Wearable Electronics in Health Care Applications and Enery Harvesting

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ABSTRACT

This research gives a comparative analysis of a link between the magnitude of the received voltage and the received power using three different antennas. The antennas were used to receive radio waves. Conventional etching methods as well as contemporary inkjet printing methods were used during the fabrication of the antennas, which were created with the intention of operating in two separate frequency bands. The relay will then detect the overlaid signal coming from the source, and it will send the destination the signal when it has been decoded. It is possible to compute closed-form outage probability as well as ergodic rates at both the relay and the destination. This issue has been shown to be NP-Complete from a mathematical perspective, and as a result, it cannot be solved with simple effort. In order to achieve this goal, we present a series of approximation algorithms that have been shown to perform well from the point of view of constructing a minimum dominating set (DS). These algorithms combine energy-saving strategies with energy-harvesting strategies in order to extend the lifetime of the network while still meeting the real-time requirements of EH-WBANs. To be more specific, we first provide a centralised method that is able to create DSs with the smallest possible size and find the greatest possible number of DSs. Because the rectifier circuit contains a Schottky diode, which is a non-linear device, the input impedance and echo characteristics will change dramatically depending on the load size and input power. As a result, it has been difficult to design a multi-band high efficiency rectifier with a high dynamic range. As a result, an enhanced impedance compression approach has been presented as a means of reducing the impedance range of nonlinear diodes that have a large dynamic range.

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INTRODUCTION

The increased incorporation of electrical and electronic devices into one's day-to-day activities has had a significant positive impact on the overall quality of one's life. As compared to the past, the amount of time and energy necessary to complete a job while retaining the same level of efficiency is much less. The use of sensing systems has seen a meteoric rise in the last several years particularly in the context of the electronic industries. These sensing systems have been built and validated both in a controlled laboratory environment and in real-world scenarios. This would have a significant influence on the health care system, both for populations at high risk and for the entire community. For instance, self-powered, maintenance-free, remote patient monitoring devices might cut down on the amount of time patients spend in the hospital, which in turn would result in a considerable reduction in overall healthcare expenses.

One of the primary goals of ongoing research efforts is to do away with the need for supplemental electrical power or for batteries that can be recharged. Another area of study that is particularly active is the modification of wearable devices such that they are able to extract information from bodily fluids. This would give real-time biological information that might be potentially beneficial for medical diagnoses. Wearable devices having these two qualities would be able to gather continuous biological data for diagnostic and prognostic reasons, and they would be able to function without requiring any maintenance month after month. The purpose of this paper is to discuss and classify all of the different types of energy harvesting that are used in wireless telemetry bio-devices and biomedical implanted devices. This will allow for the development of appropriate solutions to the challenges and problems that are currently being faced.

Users expect wearable gadgets, which are becoming more widespread, to offer increasingly sophisticated functionality. Taking this into consideration, there are two significant ongoing thrusts that serve as the foundation for this mini-paper. It has been shown that collecting energy from human or natural sources may be a viable alternative. Several researchers have discovered potential remedies that might be helpful and included in a paper study. Therefore, a number of studies have provided papers that only focus on one type of energy harvesting for biomedical implanted devices, such as kinetic energy from body motion, vibration, piezoelectric material, or wireless transfer energy, or using thermal and solar energy from the environment sources. These papers can be found in several different places online. In offered an excellent analysis of a power harvester that used the motion of the human body to power biomedical sensor nodes. This study offers a comprehensive analysis of the research that has been conducted about the topic of energy harvesting for biomedical implants. The majority of implanted devices get their power through an inductive connection that is driven by radio frequency. The rise in temperature that occurs as a result of heat dissipation in a tissue also indicates an increase in the electromagnetic field density, which is harmful to biological tissues. The present status of research and development of wireless sensors for medical applications is discussed in this paper article that we have written. This presentation covers the most current advancements that have been made in terms of wearable, epidermal, and implantable devices. In addition, we provide an expanded discussion on both the obstacles and potential future prospects associated with the use of wireless sensors in the healthcare industry. In this study, we explore both new passive and active wideband wearable antennas that may be used for applications that include energy harvesting.

