SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

A Comparative Review on Acoustic and Inductive Power Transfer

Muhammad Izzul Syafiq Faiz[1], Md Rabiul Awal[1,*], Md Rubel Basar[2], Nurul Adilah Latiff[1,] Muhammad Syarifuddin Yahya[1], Shakir Saat[3]

[1] Dept. of Electronic and Instrumentation, Faculty of Ocean Engineering, Technology and Informatics, Universiti Malaysia Terengganu (UMT), 21030 Kuala Nerus, Terengganu, Malaysia
[2] Dept. of Information and Communication Engineering (ICE), Faculty of Computer and Communication Engineering (ECE), Bangladesh Army University of Engineering & Technology, 6431, Qadirabad Cantonment, Natore-6431, Bangladesh
[3] Centre of Telecommunication Research and Innovation, Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia

ARTICLE INFO

Article history:
Received 20 June 2023
Received in revised form 8 November 2023
Accepted 28 February 2024
Available online 25 April 2024

ABSTRACT

Wireless Power Transmission (WPT) has emerged as a prominent player in numerous industries recently. It is already established in wireless charging for electric cars and electronic gadgets. However, it has promising applications in medical implants and imaging as well. Among several proposals, Inductive Power Transfer (IPT) and Acoustic Power Transfer (APT) have shown a major impact on this area of interest. This paper presents a comparison between IPT and APT for wireless power transmission (WPT). Most recent proposals are reported, and several key parameters are considered to evaluate the proposals. That includes operating frequencies, separations gaps, powers and power transmission efficiencies and experimental validity. It is found from the review that; a maximum 818 kW of power is transmitted using IPT for electric vehicles. However, APT can transmit 1.068 kW and 5.4 W through wall and in-body medium (implants). Over 90% efficiencies are found for both APT and IPT. In fact, power transfer with 95.66% efficiency over a 6 cm distance of 23.4 W is achieved for APT and 95.6% with 20 cm separation gaps is achieved for IPT for 20 kW power. A wide range of frequencies are applied for both APT and IPT. However, lower frequencies are mostly suitable for high power, more specifically less than MHz ranges. Naturally, lower frequencies are preferable for low power high efficiencies.

Keywords:
Acoustic Power Transfer; Inductive Power Transfer; Electric Vehicles

1. Introduction

1.1 Acoustic Power Transfer

Wireless power transmission (WPT) is widely employed in a variety of applications, including implantable medical devices (IMD), electrical vehicles (EV), and data and power delivery through metal walls as reported by many authors [1–4]. Nikola Tesla demonstrated a capacitive coupling power device in 1921 to turn on an electric bulb wirelessly sandwiched between two capacitor plates [5]. It is the first step towards wireless power transfer. Tesla predicted the WPT's technological progress in 1914. He demonstrated that WPT is a viable and elegant technique to power future

* *Corresponding author.*
E-mail address: rabiul.awal@umt.edu.my

https://doi.org/10.37934/araset.44.1.188224

wireless power. Unfortunately, the researchers were unable to disclose Tesla's progress until the 1980s [6,7]. WPTs are now viewed as part of a potential future-oriented field [8]. To energy is transferred, this approach relies on electromagnetic fields for the Inductive Power Transfer (IPT) method and wave propagation for the AET method. Following that, Acoustic Energy Transfer (AET) has emerged as one of the most successful wireless power transmission techniques among all other techniques used, including inductive, capacitive, and microwave-based systems [9]. Vibration-induced acoustic wave propagation from a piezoelectric transmitter that generates an elastic vibration-induced electrical response in a piezoelectric receiving element is the underlying mechanism of AET (Bhargava & Shahab, 2020). Recent study has demonstrated the ability of acoustic waves to stimulate and convey information within the human body [10]. The device will be implanted within human tissue to monitor the patient's condition. The frequency used is high enough to convey data while remaining secure. By utilising acoustic waves' ability to penetrate further into bodily tissue without being severely weakened [11]. APT is seeing increasing use in biomedical technology [12], data transfer, and through-wall transmission [13]. Current research has looked into the use of APT to offer biomedical implants with minimal electrical power in order to reduce battery replacement concerns and maintenance expenses for devices in inaccessible areas [14,15]. This procedure will not necessitate any specific procedures. It is regarded as safe and affordable. Ultrasound is another method for powering implantable microdevices [16]. Other advantages include omnidirectionality, which allows it to transmit and receive messages from all directions. Despite the regular arrangement, the waves were transported at an angle of about 180°. The technology also generated higher output or efficiency over longer distances and with smaller instrument sizes. In circumstances where the transducer size to wavelength ratio is significantly bigger than the working distance, near-field ultrasound is typically utilised, in which the initial ultrasonic beam is not really omnidirectional, but a homogeneous medium is generated by wave reflection [17]. Higher efficiencies have been examined theoretically in some circumstances by [18]. Their study indicates that within short distances (less than 1cm), inductive power is more effective, but between 1 and 10 cm, the ultrasonic method is more efficient.

1.2 Inductive Power Transfer

Per year, forest fires cause more deaths than any other natural disaster in the United States, Australia, and Indonesia [19]. Recent technical advances have enabled the development of high-performance micro aerial vehicles (MAVs), such as fixed-wing aircraft, flapping-wing aircraft, coaxial helicopters, tri-rotor helicopters, and quadcopters [20]. This MAV can be utilised to track and report the circumstance. In earlier studies, researchers used unmanned aerial vehicles (UAVs) in conjunction with data telemetry and thermal infrared imaging equipment to collect high-resolution video data for tracking forest fires. These vehicles are highly suited for uses using autonomous sensor networks to remotely track, manage, and seek for environmental dangers in hostile human environments. Due to the average battery life of an MAV dipping between 10 and 20 minutes, limited flight times are among the main obstacles for MAV innovation [21,22]. Eventually, a study for flight time advancement up to approximately 30 minutes has been carried out by [23]. WPT via magnetic resonance coupling is one of the potential approaches for supplying power to MAVs to overcome restrictions.

Inductive power transfer (IPT) technology, using a relatively large air gap, can transport power from a high-frequency power source to loads via magnetic coupling without direct engagement [24–27]. This efficient approach was created swiftly and has previously been employed in a variety of current applications such as wireless charging, underwater power supplies, and electric automobiles

[28–30]. Electric vehicles are classified into two types: large vehicles such as buses and small vehicles such as electric bicycles [2,31]. As per recorded, there were more than 200,000,000 electric bicycles were used in China until the end of 2015. Additionally, the electric bicycle is identical to a regular bicycle. People began to adopt electric bicycles because they go faster than traditional bicycles and use less human force. The distinction is that the electric bicycle has an electric motor whose role is to store electrical energy that may be used to drive the bicycle. As technology advances, nickel cadmium, nickel metal hydride, and lithium-ion batteries are becoming more popular as the most optimal type of battery since they are smaller and have a higher energy storage density than traditional lead-acid batteries. Electric bicycle technology has advanced over the years. The system is improving and will give a better experience for users. The charging procedure is problematic for consumers and can be enhanced by Inductive Power Transfer (IPT) technology. IPT systems can deliver power even without physical interaction. Furthermore, when the battery for the electric bicycle becomes low, the rider can recharge it in a safe location. For example, an IPT system is safe in a moist environment. Furthermore, IPT systems are quite valuable and can be used in a variety of applications such as material handling [32,33], lighting [34], battery charging [35,36] and biomedical implant [37,38].

2. APT Technology and IPT Technology

Acoustic energy transmission relies on wave propagation to transfer energy from the transmitter to the receiver. The advantage of APT over many other approaches is the use of ultrasonic waves at lower frequencies, which allows for smaller receiver and transmitter sizes, lower amplitude, higher penetration range, no electromagnetic delay, strong directionality, and biological protection [39,40]. Many researchers have investigated the use of APT to provide low electrical power to biomedical implants to remove battery replacement problems and minimize the risk for devices in unreachable areas [14,15,41]. An ultrasonically powered implantable micro-oxygen generator (IMOG) capable of in situ tumor oxygenation via water electrolysis, an ultra-low-power 2.45-GHz complementary metal-oxide-semiconductor (CMOS) transmitter for cochlear implants and a wireless programmable electronic framework for implantable chronic monitoring of fluorescent-based autonomous biosensors are presented in the mentioned works [14,15,41].

