The Digital Stethoscope with the Heart Rate Display: A Review and Its Implications for Learning

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Abstract

A stethoscope is an important medical tool for initial examination of a patient's heartbeat, including detection of arrhythmias (heart rhythm disturbances). This digital stethoscope equipment has input voltage specifications from a power supply of +6 Volt DC and +12 Volt DC, condenser mic as a stethoscope sensor, LED as a heart rate indicator, seven segments as a heartbeat display and timer, earphones as a tool for hearing sounds heartbeat and amplifier circuit. The research was carried out using system operations and supporting blocks to analyze the results of tool testing. The voltage measurements in the tool support block were obtained according to the plan, the start timer circuit voltage was 4.6 VDC (working), the NE555N IC output voltage was 5.8 VDC and the voltage at the transistor collector leg when the condenser mic received a sound signal. A digital stethoscope can display heartbeats for a duration of 15 seconds, so it still requires manual calculations to determine the heartbeat for 1 minute. Based on the test results, this Stethoscope will be an effective learning aid to improve students' medical skills.

Keywords: Stethoscope, Heart Rate, Seven Segment

Abstrak

Stetoskop merupakan alat medis penting untuk pemeriksaan awal detak jantung pasien pasien termasuk deteksi aritmia (gangguan irama jantung). Peralatan stetoskop digital ini memiliki spesifikasi tegangan masukan dari catu daya sebesar +6 Volt DC dan +12 Volt DC, mic condenser sebagai sensor stetoskop, LED sebagai indikator detak jantung, Seven segmen sebagai penampil jumlah detak jantung dan timer, earphone sebagai alat untuk mendengar suara detak jantung dan rangkaian penguat (amplifier). Penelitian dilakukan dengan operasional sistem dan blok penunjang untuk menganalisa hasil pengujian alat. Pengukuran tegangan di blok penunjang alat diperoleh sesuai dengan perencanaan, tegangan rangkaian start timer sebesar 4,6 VDC (bekerja), tegangan output IC NE555N sebesar 5,8 VDC serta tegangan di kaki colector transistor saat mic condenser menerima sinyal suara. Stetoskop digital dapat menampilkan detak jantung untuk durasi 15 detik sehingga masih memerlukan perhitungan secara manual untuk mengetahui detak jantung selama 1 menit. Berdasarkan hasil pengujian Stetoskop ini akan menjadi alat peraga pembelajaran yang efektif untuk meningkatkan keterampilan medis pelajar.

Kata kunci: Stetoskop, Detak Jantung, Seven Segmen.

Introduction

The numerous health issues that exist now are directly correlated with the advancement of medical technology. In the medical field, health equipment development is anticipated to be a solution, particularly in the processes of disease diagnosis (examination) and therapy (treatment). A diagnostic device uses a variety of auxiliary features to accurately and quickly identify health issues. A stethoscope, one of the

diagnostic tools, is a fundamental piece of equipment that has changed over time for medical professionals. The stethoscope is used to examine and diagnose heartbeat and other sounds in the human body. In order to detect abnormalities in heart arrhythmias (heart rhythm disorders) before pursuing further diagnostics, medical professionals, including doctors, midwives, and nurses, must use stethoscopes to check the patient's heartbeat during the initial diagnosis [1]. Studies on stethoscopes that measure heart rate using condenser microphones, earbuds to listen to heartbeat sounds, and an LCD display as an indicator [2].

Stethoscopes have advanced quickly, but occasionally they have drawbacks, particularly if you need to send diagnostic data via the internet. Sometimes, the nation's disparities in network dependability and access make it impossible for stethoscope technology to advance. As a result, it is still important to provide a stethoscope-related solution with capabilities like digital stethoscope technology that do not require internet-based technology. Among them is the digital stethoscope technology that will be examined in this study, which has a seven-segment display that shows the results of a 15-second timer check and heart rate data.

Literature Review

A stethoscope is a doctor's hearing device to hear sounds coming from inside the body, especially the heart and lungs, in additions to joints and partially blocked arteries. Listening to these sounds with a stethoscope is called mediate auscultation, or usually just auscultation. The advantage of a stethoscope is that it allows medical professionals to listen to the sounds produced by the heart and lungs, the stethoscope is used to diagnose or to check heart sounds/beats in the human body. The specifications for stethoscopes in general are as follows [3]:

- Chestpiece is made of stainless steel and Soft PVC;
- Y Tubing is made of soft PVC and Polyurethane;
- Binaural is made of Stainless steel;
- There are spare ear tips and membranes

Figure 1. Stethoscope

The diaphragm vibrates in response to the sound of the body when it is placed on a patient, producing acoustic pressure waves that are then perceived by the listener. The "bell" causes skin vibrations on the patient's body, which in turn cause acoustic pressure waves to travel to the hearing ear [4]. With a sphygmomanometer, the stethoscope functions by transmitting the sound of the arm's blood vessels pulsing when the blood pressure is lowered. The value of the systolic pressure is shown by the pointer when the

pulse is first heard. The pulse detected by the stethoscope will vanish when the air pressure drops further.