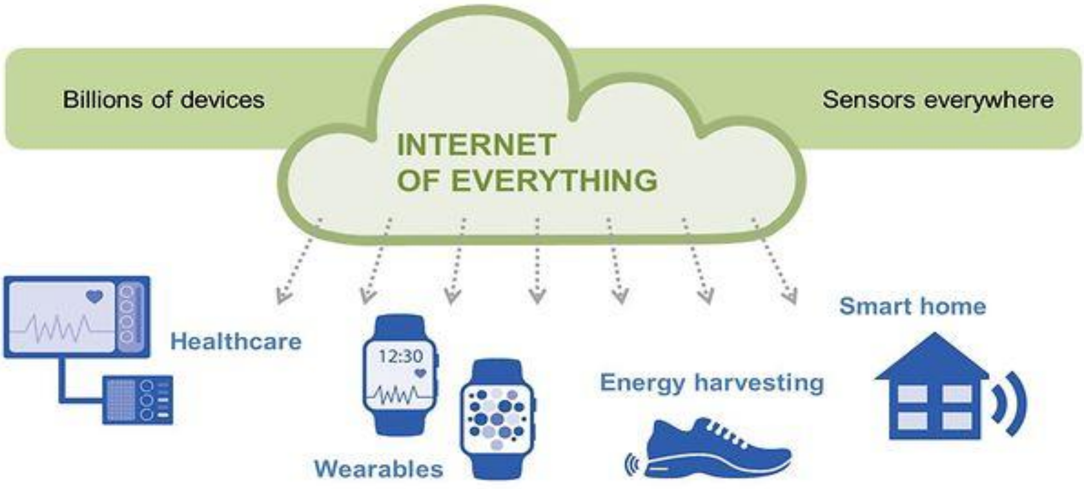

Figure 1 Data gathering

In order to increase the effectiveness of the system, amplifiers could be attached to the feed line of the wearable antenna. Batteries that are small and lightweight are used to provide the active components of energy harvesting systems with the bias voltage. For mobility and efficiency, any wireless device needs an energy source that is small, inexpensive, and lightweight. This combination of features is essential. Batteries that only have a limited capacity will run out of juice far before the system has completed its useful life. Hence, power supply based on a modulated carrier are rectified in order to power the implant via wireless penetrations through the skin. The patient's mobility, quality of life, and sense of safety may all be improved thanks to this wireless technology. In this line of study, the impacts of the human body on the electrical performance of wearable electronics are being examined. For use in wearable energy harvesting applications, brand new wide band slot and notch antennas were designed and built. Printed slot and notch antennas are not only economical to produce but also very space-efficient. In addition, for active slot and notch antennas, it is possible to construct a small low-cost harvesting system by combining the active components with the radiating elements on the same substrate. This would make the system more compact. Wearable printed active antennas for applications involving the harvesting of energy are presented in the literature rather seldom. In point of fact, implanted biosensors are required for some applications, such as deep brain stimulation (DBS), since this is the only method to get access to the relevant bioinformation. As compared to non-invasive biosensors, implanted biosensors are subject to much more stringent limits and limitations in terms of size, power, biocompatibility, and longevity.

This makes the creation of implantable biosensors an extremely difficult task. A number of printed antennas with the purpose of energy harvesting applications were discussed through. Wearable communication and medical devices often make use of small printed antennas. Investigations on the electrical characteristics of human tissues may be found respectively.

These silicon sensors have been put to use in a variety of applications, both in the industrial and environmental sectors. As a single biosensor is produced by closely combining a sensing device with its corresponding readout circuitry, analogy-to-digital converter, digital signal processing, communication, and powering devices. This results in the sensor being able to detect and analyse a single biomarker. There are already medical applications that prefer implanted biosensors because of the benefits afforded by direct access to an analyst.