Inductive Power Transfer (IPT) is a wireless power transfer (WPT) technique that transfers electrical energy between two objects by using electromagnetic fields. The method works by using two wire coils, the primary and the secondary, that are positioned close to one another. The primary coil is coupled to an alternating current power source, which produces an alternating magnetic field. This magnetic field causes an electrical current to flow through the secondary coil, which is then utilized to power a device or charge a battery [27]. There seems to be a strong demand in recent times for wireless sensors to assist structural health monitoring (SHM) and industrial applications especially for metal walls. Normally, wires were used to connect the metal walls. Therefore, drilling holes for feed wires decreases the integrity of the system and creates functional problems, such as the risk of exposure of hazardous materials, failure of pressure or vacuum. In summary, IPT through metal walls is difficult but not impossible. For optimal transfer efficiency, materials, frequencies, and coil layouts must be carefully considered [42–44].

Moreover, a dual band coaxial fed microstrip antenna design was presented in this paper [45]. A metallic U-shaped patch is produced on the substrate, and a slot is etched int the ground. The diameter of the antenna is 36mm x 34mm and it is appropriate for applications that are mobile. For implementation, a Rogers RO4350 substrate with a relative permittivity of 3.66, tangential loss of 0.004, and thickness of 1.524mm is used. The computed and measured findings demonstrate that the antenna operates at frequencies of 1.22GHz and 5.7GHz, accordingly, with bandwidths of 20MHz and 90MHz. It meets the specifications of GPS and Wireless Sensor Networks systems.

2.1 Fundamental Outline of APT

The APT has been discovered since the invention of the first musical instrument. Generally, there are two operating sides of APT which consist of transmitter (primary side) and the receiver region (secondary side). The transmitter will vibrate once it receives applied power, basically electrical power. The vibration will be propagated through the attached medium (air, metal, in-body or even the liquid) omnidirectionally. The receiver then collects the propagated vibration and transforms it to usable electrical power.

2.2 Benefit of APT

APT is regarded as the most secure version of WPT due to the safer use of sound or vibration to propagate energy within the safe frequency level. Additionally, it does not struggle from misalignment and has greater penetration depth within 10cm-20cm of tissue thickness with the frequency apply is less than 10MHz. In a nuclear plant site, the physical presence and modern composite materials in example which is made by carbon fiber epoxy is not allowed. In this case, AET is a good choice since it does not contain any electromagnetic features [46]. Hence, AET is appropriate for liquid or liquid-based situations such as animal tissues [47]. Subsequently, AET can be used for both wall-through and in-body power transfer.

2.3 Fundamental Outline of IPT

Power transmission based on magnetic resonance coupling was first introduced by MIT researchers [48]. The IPT idea is related to the transformer which the alternate magnetic field in the primary coil produces an output power on the secondary coil when these two coils are closely coupled [49]. Power and data transmission via electromagnetic coupling is not a new concept. The wireless development of power and data over metal obstacles, on the other hand, is rather different due to electromagnetic waves not being able to efficiently flow through metal, particularly ferrous metal obstacles, due to the shielding effect of metal. Despite having had great success in several areas of theoretical and industrial research of wireless power supply applications, IPT is hardly ever used because of the losses brought on by the shielding effect [50,51].

2.4 Benefit of IPT

IPT removes the need for physical connectors or cables to transfer power, which contributes to safety and reducing equipment damage, i.e., it offers convenience and flexibility. Recently, the interest of IPTs in automotive industries have increased due to affectless charging by the dust, chemicals and the surrounding temperature and the ability to change into dynamic charging system when the vehicle is moving [53-56]. Besides that, implementations of IPTs are already widely acknowledged in production of clean factory automation semiconductor and liquid crystal displays where total cleanliness is crucial the field of material handling [57].

3. Recent Developments

3.1 Development of APT

Piezoelectric internal fixation devices are an unique approach to increase bone healing and shorten the time it takes to heal broken bones [58]. A PZT-5 with 36 × 6 × 1mm dimension was built and operated between 1-10 MHz of frequencies. The in vivo experiment by an external transducer generated 600mV of output voltage and more than 100μA of average output current alongside 10mW of the peak power density [59]. External ultrasound has the potential to generate microampere direct currents in vivo from implanted piezoelectric materials. Piezoelectric materials can transform mechanical energy into electrical energy, and ultrasonic waves can create mechanical vibrations that cause this conversion. According to the findings of the research, an ultrasonic transducer with a frequency of 2.25MHz, an input power of 10V-20V, and an output power of less than 10mW/cm2 can generate more than 20A with rectification. Several attempts at wireless energy transfer for biomedical implants using AET have occurred since then. Furthermore, the use of implanted devices that create electrical currents in vivo raises significant moral and regulatory concerns about the possible hazards and advantages for patients, as well as the need for comprehensive testing and evaluation of such devices' safety and effectiveness. As a result, any research or development of such technology must proceed cautiously and in accordance with stringent ethical and regulatory norms.

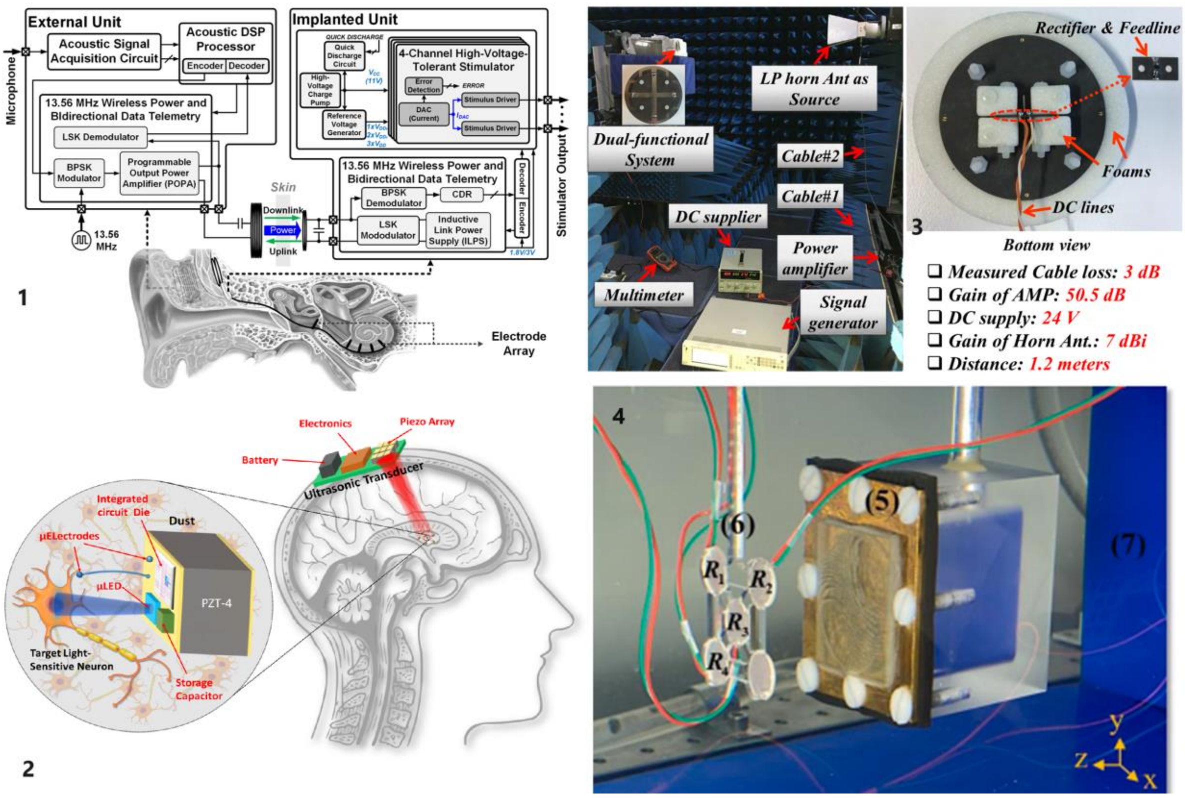

Fig. 1. (1) Block diagram of the BGCI microsystem and the conceptual structure diagram of the BGCI microsystem placed in a human ear © 2019 IEEE [68], (3) Rectenna measurement setup for electrically small Huygens antenna-based fully-integrated wireless power transfer system © 2019 IEEE. [70], (2) Conceptual illustration of an optogenetic microstimulators powered by ultrasonic waves. © 2019 IEEE.[72], (4) experimental setup of a two-focus 3D-printed transmission acoustic phase hologram alongside the fabricated ultrasonic source device to excite the five-element receiver array (5: ultrasonic source device, 6: receivers, and 7: acoustic absorber sheet); © 2022 Elsevier B.V. All rights reserved. [83]

Following that, two significant studies on this auditory projection have been reported by Awanabe *et al.* and Suzuki *et al.* [10,60]. Both works proved that AET are ideal for in-body implants. Acoustic and ultrasound technology has been utilised for a wide range of medical applications, including imaging and therapeutic interventions. Ultrasonic technology could be used to transmit power and information to implanted medical devices. The utilisation of ultrasonic waves to induce vibrations in the tissue around the implanted device is the fundamental concept behind ultrasonic power and information transmission. These vibrations can then be employed to power the device and send and receive data. In the first study, a wearable interface prototype with a single-chip microcontroller was used to assess the device's dimensions and power requirements. The prototype could transmit data at a 250kbps acoustic wave rate. Later, the work became more focused on transmitting electricity and information. The proposed design had two piezo oscillators. One of the sides will collect data from the living organism and communicate it to the outside of the receiver. By using 1MHz of optimal frequency with 30mm separation distance, an average of 20% of efficiency was recorded during the study. A year after, one prototype was designed and an average of 36% of efficiency was recorded by Suzuki *et al.* [61].