The diastolic pressure is the measurement made by the hands after the pulse stops [5]. This tool can identify whether an individual's illness exhibits abnormality symptoms or not. In connection with this, the doctor's diagnosis results are dependent on experience and hearing, which means that human mistake or tool-related factors may lead to a misdiagnosis. Furthermore, the subjective nature of the diagnosis and its unreliability in identifying heart problem symptoms are drawbacks of this approach [1].
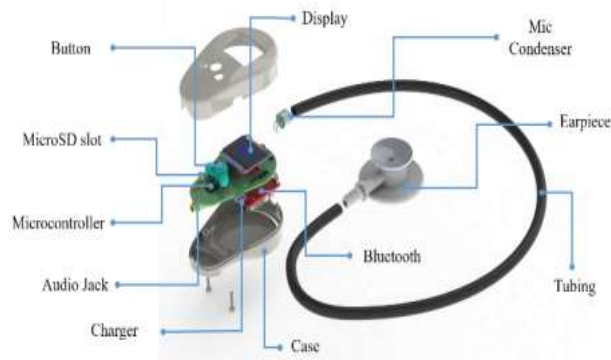

Figure 2. A Digital Stethoscope

Method

This research will review stethoscope equipment that uses a heart rate display using seven segments both in terms of its design and analysis of testing parameters related to this stethoscope equipment. The research steps related to the digital stethoscope equipment are as follows:

- Reference review related to a digital stethoscope equipment;
- Implementation and review of the digital stethoscope circuit using seven segment heart rate display output;
- Analysis of the testing parameters of the digital stethoscope equipment.
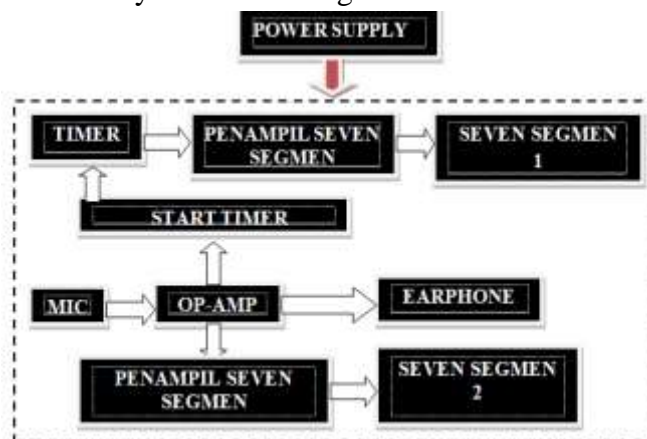
A system block diagram is as follows:

Figure 3. The Digital Stethoscope Block Diagram

Some parts that support the performance of the digital stethoscope equipment system are as follows:

1. The Power Supply block is a voltage source for the system as a whole. This circuit will convert AC voltage from PLN into DC voltage to +6 Volts DC and +12volt DC.
2. Timer block is a timer circuit and tool operation limit.
3. A seven-segment viewer block that doubles as a timer and heart rate viewer circuit. Block 1 of Seven Segment serves as a timer display, while Block 2 of Seven Segment shows the results of the number of heartbeats. In order for the binary numbers to be presented on the seven-segment screen, they must first be translated to decimal numbers.
4. Condenser Mic Block captures sound waves that have weak power and converts them into electrical waves.
5. Start Timer functions as a command for the timer to start.
6. The purpose of the amplifier circuit block is to compare the signal from the condenser mic with the reference voltage (Vref), which is adjusted with a trimpot and amplifies the sound waves that were previously received.
7. The earphone block serves to convert electrical waves into sound waves. The sound source sends a signal to the earphone driver to cause a magnetic field.

Parameter testing related to this digital stethoscope equipment includes:
• Measurement of the output voltage of the power supply circuit.
• Measurement of voltage on the Trigger pin of IC NE555N start timer circuit.
• Measurement on the collector terminal of Transistor BC549B mic condenser amplifier.
• Measurement at the output of Transistor BC557 final amplifier;
• Measurement on the base leg of Transistor BD139 reset circuit

Results and Discussion

The system as a whole receives input voltages of +12 VDC and +6 VDC. While batteries might vary in how much power they supply when they are drained, DC power supplies can deliver electricity in a steady and consistent manner. On the other hand, batteries have a finite capacity and must be changed or recharged, but DC power sources can run continuously as long as they are linked to a power source. For several electrical equipment and experiments, the ability to precisely adjust the voltage and current output is commonly provided by DC power sources [6].