The decade of the saw the development and widespread use of semiconducting sensors, which led to the popularisation of sensing systems. For the formation of the substrates of these sensors, single-crystal silicon has been a notable material that has been given a high preference for the most part. Single-crystal silicon sensors have a number of benefits, including a high level of stability and repeatability in their responses, a high signal-to-noise ratio, the capacity to perform in difficult environments, and the ease with which they may be customised. The microelectromechanical system (MEMS) fabrication process was used in the production of these silicon sensors. Improved reproductivity, high precision, sensitivity, and selectivity are some of the characteristics that are associated with the MEMS method. In addition, the frequency deviation ratio was found to be equal to 0.123 due to the fact that the first sideband had a height that was 24.2 dB lower than that of the centre band.

LITERATURE PAPER

G. You, L. Zhu, and J (2019): The creation of gadgets that can be surgically implanted is very necessary because of the direct impact they will have on the lives and security of all people. This article discusses the current problems and difficulties that are associated with all of the many ways that energy may be harvested for implanted biomedical devices. We analyse the benefits, drawbacks, and likely directions that each approach will go in the future. The idea of generating power for implanted devices by the collection of energy from natural sources and the motion of the human body has recently received new significance. The collection of kinetic, electromagnetic, thermal, and infrared radiant energy are the topics of discussion in this overview. The usual uses of these systems for energy harvesting are used to show the current problems and difficulties associated with using them. Also, a discussion on the development of research on implanted devices is included, along with some suggestions. It is anticipated that the findings of this analysis would encourage an increase in research activities directed towards the development of battery-less implanted devices with decreased over hole size, low power, high efficiency, high data rate, and enhanced reliability and practicality. According to the most recent research, we feel that the inductive coupling connection is the most appropriate technology that may be utilised to power devices that do not have batteries. As a result, MATLAB was used in this investigation to verify that the inductive coupling approach has a high-power efficiency based on the values that were provided. Battery-free implantable and portable medical devices are likely to become a reality in the not-too-distant future because to ongoing research and technological advancements.

M. Shiomi (2019): Wearable technology provides a significant amount of untapped potential for the development of patient-centred medical applications. Our way of life is altered as a result of the information it provides about our physical activities, the monitoring of our sleep, and the rhythms of our pulse. In this article, we discuss a novel approach to oral healthcare that notifies consumers when it is time to brush their teeth and focuses on the concept of prevention rather than treatment. It is built on an accelerometer that is worn on the wrist and has two components: first, a computationally lightweight feature extractor, and second, a strong feed-forward neural network to identify the activity of cleaning teeth. The performance of the model is evaluated using the standard performance metric known as F1 -score (i.e., 98%), which demonstrates the applicability of the model to a situation that occurs in the actual world. The trained model may take up residence inside the smartwatch and be worn on the wrist as a wearable device. If the user missed the toothbrush action, it would send tailored alerts to the user's device. In addition, it reminds users to replace their toothbrush every three months, which helps reduce the mental load associated with this task. Clinical Significance: This research may assist patients in maintaining their dental health by making use of smartwatches as a wearable technology.

M. Neumayer (2020): A charge-coupled device (also known as a CCD) structure was used in this work to create a wearable, flexible, and extremely sensitive pH sensor. The Nernst theory predicts a sensitivity of 59 millivolts per pH at room temperature (R.T.), however a multi-cycle charge transfer and build-up that is dependent on the pH value may achieve a greater level of sensitivity. The semiconductor junction presents a challenge when attempting to create a CCD structure on a flexible film because of problems with the thermal budget associated with doping injection into semiconductor films. The Schottky junction, which is controlled by an external gate bias, is presented as a solution for this problem. A successful demonstration of a flexible CCD-based pH sensor was achieved via the optimisation of both the structure and the manufacturing process. A real-time monitoring of sweat pH was carried out as the first proof-of-concept by connecting the device to an arm. This was done in addition to the investigation of the device's essential properties. According to the findings, a flexible pH sensor such as this one might be useful for extracting biological information from sweat.