Over the last two decades, a technique for transferring energy through a metal wall has been proposed by Hu *et al.* [62]. Using acoustic waves and piezoelectric materials, electric energy can be transmitted through a metal wall. Piezoelectric materials can turn mechanical energy into electrical energy and the other way round. To accomplish this, one side of the metal wall would be joined with a piezoelectric transducer, while the other side would relate to a power supply. The electrical energy from the power supply would be converted by the transducer into mechanical energy in the form of acoustic waves that would pass through the wall. From numerical analysis, it is obvious that the output voltage will reach over 0.6V and 0.4V with a load impedance of 10Ω and 40Ω respectively. Even so, this research did not analyse the impact of diffraction on wave propagation. The effectiveness of this approach, however, may be restricted by the thickness of the metal wall and the qualities of the piezoelectric materials used. Additionally, the acoustic waves may be attenuated as they travel through the metal, which might limit the process's efficiency even further. Hence, the realistic application of the plan is also hard to achieve. Overall, while it is possible to transport electric energy through a metal wall using acoustic waves and piezoelectric materials, great thought must be put into the components and layout employed to ensure highest optimal efficiency.

A feed through applications was proposed by Sherrit *et al.* [63]. Wireless acoustic-electric feedthroughs are systems which enable electrical signals and acoustic waves to be sent wirelessly between two environments, such as a vacuum chamber and the outside world. These devices are frequently employed in scientific studies, such as acoustic levitation and gravitational wave detection. A set of differential equations that define the network's function is also included in the model. These equations account for the physical characteristics of the components as well as their interactions with one another. The operation of the wireless acoustic-electric feed-through may be anticipated by solving these equations for various input signals and operating circumstances. This electromechanical approach allows either wireless data or power transfer in a sealed jar. The approach amplified the impact of dielectric, piezoelectric and mechanical losses on the wall considered sealed. In attempt to validate the functional verification previously carried out by Hu *et al.* [62], the system was re-stimulated considering the properties of Motorola 3203HD component and examining PZT-8 for data on thickness. A year after, the actual prototype was designed to test practically by Sherrit *et al.* [64]. From this study, a total of 70% of efficiency was achieved. Even so, the maximum efficiency for the real prototype only achieved 53%. The researcher proved that a total of 100W of electricity can be transferred by using 0.2cm diameter plates. In conclusion, an efficient electromechanical network model for wireless acoustic-electric feedthroughs may be built using a mix of simulation software and reduced analytical models. These models may be used to forecast the functioning of the feed-through under various situations and to improve the design and performance of these devices for specific applications.

There are many studies were conducted related to wall-through power transfer. Nemoto *et al.* [65] conducted a study that used rheometers to evaluate the viscoelasticity of solid and liquid human skin. The ability of a material to resist deformation and return to its original shape is referred to as viscoelasticity. A rheometer may be a tool for assessing the characteristics of the skin, which is a viscoelastic substance. The dermis, the thick inner layer of the skin, is critical in defining the skin's viscoelastic qualities. The dermis is a structure made up of collagen and elastin fibres, which provide the skin structural support and suppleness. A rheometer can be applied for measuring the rheological characteristics of the dermis. A rheometer evaluates the skin's deformation or stress response after applying regulated tension or strain to it. This research has reached the highest maximum of efficiency which was 88% using 38mm to deliver 100W of power. Furthermore, [13,66] had improved the earlier study by transferring 1kW of power via metal wall. A piezoelectric material placed between two electrodes linked to the electrical circuit on each side of the metal wall would be used to generate a high-power piezoelectric acoustic-electric power feedthrough. When an auditory signal or vibration is transmitted to a piezoelectric material, an electrical charge is generated that may be applied to power devices or send signals. Both researches have transferred the energy with approximately 88% of efficiency and by using 24.5kHz of frequency. Arra *et al.* [16] then achieved a maximum efficiency of 35% despite the absence of statistical data.

Acoustic power transfer systems (APTS) are a sort of wireless power transfer technology that transmits electricity wirelessly from a power source to a receiver using sound waves. APTS works by converting electrical energy to sound energy, which is then delivered over the air to the receiver. The sound energy is subsequently converted back into electrical energy via the receiver, which powers the electronic device. The optimization of APTS involves improving the efficiency and range of the system [67]. Higher frequencies can give better power transfer efficiency and a longer range, which is one technique to optimising APTS. Higher frequencies, on the other hand, might cause significant attenuation and dispersion of the sound waves, reducing the system's effectiveness and range. Another method for improving APTS is to utilise directional transducers, which can focus sound waves in a single direction, lowering the amount of energy wasted due to dispersion. Furthermore, using high-intensity sound waves can increase the efficiency and range of APTS by providing a stronger and more concentrated signal. At various frequencies, the acoustic pressure is measured. 600kHz, 800kHz, 900kHz, 1200kHz was chosen as applied frequency for this work. Research was conducted with 5cm of air gap and the output power were recorded which were 1Pa, 1kPa, 7kPa, 3kPa consecutively. The simulations were carried out using the MATLAB and COMSOL software packages, with the PZT-5H transducer being chosen for its good quality factor and electromechanical coupling.

Subsequently, Qian *et al.* [68] found a voltage doubler/tripler (2X/3X) active rectifier is used in wireless power telemetry to improve energy conversion efficiency and produce 2V and 3V of output voltages. Bone-guided cochlear implants are a form of hearing aid that stimulates the auditory nerve directly rather than the damaged hair cells in the inner ear. Unlike standard cochlear implants, which utilize an external microphone and sound processor, bone-guided implants employ a small vibrator that is inserted immediately behind the ear on the skull bone. The vibrator sends vibrations of sound to the inner ear via the skull bone, allowing the user to sense sound. This study entailed creating a microsystem with components such as a vibrator, microelectrodes, and wireless communication capabilities. Implanting the device in an animal model or human participants and analysing its effectiveness in terms of sound perception and safety would be in vivo testing. The SOC microsystem for the CMOS bone-guided cochlear implant (BGCI) has been developed, and in-vivo scientific experiments on guinea pigs have been conducted for feature validation. The BGCI microsystem is shown to elicit the auditory nerve in the cochlea and produce Wave eIII in the EABR waveform. 59% of efficiency has been recorded for this work. In addition, Mahmood *et al.,* [69] has conducted a research on low-power medical devices. Wireless power transfer using ultrasound sensors for low-power medical devices is an innovative technique of powering such devices without the use of connected connections. The researcher aims to create a system that uses a sound wave to wirelessly transfer electricity to low-power medical equipment. An ultrasound transmitter and receiver are included in the proposed system. The transmitter gives out ultrasound waves, which are picked up by the receiver and converted into electrical energy. This energy can subsequently be used to power the medical equipment. The system was built to function at a frequency of 40 kHz, which is within the medical application's safe range. It has been tested on low-power medical equipment such as glucose monitors and blood pressure monitors, and the findings demonstrate that the system can operate these devices well. A total of 0.318mW of power has been successfully transferred with 4cm of active range. 69.4 % of efficiency of the system has been recorded.