In the long run, DC power supplies are typically less expensive than batteries, particularly for applications that need a steady supply of power. Periodically replacing

batteries is necessary, which raises the system's cost [7]. The following is the full wave rectifier wiring diagram:
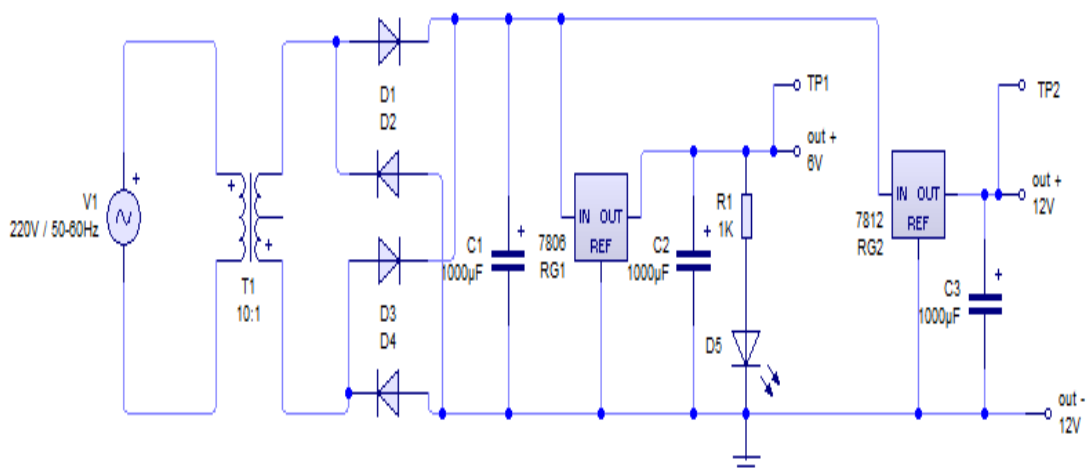

Figure 4. The wiring diagram of the full wave rectifier circuit

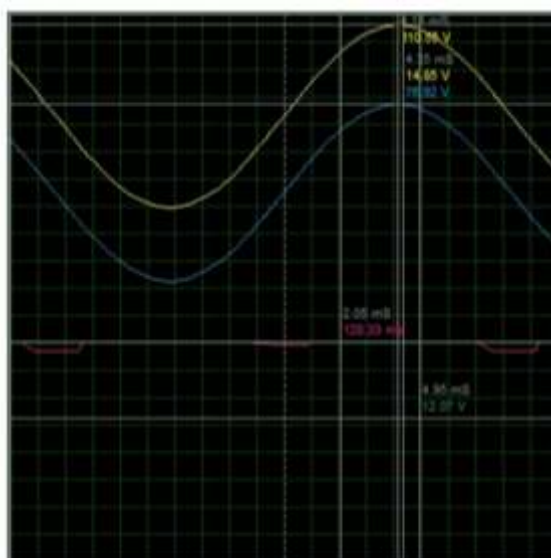The result of full wave rectifier as follows:

Figure 5. The Result of the Full Wave Rectifier Circuit

Analysis based on Parameter testing of digital stethoscope equipment is as follows:

1. Timer circuit

    This circuit makes use of the charge and discharge principles of capacitors and modifies the rate or duration of the capacitor's charging using a variable resistor. The variable resistor's resistance setting determines how quickly the capacitor charges, and vice versa.

2. Viewer and Seven Segment Circuit

    IC CD4026BE is used in the seven-segment counter circuit. The IC CD4026 is typically utilized for performing calculating functions and has a seven-segment decoder available along with a BCD Counter, or counter circuit, that counts from 0 to 10. The switch now has this circuit inserted as a timed start

command. Two (two) spectators of the first and second seven portions are present.

3.   Start Timer Circuit

The IC NE555N, which is frequently used for timers with monostable circuit operations and pulse generators with a stable circuit operations [8], is used in this timer start circuit. When the timer starts, the trigger portion of the device sends commands to IC 555. The transistor is assembled in series with R1 and connected to pin two of the NE555N. When pin two of the IC receives a trigger from the transistor, the NE555N output will issue a high voltage. This process is carried out by the amplifier circuit or operational amplifier upon detection of the heartbeat.

4.   Condenser Mic Circuit

Condenser mic circuitry serves as a sensor to record sound waves that the internal plate will receive. This is the reason the microphone can react to high-frequency or far-off noises. Sound waves are received by the mic condenser circuit, which then transforms the sound frequency into an electrical frequency.