T. Bretterklieber (2020): People's expectations of the degree of care they should get from medical professionals continue to rise in tandem with the progression of medical technology. Individuals' day-to-day personal health information is of utmost importance for the real-time monitoring of their vital signs and health issues, which, in turn, may assist individuals in better comprehending their physical states and in recognising symptoms at an earlier stage. A wearable mobile user health information-aware system was built by papering a plethora of relevant literature in the disciplines of WIT120, sensing, and communication. After this, the application possibilities and future development prospects of the system were rigorously assessed. The term "magnetic energy harvesting" refers to a process that may be used to collect electrical power from the alternating current that flows through the main winding. It is an appropriate method of energy harvesting for the measuring equipment that are installed on overhead high voltage wires (OHL). For OHL applications that have a high-power consumption, other factors, like as the weight of the system, need to be taken into consideration as well. In addition, the large dynamic range of the main current is an essential element to take into consideration. The performance of the transformer that is used in magnetic energy harvesting devices is analysed in this body of work. In this article, a model of the transformer is described that is appropriate for the high current range required for OHL applications. In order to verify the theoretical predictions regarding the obtainable power density, comparative measurement experiments are given.

A. Khan (2022): Energy harvesting in underwater acoustic wireless sensor networks (UAWSNs) either extends the lifespan of a network by increasing the amount of battery power available in sensor nodes or assures that nodes can function without the use of batteries. This, in turn, leads to a sustainable and dependable functioning of the network that has been implemented for a variety of activities that take place underwater. This paper presents an overview of the several methods that may be used to gather energy for UAWSNs. Our research is distinct from any other that has been done on the topic of extracting energy from the ocean because it makes use of cutting-edge methods that have been developed in the last ten years. It examines each method of harvesting in terms of its fundamental principle, the advantages and disadvantages of that principle, and the total amount of electricity that may be gathered (energy). The presentation of the benefits ultimately leads to the selection of the most appropriate strategy for the most appropriate underwater applications. The shortcomings of the approaches being discussed provide a glimpse into how such approaches may be enhanced and improved in the future. Additionally, the harvested techniques are separated into various categories based on the energy harvesting mechanism that is involved.

L. Costanzo (2022): These categories are then compared based on the maximum and minimum amount of power harvested, which assists in the selection of the appropriate category in consideration of the power budget of an underwater network prior to deployment. An energy harvester that is worn on a backpack is designed to convert the mechanical energy that is created when a person walks into electrical energy. This oscillation of the backpack is caused by human walking. It has the potential to be a highly attractive option for delivering portable devices, particularly in situations involving military applications, outdoor sports, and disaster aid. In this article, a backpack energy harvesting system that can self-adapt its operating condition to maximise the extracted power while simultaneously supplying a dc load is presented and studied, both analytically and experimentally. The goal of the system is to extract the maximum amount of power possible from the environment while simultaneously supplying a dc load. It is based on a mechanical motion rectifier that transforms the up-and-down oscillation of the backpack into a unidirectional spin of a dc generator. This allows the backpack to be used to generate electricity. In order to get the most power out of the generator, there is a power electronic interface that uses a maximum power point tracking technique.

METHODOLOGY

The use of energy-harvesting nodes in wireless communication is a strategy that shows great promise for achieving the greatest possible level of energy efficiency. Nevertheless, in order to collect the energy together with the information flow, certain signal processing techniques and associated architectural frameworks are required. Implantable biomedical devices may be categorised into two categories. The first category contains equipment driven by energy gathered from the human body and covered by secondary forest. The second approach makes use of structures that are fuelled by energy extracted from the surrounding environment and are cloaked in secondary forest. Kinetic and thermal energy may be generated as a result of human actions. There is a wide range of power produced by the body depending on the activity. A total of around 81 mW of power may be generated when one is sleeping, but sprint walking and motion generate 1630 mW. The temperature of the human body can be maintained regardless of the temperature of the surrounding environment. Buck converter devices are in great demand in various bio medical applications because of their extremely strong conversion efficiency, quicker transient response, fewer components, and simple design.

The energy harvester, the energy storage element and the power management circuitry, the sensor, an ultra-low power microprocessor, and a low power transceiver are the five essential components that make up an energy harvesting system. When the energy harvester is not actively collecting energy, such as during the night for a solar panel system, the energy storage component is necessary in order to store the energy that has been accumulated so that it may be used later. The component that stores the energy has to be rechargeable. Since it connects with the harvester, charges the storage element, and supplies power to the system, the power management is an extremely important component. The microcontroller is responsible for recording and processing the data collected by the sensors.