More studies on AET for biomedical has been carried out by Basaeri *et al.,* [1]. The author addresses the impact of misalignment and misorientation on acoustic power transmission efficiency utilizing piezoelectric receivers for biomedical implants. The research shows how piezoelectric receivers may be used to harvest energy from acoustic waves generated by external sources, such as ultrasonic transducers, and use it to power biomedical implants. However, misalignment and misorientation of the piezoelectric receiver in relation to the external source can dramatically limit energy transfer efficiency. Using both analytical and numerical models, the study explores the impact of misalignment and misorientation on power transmission efficiency. According to the findings, misalignment can lower power transmission efficiency by up to 50%, while misorientation can reduce efficiency by up to 80%. The researcher has carried out the studies with two different values of frequencies applied which the first value is 88kHz and the second is 628kHz. For 88kHz of frequency applied, 0.23mW of power level has been supplied with the active range was 1.1cm. The efficiency for this system was 10.29%. For 628kHz of frequency applied, 0.12mW of power level has been successfully transferred with 0.3cm of gaps. The efficiency of the system was 4.82%. The size for the system purposed was 2mm × 2mm.

[70] proposed an innovative wireless power transmission and communication system based on electrically tiny Huygens antennas. The proposed system is made up of a transmitter and a receiver, both of which are outfitted with an array of Huygens antennas. A power amplifier drives the Huygens antennas, which send electromagnetic waves towards the receiver, in the transmitter. The electricity that comes from the incoming waves is collected by the receiver using a rectifying circuit and used to power a load or charge a battery. The authors prove that even with electrically small antennas, the suggested system may achieve great efficiency and range. Furthermore, by altering the amplitude and phase of the radiated waves, the same antennas can be used for communication. This allows the system to send both data and power at the same time, making it ideal for a variety of applications such as wireless sensors, internet of things devices, and biomedical implants. In general, the suggested system offers a substantial advancement in wireless power transmission and communication since it provides a compact and fully integrated solution that can work effectively over vast distances. At 907 MHz, the Huygens-based WPT rectenna achieves a peak AC to DC conversion efficiency of 87.2%.

Additionally, Freychet *et al.,* [71] in this paper describes how to use acoustic waves and advanced piezoelectric transducer mountings to pass power and data through metal walls. These ideas may be used to create a mobile sensor supply system for use in closed or metallic environments. This technology enables wireless power and data transfer through metal walls. This is helpful for a variety of situations where wire or direct access to a device is either impractical or undesirable. By implemented 268kHz of applied frequency, the output power that has been recorded was more than 150mW with 80% of frequency. Acoustic Power and Data Transfer (APDT) systems that are detachable and reusable have been investigated in this paper, with positive results in terms of power transfer efficiencies. Lastly, both the scientific and commercial production of APDT benefit from these two fixation solutions because they allow fast and non-disruptive implementation in operational environments. This type of technology has a chance to transform a variety of industries, including building, manufacturing, and security. Its versatility and simple use make it an appealing choice for any application requiring wireless power and data transfer over metal barriers. Furthermore, Rashidi *et al.,* [72] proposed a new micro-scale ultrasonically powered optogenetic microstimulator aimed at treating Parkinson's disease. The technology employs ultrasonic waves to wirelessly transfer power to the implanted device, which may then use that power to create light pulses for optogenetic stimulation. The fundamental innovation in the system is the employment of a power-efficient active rectifier and charge-reuse capability, which helps reduce power consumption and extend the battery life of the implanted device. This technique increases the active rectifiers' power conversion efficiency in two ways. The first one is, by reducing the comparators' time delay and the second one is by recycling the active diodes' power consumption. The device was tested in real mice and shown to be capable of stimulating neurons in the brain with little power usage. They believe that this sort of technology might be beneficial for a variety of applications, including neurological problems therapy. Overall, this research shows an intriguing advancement in the realm of optogenetics and implantable devices, and it will be fascinating to see how this technology progresses in the future.

Acoustic-electroelastic modelling is a technique used to investigate the behaviours of piezoelectric materials in response to an electric field and mechanical stress. This modelling may be used to evaluate the efficiency of piezoelectric discs, which are used to transform electrical energy into mechanical vibrations and vice versa, in the context of high-intensity focused ultrasound (HIFU) power transfer systems [73]. The behaviour of the piezoelectric disc is represented by a series of equations that connect the electric field, mechanical stress, and the subsequent deformation of the disc in an acoustic-electroelastic modelling technique. Typically, the equations are numerically solved using finite element analysis (FEA) techniques, which entail breaking the disc into small components and computing the operation of each element depending on its material attributes and boundary circumstances. For this system, 0.5MHz of frequency were applied and the output power were 51.5mW with 7.4cm of air gaps. The efficiency of this system was 75%. In conclusion, the results showed that if the frequency components in the nonlinear acoustic field correlate with the structural resonant frequencies of the receiver, the presence of the HIFU high-level excitation would cause disproportionately large responses in the piezoelectric receiver. Next, implantable ECG monitoring devices based on wireless power transmission are medical gadgets that allow healthcare providers to continually monitor the electrical activity of a patient's heart. Kim *et al.* [74] created one such device that uses wireless power transfer technology to power the implanted device. The system is made up of an ECG detecting unit and a wireless power transfer unit. Power receiver and transmitter make up the wireless power transfer device. The power transmitter, which is external to the patient, oversees producing an alternating magnetic field. The power receiver, which is inserted inside the body of the patient, has a coil that is intended to take in the magnetic field and convert it into electrical power. A sensor and an analogue front-end circuit form the ECG sensing device. The sensor is connected to the heart and monitors the electrical impulses that the heart produces. The analogue front-end circuit oversees enhancing and filtering the signals before they are wirelessly transferred to an external monitoring device. The system has recorded 10% of efficiency for implantable electrocardiogram (ECG) monitoring device. The system proposed by the researchers was built in size of 24 × 27 × 8 mm3. This study also has been implanted inside a rat's body. With an active range of 4mm, a total of 0.18W has been transferred with 6.78MHz of frequency applied.

Furthermore, Sedaghatkish *et al.,* [75] has carried out a studied which relating the medical fields and AET systems. Acoustic streaming takes place when sound waves travel across a fluid medium, enabling the fluid to move in a specified pattern. This fluid flow pattern can be used to improve medicine delivery to tumours near large hepatic veins, such as hepatocellular carcinoma. Thermosensitive liposomes are a form of drug carrier that can release their contents in reaction to temperature changes. This characteristic can be used to deliver medications directly to the tumour location, where a localized temperature increase can be created utilizing audio streaming. In this work, the acoustic field generates fluid motion via the phenomena of acoustic streaming, resulting in heat generation owing to viscous dissipation. This heat creates a localized rise in temperature, which allows medicines to be released from the thermosensitive liposomes. The device area for the system was set up for 20mm × 87.2mm × 6.75mm. The efficiency of the system is 56% was recorded for an active range of 0.453cm and the frequency applied was between 0.5MHz and 2MHz. Additionally, High-intensity Focused Ultrasound (HIFU) with robot assistance is a non-invasive therapeutic approach that employs ultrasound waves to heat and eliminate specific tissue. Recently, there was an increase in interest in employing HIFU for arterial wall targeting to treat disorders such as atherosclerosis, arterial stenosis and aneurysms. Plus, Groen *et al.,* [76] has carried a studied which related to medical field with 3.5MHz of applied frequency in 0.1cm of separation gaps. The efficiency of this system was recorded below 50%. Next, Acoustic power transmission via air/skin contact is a new technique with the potential to revolutionize wireless power transfer. Power is delivered from a power source to a receiver via sound waves in this method. Yosra *et al.,* [77] investigated the viability of this technique, and the results revealed that it is certainly feasible to deliver electricity wirelessly using acoustic waves. The research focuses on contactless power transmission across the air/skin interface, which includes the application of high-frequency sound waves to penetrate the skin and transmit power to the underlying tissues. The research was conducted by using 3 different values of frequency applied which were 40kHz, 80kHz and 200kHz. The distance separation of the transmitter and receiver was 24cm for all 3 applied frequencies. The different output power of 3. 104µW/cm, 8,4. 10-3µW/cm, 6. 10-4µW/cm was recorded respectively to the frequency applied.

