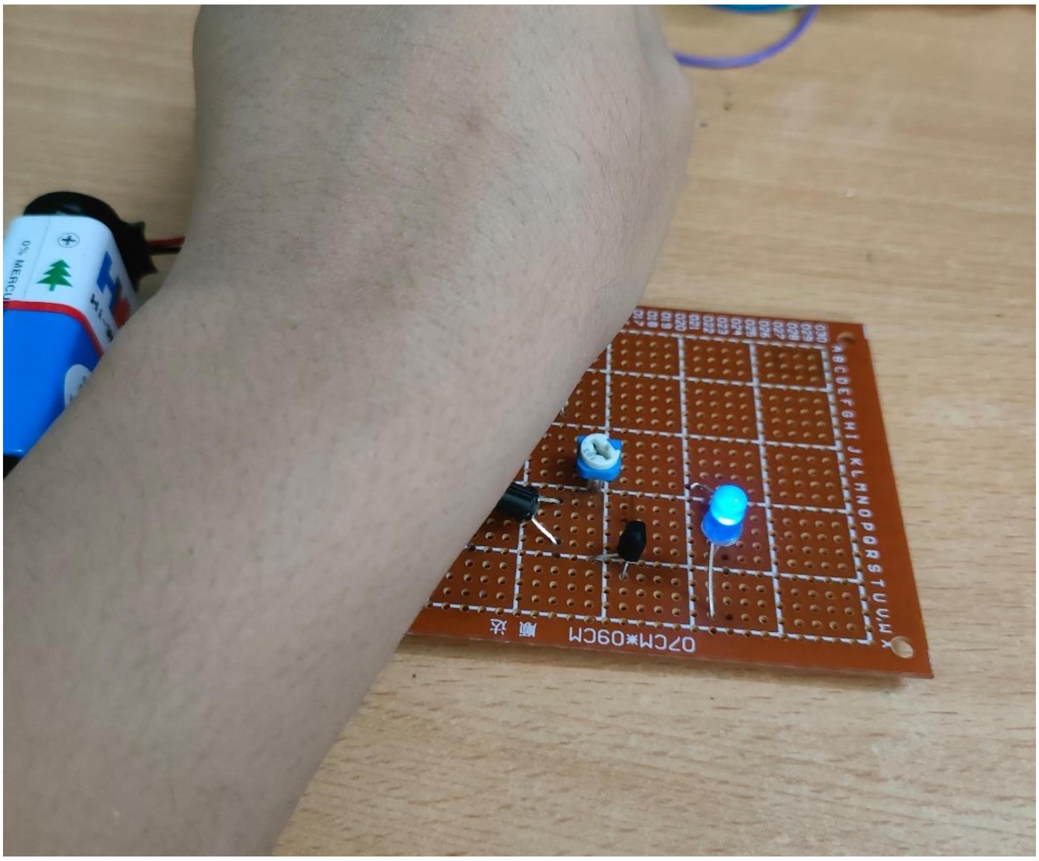
WORKING OF HEARTBEAT TRANSDUCER

Working Principle: The principle behind the transducer's operation is that the blood density in the skin fluctuates with each heartbeat**.** When the heart contracts, blood is pumped into the capillaries, increasing the blood density in the skin. This increased blood density reflects more infrared light. Conversely, when the heart relaxes, blood flows away from the capillaries, decreasing the blood density and reducing the amount of reflected infrared light. By monitoring the changes in reflected infrared light, the transducer can detect the presence of a heartbeat. The frequency of the LED's blinking corresponds to the heart rate.

- **Infrared Light Emission:** The infrared LED emits infrared light, which is directed towards the skin.
- **Skin Reflection:** The infrared light is reflected from the skin surface. The intensity of the reflected light varies with the blood density in the skin, which changes with each heartbeat.
- **Phototransistor Detection:** The infrared phototransistor detects the reflected light and converts it into an electrical signal. The strength of this signal varies with the intensity of the reflected light.
- **Signal Amplification:** The electrical signal from the phototransistor is amplified by the transistor (Q1).
- **LED Indication:** The amplified signal is used to drive the LED (LED1), which lights up when a heartbeat is detected.



FLUCTUATION OF LED ACCORDING TO OUR PULSE



Recorded Heart Rate: 68 beats/minute

APPLICATIONS OF HEARTBEAT TRANSDUCER

Heartbeat transducers have a wide range of applications in the medical field, including:

- **Diagnosis of heart diseases:** ECGs can help diagnose various heart conditions, such as arrhythmias, heart attacks, and coronary artery disease.
- **Monitoring heart health:** ECGs can be used to monitor the heart's electrical activity over time, allowing for early detection of any abnormalities.
- **Evaluating the effectiveness of treatments:** ECGs can be used to assess the effectiveness of treatments for heart diseases, such as medications or surgical procedures.
- **Research:** ECGs are used in medical research to study the heart's electrical activity and develop new diagnostic and therapeutic techniques.

ADVANTAGES OF HEARTBEAT TRANSDUCER

- **Non-invasive:** Heartbeat transducers are non-invasive, meaning they do not require any surgical procedures.
- **Portable:** Modern ECG machines are often portable, making it easy to use them in various settings, including hospitals, clinics, and even at home.
- **Accurate:** ECGs are highly accurate in detecting abnormalities in the heart's electrical activity.
- **Affordable:** Heartbeat transducers are relatively affordable, making them accessible to a wide range of patients.

PBL OUTCOME

The outcome of a project-based learning (PBL) initiative focused on a heartbeat transducer could include several key components:

1. **Understanding of Biomedical Engineering Principles:** Students gain insights into how transducers convert physiological signals (like heartbeats) into measurable electrical signals.

2. **Technical Skills Development:** Participants learn about circuit design, programming (if applicable), and sensor integration.

3. **Prototype Creation:** Teams develop a working prototype of a heartbeat transducer, showcasing design and functionality.

4. **Data Analysis:** Students collect and analyze data from the transducer, learning how to interpret heart rate information and its implications for health monitoring.

5. **Presentation Skills:** Teams present their findings and prototype to peers or a panel, enhancing their communication and public speaking abilities.

6. **Real-World Application:** Discussion of how heartbeat transducers can be used in clinical settings, personal health monitoring, or fitness technology.

7. **Teamwork and Collaboration:** Participants develop skills in working collaboratively, managing projects, and resolving conflicts within a team setting.

8. **Reflection and Feedback:** After project completion, students reflect on their learning experiences and receive feedback for future improvement.

These outcomes collectively foster a deeper understanding of both technical and soft skills relevant to engineering and healthcare fields.

COURSE OUTCOME:

- **CO1:** Demonstrate BJT single stage amplifier, its hybrid equivalent and hybrid models.

- **CO6:** Design and analyze transistorized series and shunt voltage regulators.

CONCLUSION

Heartbeat transducers are essential medical devices that play a crucial role in the diagnosis and treatment of heart diseases. They are non-invasive, portable, and accurate, making them a valuable tool for healthcare professionals. While they have some limitations, heartbeat transducers continue to be an important part of modern medicine. The heartbeat transducer presented in this report is a simple yet effective device for monitoring heart rate. It utilizes the principle of infrared light reflection from the skin to detect changes in blood density, which correspond to heartbeats. The circuit design incorporates an infrared LED, phototransistor, amplifier, and LED indicator to provide a visual representation of heart activity. While this is a basic design, it demonstrates the fundamental principles of heartbeat measurement using optical techniques. More advanced transducers may employ additional features such as data logging and wireless communication for remote monitoring.

REFERENCES

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