In the last step, the transceiver sends the data to a centralised host. By drawing power from the body rather of relying on batteries, implanted medical devices have a longer lifespan and do not need frequent battery changes or charging. Heat and motion are the two distinct ways by which energy is released from the human body. These systems, such as breathing and body heat, release energy continually and automatically. This kind of energy source, known as involuntary, does not ask for any form of conscious activity on the part of the user. The human being is the source of energy for voluntary energy sources such as walking and leaping, which may provide a greater quantity of energy than involuntary activities such as other spontaneous activities. The human body is a source of energy that may be gathered and used to power biomedical equipment such as body sensor networks, implants, and even wireless sensor nodes. These technologies can be powered by the human body. This energy may then be harvested by the energy harvesting system to power biomedical implants and body sensor networks. The energy harvesting system recovers energy that is intermittently accessible from various ambient energy sources. Due to the fact that there is access to a small amount of ambient energy, it will be an appealing choice for low-power applications such as mobile phones, MP3 players, as well as health monitoring and integrated bio wearable implants. The amount of electricity that is typically used by a mobile phone might vary anywhere from 1 watt to 10 microwatts. While each of these characteristics plays an important part in the human body, the on-body sensors that are used to detect them each take a somewhat different approach in terms of the method by which they do their job.

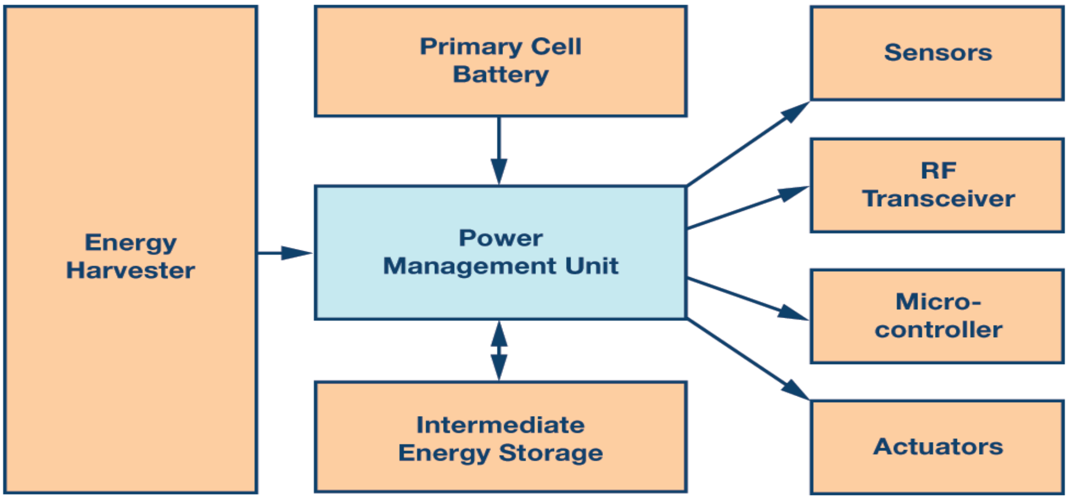

Figure 2 Energy harvesting

The technique of creating electrical energy from environmental energy sources is referred to as energy harvesting (EH), sometimes known as energy scavenging. There are many different types of alternative energy sources, including thermal energy, solar energy, and kinetic energy. It is possible to utilise the energy generated from these sources to either charge the batteries in portable devices or replace them entirely. This section displays some of the products available for the critical physiological ions and signals in the body. For the purpose of managing diabetes, digital glucose metres are the gold standard, and several businesses, such as Life Scan, Hoffmann-La Roche, Medtronic, and others, have established themselves as the industry leaders. The first category employing on-body sensors is the major way of detecting physiological signals from the body. The detection of blood glucose, physiological signals like the pulse and breathing, and body movements are all examples of the types of information that may be gathered by on-body wearable sensors. This eliminated the need for any kind of previous skin preparation with wet gel. Screen printing, in which silver flake ink was used, was the method that was used in the formation of the sensors. This monitoring may help check that treatment standards are being followed and may also aid in enhancing the benefits of pharmacological therapy. In addition to the sensors that were produced and analysed in a regulated setting, a number of prototypes have been approved and are now being marketed on the market. These models have been used by a great number of human cultures in order to address their peculiarities. Interoperability results in data having an unprecedented degree of portability. The second category is concerned with the identification of significant physiological parameters of the human body.