Besides, [78] proposed two different techniques for coupling ultrasound into ceramic/metallic packages in this paper. The research focuses on the use of piezoelectric transducers in implanted devices for wireless power and data transfer, which can increase device dependability and durability. The study outlines the creation of a ceramic package that holds the piezoelectric transducer and the implanted device's electronics. Ceramic materials are appropriate for this use, according to the researchers, because of their biocompatibility, mechanical robustness, and capacity to tolerate high temperatures. To achieve theoretical results for ultrasonic transmission through two separate package designs, the classic wave approach and modal extension are used in this work, and these methods are verified experimentally. Alumina packages with titanium lids are used to illustrate the package design, which is intended to be acoustically transparent at ultrasonic frequencies. As a result, the researchers claimed that bulk modes are shown to be more efficient than flexural modes at coupling ultrasonic energy to a piezoelectric receiver. Also, Meesala *et al.,* [79] presents a method for evaluating the shock formation distance of acoustic waves produced by a baffled disc with arbitrary deformation in a weakly viscous fluid medium using an analytical approach. Shock wave formation in acoustic energy transfer systems can occur when the acoustic waves become excessively intense, causing a rapid increase in pressure and temperature and the production of a shock wave. The shock wave might harm the system and limit energy transfer efficiency. As a result, it is critical to analyse and forecast the factors that may lead to shock development. The theory of nonlinear acoustics may be used for evaluating shock production. Nonlinear acoustics explains the action of acoustic waves in medium with high enough acoustic pressure to generate nonlinear phenomena such as wave distortion, mixing, and shock production. Based on system factors such as acoustic power, frequency, and shape, nonlinear acoustics models may be used to anticipate the conditions in which shock production can happen. For a specific deformation profile, the renormalization method is used to predict the nonlinear wave produced by a finite amplitude baffled circular disc.

Other than that, Acoustic Power Transfer (APT) is a promising technique that uses ultrasonic waves to transmit electricity between two devices wirelessly. However, APT has inherent efficiency and robustness limits, particularly when it comes to transmitting power over longer distances or in the face of barriers or ambient noise. Using multiple input single output (MISO) configurations is one way to increase the performance and reliability of APT. In a MISO system, several transducers broadcast ultrasonic waves to a single receiver, which collects the acoustic power and converts it to electrical power. The use of numerous transducers has various advantages. First, it improves total power transfer efficiency by offering better directional control over ultrasonic waves, which lowers energy losses due to scattering or reflections. Second, it enhances the APT system's resilience by allowing for greater adaptability to environmental changes or disruptions. The result of employing numerous transmitters was investigated in two scenarios: (i) aligned transducers (with the circular patterned transducer) and (ii) non-aligned transducers (with the square patterned transducer). The results reveal that when transducers are aligned, performance improves significantly. For a 40 mm diameter transmitter and a 10 mm diameter receiver, the normalised transmitted power and efficiency are almost doubled by two. When transducers are not aligned, transmitted power increases even more, reaching up to 45 times the original value performances of SISO configurations. In addition, K. Kim *et al.,* [80] discusses applying sound waves to charge implanted medical devices wirelessly. This method has the possibility to eliminate the requirement of batteries in tiny implanted devices such neurostimulators. The study states the design and production of self-focused transducers, as well as the development of an acoustic wave-powered system for wirelessly powering an implanted neurostimulator. Experiment findings demonstrate that the system can effectively power the neurostimulator with up to 92% efficiency. The author presented an APT-based neurostimulator with a self-focused 3.6 MHz acoustic transducer integrated with a receiver circuit consisting of a power management module and a pulse generator. The overall size of the device was 8 mm 8 mm 8.6 mm, which is enough to be implanted through a tiny cut. An external transmitter's focused beam was received by another focused beam from a receiver transducer, and this optimized pair of transducers with a receiver circuit generated 1.5 V, 1.3 ms pulse trains that successfully conveyed stimulation pulses.

Next, Pop *et al.,* [81] research focuses on the modelling and optimisation of directly modulated piezoelectric micromachined ultrasonic transducers (PMUTs), which are small devices capable of converting electrical inputs into ultrasonic waves and vice versa. Medical imaging, industrial sensing, and consumer electronics are just a few of the applications for these transducers. The model proposed can be used to improve the design of PMUTs for specific purposes, such as increasing sensitivity or decreasing power use. As compared to standard continuous wave (CW) systems, this system consumes 80% less energy. As compared to the same energy levels, the dMUT improves the SNR by three times and the peak reachable contact range at 3 dB above the noise floor. Additionally, Coccolo *et al.,* [82] morphing distributed autonomous (MODA) system is a one-of-a-kind platform that incorporates shape-changing characteristics to improve vehicle performance and flexibility to various missions. This system's underwater acoustic modem must be dependable, robust, and capable of operating in a variety of water conditions. To enable for real-time data transfer between the vehicle and the base station or other vehicles, the acoustic modem in this study has a high data rate and a long communication range. The proposed system able to deal with multipath propagation, which can cause the signal to disperse and arrive at the receiver through many pathways, resulting in signal distortion and fading. This system uses advanced acoustic modem technologies such as spread-spectrum methods, adaptive equalization, and advanced coding schemes to address these issues. These techniques can help improve the signal-to-noise ratio, reduce multipath interference, and increase the robustness of the communication network. In short, the proposed MODA system requires the use of an advanced underwater acoustic modem capable of high data speeds, large communication ranges, and multipath propagation. To improve reliability and redundancy, the system may employ numerous modems.

Moreover, [83] this study has proposed a contactless ultrasonic power transfer systems with multi-focal transmission acoustic phase holograms are a form of technology that can be used for transmitting power over short distances utilizing ultrasonic waves. It is practical to produce numerous focal points at different places using a multi-focal transmission acoustic phase hologram, each with its own power level and trajectory. This provides for more efficient and flexible power transfer since energy may be targeted to specific devices or locations as required. In this study, the ultrasonic device generates sound waves with a waveform generator and an input voltage of 30.4 V peak-to-peak, which are subsequently transported through the water domain to the array of receivers and a power ratio of 23.4 was recorded on average. Contactless ultrasonic power transfer systems based on multi-focal transmission acoustic phase holograms have a wide range of applications, including medical devices, consumer electronics, and industrial automation. Next, Danielis *et al.,* [84] proposed this study's simulation model for energy consumption and acoustic underwater communication of autonomous underwater vehicles (AUVs) is a mathematical model meant to estimate the energy consumption of an AUV throughout its mission and assess the acoustic communication between the AUV and a distant station. The model considers many parameters that influence energy usage, such as vehicle speed, mission length, and climatic conditions. A vehicle motion model, an energy consumption model, and an audio communication model are all part of the simulation model. Based on input characteristics such as the targeted path and the vehicle's control system, the vehicle motion model forecasts the AUV's direction and speed. The energy consumption model calculates the power needs of the AUV's propulsion system, sensors, and communication devices, as well as friction and other loss of energy. The acoustic communication model forecasts acoustic signal transmission in the submerged environment and computes the signal-to-noise ratio (SNR) at the receiver. For the simulation results, this system transmits 100 kHz – 130 kHz of frequency in approximately 200 m of range. The possible communication range rises from 350 m to 700 m for 20 kHz - 50 kHz. And The performance of the 1-5 kHz band nearly doubles. After 4100 metres, communication is unattainable. Finally, at 100-900 Hz, the communication range significantly improves to 8500 m. for the selected input power applied, As using 2.8-W transferring power, the highest communication range is approximately 200 m. While utilizing 8 W, the maximum communication range improves slightly to 300 m. By using 35 W transmitting power, this figure is doubled, resulting in 700 m for the last attainable reception and 250 m for effectively receiving half of the packets. When the highest transmitting power, 80 W, is used, half of the packets are successfully transmitted over roughly 400 m, whereas the longest possible communication range is 1000 m.

Furthermore, The Wireless Acoustic Emission Sensor System with ACMD-IGWO-XGBoost Algorithm for live Tree Moisture Content Diagnosis is a novel technique by Z. Yang *et al.,* [85] for measuring the moisture level of live trees that employs a wireless sensor network and a machine learning algorithm. These sensors are linked to a wireless network, which feeds data to a central processing unit (CPU), which analyses the information and diagnoses the moisture content of the tree using the ACMD-IGWO-XGBoost algorithm. The ACMD-IGWO-XGBoost method is a hybrid of the

Adaptive Cluster Mean Distance (ACMD) algorithm, Invasive Growth-based Optimisation (IGWO), and eXtreme Gradient Boosting (XGBoost). This hybrid technique is intended for enhancing the diagnostic method's precision as well as effectiveness. In comparison to the IGWO model, which predicted using the original AE signal, when compared to the IGWO model, which used the original acoustic emission (AE) signal for prediction without decomposition, VMD-IGWO and ACMD-IGWO reduced prediction error while also reducing the number of prediction deviation points, with ACMD-IGWO reducing by nearly 118.4%. For a month, samples were taken for 60 seconds every 1 hour and 24 hours a day on the same tree. 43,200 AE waveforms and 4.32 × 108 sampling points were captured in total. Finally, Robinia Pseudoacacia, Photinia serrulata, Pinus massoniana, and Toona sinensis were monitored in the field. The average diagnostic accuracy was 96.75%, demonstrating that the diagnostics method is very applicable in a variety of working environments. Other than that, H. S. Kim *et al.,* [86] proposed an innovative method for transmitting acoustic energy across many mediums. The technology employs ferroelectric materials to improve contact electrification, allowing for efficient energy transmission across diverse media such as liquids and solids. To begin, the article covers the process of contact electrification, which involves the generation of electric charges on the surface of a substance by contact with another material. Explain how ferroelectric materials may be utilised to improve contact electrification. Following that, the article discusses how a ferroelectric material can be used to improve contact electrification between two materials, such as a liquid and a solid, to allow for efficient energy transfer. Finally, the article describes experiments that were carried out to demonstrate the efficacy of this method. In a nutshell, this study has successfully transferred 8 mW of power within 6 cm of range underwater.