5.   Amplifier circuit

The mic condenser will supply input to the amplifier circuit that uses operational amplifier integrated circuit components. The input will be linked to the LM741N IC's inverting input, and to set the reference voltage (Vref), it will be connected to R1 and VR1 for the non-inverting input. The comparator's output will be high when the voltage provided by the mic condenser exceeds the reference voltage (Vref), and vice versa [9]. In addition, the comparator's output is coupled to a capacitor for filtering, resulting in a purer sound from the earphones. The heart rate counter circuit will display a number on the seven segment to calculate the number of heartbeats based on the number of high voltages given by the comparator, and the comparator IC output also serves as a trigger for the start timer circuit. The start timer circuit will activate when the condenser mic receives sound waves.

6.   Reset circuit

This module's reset circuit disconnects (blocks) the digital pulse that the timer circuit sends to the timer display circuit [10]. Two CD4017B integrated circuits are used in this design. The first IC uses its output on pin five, which is connected to the second IC clock, and the second IC uses its output on pin three. Both ICs have 10 outputs total. Therefore, the output of the first integrated circuit is multiplied by the output of the second IC to obtain the result of fifteen seconds. The second IC's output is then linked to the base of the BD139 transistor as an electronic switch to turn on the relay.

The wiring diagram of the the heart rates display using the seven segment is as follows:
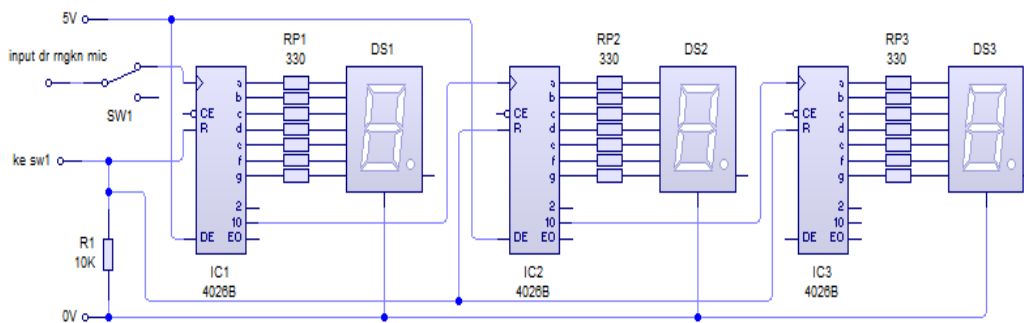
Figure 6. The Wiring Diagram of the Seven Segment Circuit

An output voltage of + 6 VDC and + 12 VDC is derived based on multimeter readings of the voltage of the AN7806 regulator and AN7812 power supply regulator. Additionally, a value of 4.6 VDC connected to the trigger voltage on the transistor's base leg was obtained from the multimeter reading of the voltage on the Trigger pin IC NE555N start timer circuit. When the timer is on, the output voltage of the NE555N IC is 5.8 VDC; when the microphone receives a sound signal, it measures 1.3 VDC at the collector leg of the BC549 transistor; when it does not, it measures 372 mVDC. Measurement of the Base voltage of transistor BD139 to show the reset circuit is working at 2.3 VDC and when the reset circuit is not working at 0 VDC.

The voltage measurements demonstrate that the digital stethoscope equipment system's supporting blocks are operating rather well, and the seven-segment display can display the heart rate for up to 15 seconds based on the equipment's settings. Nevertheless, due to the equipment's restrictions, the heart rate can only be displayed for 15 seconds. To manually calculate the expected heart rate for 1 (one) minute, multiply the acquired time rate by 4. This slightly reduces the accuracy of the results because it is possible that the next 15 seconds will produce fewer or more heart rate values than when the stethoscope is used.

This device is not impacted by internet connectivity or network since it does not require internet-based heart rate data transfer. Another factor is that the seven-segment display uses a type of display that is comparatively less expensive than digital LCDs, which are backed by great capabilities. In addition, if the seven-segment display component is damaged, the replacement parts are also less expensive. If the equipment needs to be maintained and serviced, this is a benefit [11]. But this apparatus can be improved to measure heart rate over a longer period of time and, if feasible, incorporate additional functions. In addition, to confirm the reliability of this digital stethoscope equipment, the circuit for each block must be tested using other measuring tools, such as an oscilloscope. One other thing to note is that this apparatus is larger than a standard stethoscope due to its multiple pieces, one of which is the power supply block, which is manually assembled to provide power to the apparatus [12].

Conclusion

The digital stethoscope can be used as a heart rate sound recorder or detector. Additional circuit blocks, including condenser microphone, start timer, amplifier circuit, earphone, seven segment circuit, and reset circuit, support this apparatus. The benefits of this digital stethoscope include the ability to show the number of heartbeats through a

seven-segment display, a timer that sets a limit on the tool's operation, and a start timer command that initiates the tool's use. This digital stethoscope's drawback is that manual multiplication is required to get the heart rate readings in a minute. In order to present the results on a website or telemedicine application, it is also necessary to design features and integrate the internet of things (IoT) approach. Furthermore, medical students can benefit greatly from using a digital stethoscope as an instructional tool.

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