Wearable sensors with a cheap cost and high efficiency were used to pick up on certain signals, including the heartbeat and the breathing rate. This section discusses the performance of many of the efficient and flexible sensors that have been used as dry electrodes in the past. It was stated that work has been done on the manufacture of printable and flexible dry electrocardiogram (ECG) electrodes. Experiments were able to be carried out more effectively by using these printable, flexible, and wearable dry electrodes for the purpose of detecting ECG signals. For instance, nc is 1.6% at ambient temperature when the temperature gradient is 5K, while the most effective thermoelectric materials may attain maximum Carnot efficiency values of up to around 17% for very minor temperature gradients. Interoperability in the healthcare industry refers to the degree to which different computer systems and medical equipment can read patient data and provide it in a format that is simple to comprehend.

This means that information will be able to be exchanged among hospitals, pharmacies, laboratories, physicians, and patients, independent of which vendor is employed to perform the data exchange. The sharing of information across hospitals is often disorganised and inefficient, which is one of the primary motivations for the development of interoperability standards. This approach was used in a prior investigation [31] to power a quartz wristwatch. Thermoelectric harvester technologies are potential approaches to create electricity from temperature changes in the environment (See beck effect). This amount of power is enough for bio-implantable devices such as cochlear hearing replacements, implanted nerve and muscle stimulators, and wireless patient diagnostics.

EXPERIMENT RESULT

A large number of thermocouples, coupled electrically in series with high thermal resistance and thermally in parallel to create a thermopile, are included inside thermoelectric generator. Its structure is perfect for gathering energy from the body and dissipating heat. Nevertheless, the proportion of energy that may be collected by the generator is limited by the Carnot efficiency formula, which reads [(Th-Tc)/Th].The first form of motion utilises relative motion in which the generating system remains stationary, and the second type of motion makes use of rigid body motion in which the inertia force of the weight is put on the generator. The most fundamental configuration of these generators. The first form of motion utilises relative motion in which the generating system remains stationary, and the second type of motion makes use of rigid body motion in which the inertia force of the weight is put on the generator. The most fundamental configuration of these generators.

Figure 3 Implanted biomedical equipment

The research on both kinds by employing bicycle generators, mobile phones, and radios. He came to the conclusion that the second type is more susceptible to vibratory motions than it is to steady movements because it employs inertia, which may be defined as the resistance to movement. Electromagnetic transducers may produce flux variations by rotating the circuit along an axis, therefore altering the surface associated with the magnetic flux. Even when the temperature of the environment is very low, this quality enables the metabolic processes that are essential for the creation of energy to continue. As a result, there are two different kinds of energy created. The actions of the human body provide a potentially useful source of power for implanted biomedical equipment. Energy harvesting systems, whether designed for people or the environment, may easily access kinetic energy as a source of readily accessible energy. This section provides a concise explanation of the fundamentals underlying the operation of various types of transducers that can extract electrical energy from kinetic energy. These transducers include piezoelectric, magnetic induction generator, and electrostatic transduction methods, as well as the following. In the brothers Jacque and Pierre Curie made the discovery that was the precursor to the piezoelectric effect. The purpose of this article is to provide a thorough summary of recent research contributions on wireless energy harvesting strategies, algorithms, architectural designs, performance measurements, and application areas that are appropriate for future wireless networks. The numerical results support the findings of the analytical research and demonstrate that the EH-FD-NOMA achieves a higher level of performance than its competitors. The difficulties inherent in energy collecting and in UAWSNs are broken down here for the purpose of illuminating these obstacles and illustrating how they may be overcome to increase the amount of energy that can be collected. In conclusion, some suggestions have been made for future lines of inquiry regarding research directions. This interface regulates the voltage that is output by the generator.