Additionally, J. Zhang *et al.,* [87] proposed an approach for choosing sensors in a linearly limited beamformer guided by relative acoustic transfer functions. The relative acoustic transfer function (RATF) is applied in this technique to determine the relative transfer function between two sensors. This enables the selection of a subset of sensors that are well-correlated with the intended signal of interest while reducing interference from other sources. The suggested technique consists of two major steps: 1) picking a subset of sensors that maximizes the RATF of the desired signal, and 2) estimating the signal of interest from the selected subset of sensors using a linearly constrained beamformer. Simulations and real-world experiments show that the suggested technique may greatly enhance the signal-to-interference ratio and localization accuracy when compared to standard beamforming methods. Since the number of selected sensors directly influences system complexity, the suggested sensor selection issue was defined by reducing total output noise power and restricting the cardinality of the selected subset. In general, this study proposes a unique approach to sensor selection for linearly constrained beamformers, with possible applications in voice recognition, sonar, and medical imaging. In addition, [88] this study introduces the Underwater Acoustic Sensor Network (UW-ASNS) idea and the obstacles encountered in creating and implementing a routing system for such a network. The objective of this paper is to evaluate and analyse the performance of two routing protocols, Vector-Based Forwarding (VBF) and Depth-Based Routing (DBR), in varied network sizes of an UW-ASNS. The study technique involves simulating UW-ASNS with varied network sizes ranging from 50 to 250 nodes using the ns-3 simulator. Packet delivery ratio, end-to-end latency, and energy usage are among the performance measures used for evaluation. For simulation, the network size is 250 x 250 x 250 with 1.6 W of transmitting power in 100 m of range and a total of 1.2 W of power was recorded during the simulation. Research findings demonstrate that VBF outperforms DBR in terms of packet delivery ratio and energy consumption, although DBR has a shorter end-to-end delay. Furthermore, as network size increases, the performance of both protocols degrades, with VBF showing a more significant drop in performance.

Furthermore, Z. Wang *et al.,* [89] discusses a wireless power transfer technique for autonomous underwater vehicles (AUVs). The method was developed to overcome the limits of existing tethered power supply, which are costly and limit AUV mobility. The suggested device employs magnetic resonant coupling to wirelessly transfer power between a stationary transmitter and an AUV receiver. The system is built with a high misalignment tolerance, which means that even if the receiver is not exactly aligned with the transmitter, it can still receive power. This is accomplished by employing numerous resonators in the transmitter, which can detect the receiver's location and orientation and modify the broadcast energy appropriately. The system is also designed with high efficiency, meaning that a significant portion of the transmitted power is received by the AUV. This is achieved by resonant coils that are tuned to the same frequency as the transmitter, minimizing losses due to impedance mismatch. From the research conducted, a total of 120 W of output power was generated with 76kHz of frequency applied. The efficiency of this system was up to 96%. Next, Grigg *et al.,* [90] study on "Development of a low-power wireless acoustic emission sensor node for aerospace applications" focuses on the development and deployment of a wireless acoustic emission (AE) sensor node for monitoring critical components in aerospace applications. The primary purpose of this study is to increase the safety and dependability of aerospace systems by giving real-time data on essential health. An AE sensor, a low-power microprocessor, a wireless transmitter, and a battery are all part of the proposed AE sensor node. The AE sensor is in the role of detecting and measuring the acoustic waves produced by the component being monitored. The proposed AE sensor node was put to the test in a lab setting, and it was discovered that it could wirelessly detect and transmit AE signals with a range of up to 100 m. Additionally, it was discovered that the sensor node's battery life could last up to three months, which is adequate for many aerospace applications. The device consumes relatively low power, using 0.33 mW in sleep mode, 17.44 mW while waiting for an event, and 38 mW when recording, processing, and transmitting an event. Overall, this study offers a potential option for monitoring important components in aerospace applications by employing low-power wireless AE sensor nodes. This technology can enhance the safety and dependability of aircraft systems, decrease maintenance costs, and boost operational efficiency by delivering real-time data on the health of crucial components.

3.2 Development of IPT

The Inductive power transfer (IPT), also known as wireless power transfer (WPT), is a technique for sending electric power from a power source to a device without the need of physical wires or connections. It operates by transferring energy between two coils that are near to each other using an alternating magnetic field. IPT technology is employed in a wide range of applications, including mobile device charging pads, electronic toothbrushes, and even electric automobiles. Firstly, a study conducted by Choi *et al.,* [91] proposed an innovative method for cancelling electromagnetic fields (EMFs) produced during wireless charging of electric cars (EVs). The suggested active cancellation approach, which entails employing a network of several antennas to cancel out the EMF created during wireless charging.

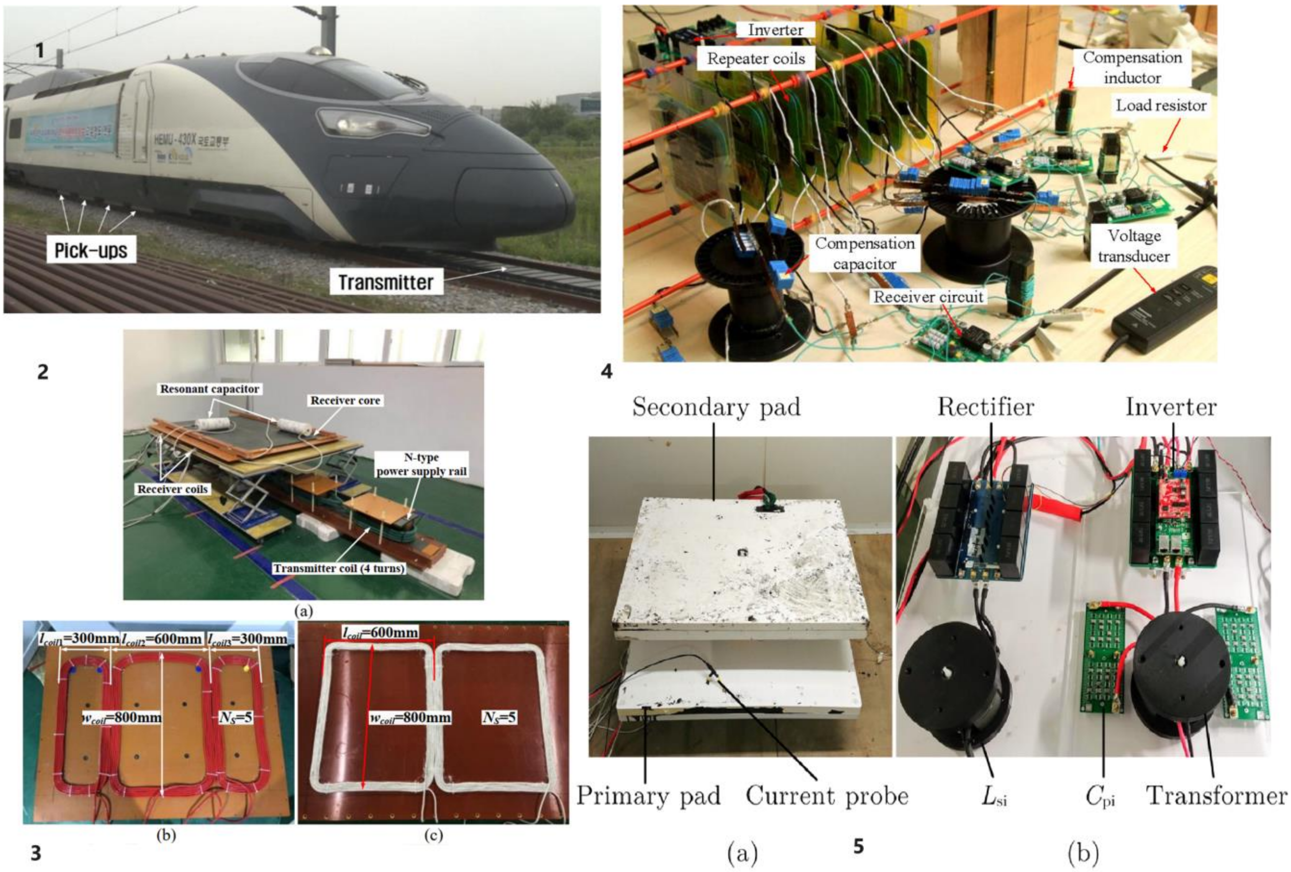

Fig. 2. (1) Wirelessly powered train HEMU running with the IPT system [123], (4) A repeater-based IPT system [109], (2) Experimental prototype. (a) Overall view of the experimental prototype. (3) (b) The mixed-pitch receiver coils. (c) The full-pitch receiver coils. (d) Resistance load. (e) High-frequency inverter [105], (5) Inductive power transfer pad for charging electric vehicle (a) the primary and secondary pads (b) the electronics [119]