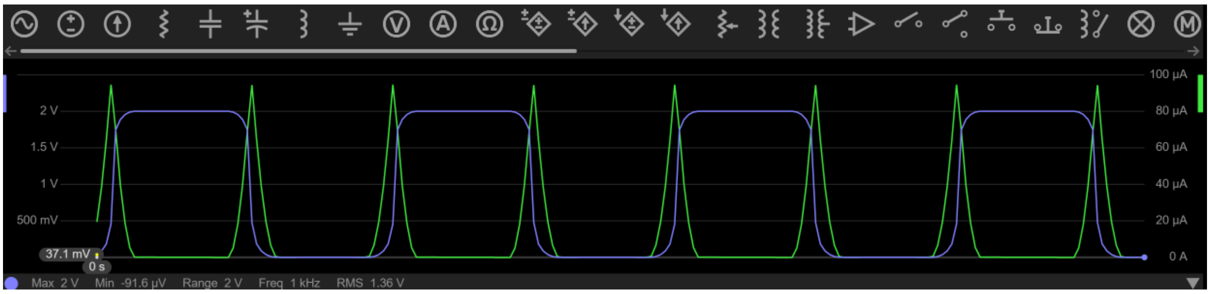

Figure 3 Energy monitoring in implantable medical devices

The results of the experiments prove that the proposed system is able to perform tracking, and they demonstrate the advantages of this system in comparison to other wearable energy harvesting systems that have been published in the academic literature. Because of its connection to the state of human health, the worldwide market for implanted medical devices is sizeable and expanding. In addition, it has developed into a profitable industry that is essential to the economy. For instance, nearly 600,000 people all around the globe had pacemaker implantation, while there were already 3 million people using the devices. In addition to pacemakers and defibrillators, implantable medical devices now include pumps for the management of diabetes and pain, neurostimulators for the treatment of pain, and implantable medical devices that are similar to pacemakers and are used to electrically stimulate the stomach, throat, and other muscles. The Internet of Things (IoT) may provide medical professionals the information they need to make better informed judgements regarding a specific therapy based on the data they have acquired from patients. It is also possible for it to lower the expenses of healthcare spent on payments for extra visits to the healthcare providers, as well as the price of on-site healthcare services. As medical professionals are able to diagnose patients from a distance, the delivery of healthcare will become more efficient and responsive. For instance, Internet of Things-enabled hygiene gadgets may be triggered in the event that a patient's overall health is deteriorating. The Internet of Things has the potential to make medical diagnosis much easier. IoT healthcare solutions have the potential to assist hospitals in lowering the expenses associated with patient care by enabling people to independently diagnose their own health concerns. The investigation and monitoring of fitness data by means of wearable trackers has been beneficial to the treatment of heart disease. With the use of this technology, doctors are able to keep tabs on their patients' dietary habits, track their calorie consumption, and keep track of their daily activities. They can also instantaneously put their patients' data in their electronic medical records and in internet databases. These tools may facilitate remote collaboration across healthcare institutions, which can streamline and enhance several aspects of patient care. Intelligent medical treatment By remotely collecting and analysing patient data, gadgets connected to the internet of things may assist medical professionals in improving their efficiency

CONCLUSION

The purpose of this research was to offer an overview of the recent advancements that have been made in the use of wireless sensors and body area networks for medical applications, with a focus on wearable, epidermal, and implantable technology. We addressed the essential needs for the design of such sensors, which included making them wearable, ensuring their safety and interoperability, and ensuring that they can reliably communicate with one another. In addition, the study addressed potential future research topics connected with wireless networks for healthcare applications and explored research issues that are involved with providing power to different medical sensors that are used in healthcare applications. It has been brought to everyone's attention that the sensing prototypes, when combined with wireless communication protocols, can create the whole wearable sensing system. The study that was conducted in relation to the information that was detected and processed was then explained with regard to data analytics, Internet of Things-enabled devices, cloud computing, and security concerns. In conclusion, a number of the problems that are associated with the existing wearable devices and the difficulties of energy harvesting have been discussed. Wearable wireless communication systems and medical sensors and systems are two potential applications for the energy harvesting system that has been presented. The rapid development of wireless sensor networks, which has been fuelled by recent developments in both hardware and software, is expected to result in substantial gains in healthcare practise and research.

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