The suggested approach is based on the superposition principle, in which the EMF produced by an antenna is precisely managed to cancel out the EMF produced by the other antennas. The paper presents the mathematical model used to calculate the cancellation signals and includes simulations to show the method's efficiency. ISEC, 3DEC, and LFEC, three different active EMF cancel techniques, have been used to the design of I-type IPTS and experimentally verified. For the 62.5 A load current, the EMF at 1 m dropped to 44 mG. Overall, the article suggests a possible solution to the problem of EMF created during EV wireless charging. The suggested technique has the potential to reduce the health concerns associated with EMF exposure while also improving wireless charging effectiveness. Next, a study titled "Improved Transfer Efficiency of Wireless Power Transmission System featuring Coil-Size Disparity" by [92] discussed on designs the WPT system to work with the system with coil size disparity using an impedance-based quality factor tuning technique. In this work, a prototype was created and shown to wirelessly transfer power up to 15cm with a near constant efficiency of 73%. The size of the transmitting and receiving coil is 19 cm and 10 cm, respectively. The operating frequency for this work was kept in constant at 945 kHz. The transmitter was fixed in place, while the receiver was gradually moved away from it along the axis. The efficiency of transmission is evaluated every 1 cm from 2 cm to 30 cm. The initial transfer efficiency for the system using the suggested impedance-based quality factor tuning technique is approximately 73% at 2 cm and remains almost constant as the transmission distance increases till 15 cm. Following that, the transfer efficiency is gradually declining. The crucial coupling point has been identified 15 cm. In comparison to the system without any modifications, the initial transfer efficiency is only approximately 55% at 2 cm. With the introduced adjustment, the transfer efficiency of the different coil size WPT system improves. At its maximum transmission distance, the starting efficiency is 1.3 times greater.

Moving forward, the IPT method has gained a lot of attention in recent years because it can be used to charge electric vehicles (EVs) and other devices wirelessly. Deng *et al.,* [93] research on "An Inductive Power Transfer System Supplied by a Multiphase Parallel Inverter" presents a novel method to developing an IPT system. A multiphase parallel inverter, a resonant capacitor, and a resonant inductor are included in the proposed system. The system is intended to be very efficient, with great power transmission capabilities, and with exceptional stability. The IPT system is powered by a multiphase parallel inverter, and the resonant capacitor and inductor form a resonant circuit that allows for efficient power transmission. In this study, a prototype was built and used as a power supply for this IPT systems with gaps of 20cm.The efficiency of this work was recorded which is 95.6%. The study also includes a mathematical model of the proposed system and demonstrates how it can be used to evaluate its performance. The simulation results are shown to demonstrate the suggested system's efficacy in terms of efficiency, power transfer capabilities, and stability. Overall, the suggested system has the potential to be employed in a variety of applications, including electric vehicle charging, wireless power transmission for consumer devices, and industrial uses. Other than that, a study title "Hybrid inductive power transfer and wireless antenna system for biomedical implanted devices" was carried by Shadid *et al.,* [94]. It is a novel method of powering and communicating with biomedical implants. To address the limitations of conventional approaches, the author offers a hybrid system that combines inductive power transmission with wireless antenna technology. The proposed hybrid system includes an inductive power transfer system that supplies continuous power to the implanted device and a wireless antenna system that allows bidirectional communication between the implanted device and an external device. The inductive power transfer system is intended to offer high-efficiency power transmission to the implanted device, whilst the wireless antenna system enables wireless communication by utilising a tiny antenna that is built into the implanted device. The approach suggested provides a few benefits over traditional techniques. It powers the implanted gadget continuously, eliminating the need for battery replacement. It also enables bidirectional connection between an implanted device and an external device, allowing for real-time monitoring and control. With 13.56MHz of applied frequency, the efficiency for this system was 72.26% at 1.5cm of separation. The suggested hybrid system has the potential to completely transform the field of biomedical implanted devices by providing a more efficient and dependable method of powering and communicating with these devices.

Next, Implantable Medical Devices (IMDs) are becoming more common for their use in tracking and treating a patient's disease. Low-power transmission between the implants and the receiver from outside patient's body is designed to ensure low medical costs and risks associated with the need for battery replacements through surgery. Rahman *et al.,* [95] has designed a prototype with 10mm x 10mm x 2.3mm. The frequency applied in this system was 250Hz with 209cm of air gaps. A total of 392uW of output power was recorded for this project. In conclusion, low-power wireless communication is a critical factor for WPT devices. It can aid in increasing energy efficiency, lowering expenses, and ensuring reliable communication with little interference. Additionally, the approach for improving the frequency of inductive power transfer based on the AC resistance assessment of a Litz-wire coil is covered in the paper "Frequency Optimisation for Inductive Power Transfer Based on AC Resistance Evaluation in Litz-Wire Coil" by Liu *et al.,* [96]. The usage of Litz-wire coils, which are coils made up of several tiny wires twisted together, is the main topic of the study. Litz-wire coils are used often in IPT operations because they have less resistance than single-wire coils. The approach for improving IPT frequency is suggested in the study and is based on the AC resistance of the Litz-wire coil. The process entails determining the ideal frequency for power transfer by measuring the coil's AC resistance at various frequencies. The output power for this system was recorded which was 40W with 147kHz of applied frequency. The efficiency for this system less than 50%. Thus, the research offers insightful information about IPT optimisation utilising Litz-wire coils and emphasises the need of taking the coil's AC resistance into account when choosing a frequency.

Furthermore, Zucca *et al.,* [97] has conducted a study on “Metrology for inductive charging of electric vehicles (MICEV)” is an area of study that focuses on the creation and improvement of measuring methods for electric car inductive charging. The objective is to guarantee evaluations of the energy transmitted during charging that are precise and reliable, as well as the safety and efficiency of the charging system. In this study, these systems, power is measured over a frequency range up to 150kHz. The main objective of this system is to design and calibrate a high-accuracy power measurement unit for static wireless power transfer for on-board measurement and IPT efficiency assessment. In general, this study is significant for the creation of dependable and effective electric car charging infrastructure, which will be essential in lowering greenhouse gas emissions and lessening the consequences of global warming. Next, [98] study on “Dynamic Wireless Charging of Autonomous Vehicles" discusses a small-scale test of inductive power transfer (IPT) as a method for autonomous cars' self-sufficient energy source. The article examines the difficulties of supplying enough energy to autonomous vehicles, especially those that need a lot of electricity, like trucks. According to the study, this issue may be resolved by dynamic wireless charging, which enables a vehicle's batteries to be charged while it is moving. A small-scale model of an electric truck is made by customizing a 1:14-scale replica to demonstrate the possibilities of such solutions in the electrification of road transportation. The outcomes of the autonomous operation of the small scales model by tracking a specified path that comprised the two coil sections for dynamic charging were shown to demonstrate the integrated operation of self-driving technology and wireless inductive power transmission. Thus, the model can be used as a simple and low-cost platform for developing, testing, and evaluating self-driving technology as well as solutions for dynamic inductive power transmission.

Moreover, Kempi *et al.,* [99] has carried out a study on “Resilient flow control for wireless data streaming in inductively coupled medical implants”. The study proposed a new flow management method for wireless data streaming in implants that employ inductive coupling for both power and data transfer. Resilient Flow Control (RFC), a proposed flow control mechanism, is intended to address these issues by combining data prioritisation, rate control, and error correction techniques to guarantee the prompt and reliable transmission of crucial medical data while making the best use of available bandwidth. Vital signs and alerts are given priority by the RFC algorithm over less important data, such as information on patient activities. Also, rate control techniques are used to dynamically alter the data transfer rate based on the bandwidth that is available and the importance of the data. The 28nm CMOS technology was used to implement the suggested communication system. Place-and-route (PNR) findings take up just 0.0048 mm2 of core space, and the power consumption during transient simulations is 306 nW at 0.5 V supply and 845.7 kHz for the master clock. The implementation offers an uplink rate of 12 kbit/s, which is adequate for the secure transmission of a 12-bit, 1-channel recording at 1 kS/s. In addition, Electric vehicle charging, wireless power transmission, and biomedical implants are just a few of the areas where inductive power transfer (IPT) devices are finding growing use. The design of the coils used in the power transfer process has a significant impact on the effectiveness and performance of these systems. In this context, Namadmalan *et al.,* [100] suggested an IPT system design optimisation approach that takes into account bifurcation and equivalent AC resistance for spiral coils. The technique considers two significant elements influencing the performance of IPT systems: bifurcation and equivalent AC resistance. Bifurcation is a thing in which the coil enters a chaotic condition, resulting in a considerable loss in the effectiveness of the IPT system. On the other hand, equivalent AC resistance influences the power transfer efficiency of the system and is impacted by coil shape and material qualities. The suggested technique employs a genetic algorithm to optimise coil design parameters such as the number of turns, radius, and width to reduce the coil's bifurcation and equivalent AC resistance. The optimisation procedure is based on a mathematical model that considers the magnetic field distribution, current density, and coil equivalent AC resistance. The suggested approach was validated using a laboratory prototype with an output power of about 200 W and an operating frequency of around 85 kHz. With over 95% accuracy, this model calculates the equivalent resistance of the coils for a given strand diameter. According to the findings of the study, the proposed optimisation strategy may greatly increase the performance of IPT systems. The optimised coil designs have lower bifurcation and comparable AC resistance values, which results in improved power transfer efficiency and less coil heating.

Dynamic charging inductive power transfer (IPT) systems for electric vehicles allow for wireless charging while the vehicle is in motion. Several factors can influence power transfer efficiency, including the distance between the coils, coil alignment, and the frequency of the alternating current used. Stoyka *et al.,* [101] conducted a study on the analytical modelling of the input current absorbed by a dynamically functioning Inductive Power Transfer System (IPTS). A total of 82.9% efficiency was measured with an applied frequency of 85kHz. The output power level was 11kW with 20cm air gaps. In general, dynamic charging IPT systems are a promising field of research and development for electric car charging, and further advances in modelling and design will be critical for their broad implementation. Next, S. Song *et al.,* [102] paper titled "Receiver Current Stress Mitigation for a Dynamic Wireless Charging System Employing Constant Resistance Control" proposes a technique for minimising the current stress of the wireless charging receiver in dynamic wireless charging systems. The suggested technique leverages a constant resistance control approach to maintain a constant load resistance for the receiver independent of changes in the charging system's coupling coefficient and operation frequency. This acts to lower the receiver's current stress and increase its efficiency. To resolve this issue, constant resistance (CR) control is used, which shapes boost input current and voltage in phase. When driving at 80km/h, the maximum stress improvement on receiver resonant current is 29% for ideal conditions and 44% for non-sinusoidal conditions. The simulation and experimental findings show that the suggested approach is helpful in lowering receiver current stress and enhancing charging efficiency. The results reveal that, when compared to standard control approaches, the constant resistance control methodology can maintain a consistent receiver output power and lower peak receiver current by up to 60%. Overall, the study gives significant insights into the issues of dynamic wireless charging systems and presents an efficient approach for decreasing receiver current stress, which has the potential to increase wireless charging system efficiency and dependability.

Additionally, Xia *et al.,* [103] research focuses on dynamic wireless charging, a system that allows electric vehicles to recharge wirelessly while driving. One of the difficulties of dynamic wireless charging is maintaining an adequate level of power transfer efficiency even when the transmitting and receiving coils are misaligned. Study suggests employing an integrated receiver with high misalignment tolerance to overcome this issue. This receiver is intended to have a broad efficient receiving area, allowing it to catch more power even when the transmitting and receiving coils are misaligned. The receiver also employs a multi-coil construction and a control algorithm that allows it to respond to variations in the location and orientation of the transmitting coil. The integrated receiver is also tiny and lightweight, which is essential for usage in electric cars. According to the research conducted, an integrated receiver with high misalignment tolerance could achieve a power transfer efficiency of more than 90% even when the transmitting and receiving coils are misaligned. Two decoupled coplanar spiral coils on the integrated receiver's lower layer serve as an auxiliary repeater to help maintain a reliable power transfer between the track's transmitter coils and the primary reception coil on the upper layer. Next, for the proposed receiver structure, an optimization model based on the Bayesian technique is created, and some essential parameters are optimized. To validate the effectiveness of the suggested design and optimization process, two 300W dynamic charging prototypes based on the integrated receiver and conventional spiral receiver, respectively, were produced. Moreover, the paper "Multiplexed Supply of a MISO Wireless Power Transfer System for Battery-Free Wireless Sensors" was proposed by Bouattour *et al.,* [104] presents a wireless power transfer (WPT) system for battery-free wireless sensors that use a multiple-input single-output (MISO) architecture. The suggested solution is designed to address the issue of powering sensors in remote places with limited access to power. The system is composed of up of numerous antennas for power transfer and a rectifier circuit to convert the received alternating current signal to direct current voltage. The rectifier circuit is optimised for performance and minimum voltage loss. A power multiplexer is also included in this system's proposal to deliver power to numerous sensors at the same time. The suggested system might be employed in a variety of industries, including environmental monitoring, healthcare, and agriculture, where battery-free wireless sensors could be used for long-term monitoring without the need for battery replacement. The unique approach's viability was studied, implemented, and assessed for a multi-input-single-output (MISO) wireless power transfer system with 16 transmitting coils and one receiving coil with a double diameter. The paper explains the proposed system in whole, including theoretical calculations and simulation results. The simulation results demonstrate that the suggested system is very efficient and can power several sensors at the same time. In summary, the research proposes a viable approach for WPT to battery-free wireless sensors, which may be useful in addressing the issue of powering sensors at remote places.

Moving forward, B. Song *et al.,* [105] article "A dual-layer receiver with a low aspect ratio and a reduced output fluctuation for EV dynamic wireless charging" offers a unique dual-layer receiver design for EV dynamic wireless charging. The suggested dual-layer receiver is made up of two layers of printed circuit board (PCB) coils that are vertically aligned and separated by a tiny air gap. The bottom layer has a wider radius and is intended to collect most of the magnetic field from the charging pad, whereas the top layer has a smaller radius and aims to capture the higher frequency magnetic field components. This two-layer design minimises the receiver's aspect ratio, making it smaller and less sensitive to the relative position and orientation of the charging pad. Furthermore, the proposed receiver includes a feedback control loop that adjusts the receiver's load impedance to maintain a constant output voltage even when the input power fluctuates due to changes in the relative position and orientation of the charging pad. A DC-DC converter and a low-pass filter are used in the feedback loop to smooth out variations in the input power and provide a consistent output voltage. Finally, a 10-kW prototype with an AC-DC efficiency of 93.2% was created for testing. The practical findings agreed with the theoretical analysis and simulation results, demonstrating that the suggested receiver could minimise the aspect ratio and accomplish decoupling between the receiving coils while decreasing output fluctuation. In addition, Y. Zhang *et al.,* [106] has carried out a study on “Multi-Objective Optimization of Single-Transmitter Coupled Multi-Receiver IPT System for Maglev Trains”. A single main coil is employed to deliver power to several secondary coils on the train in a single transmitter linked multi-receiver IPT system. The method is widely used in maglev trains, which require a lot of electricity to keep levitation and propulsion working. Finding the best settings that fulfil several competing objectives is the goal of multi-objective optimisation of such a system. In this scenario, the goals are to improve power transfer efficiency, reduce magnetic field radiation, and increase power transmission distance. A typical method for multi-objective maximising is to employ a technique known as Pareto optimization, which involves identifying the set of optimum solutions that are not dominated by any other solution. To validate the design concerns, a scaled-down single-transmitter linked dual-receiver IPT system was built. The prototype's efficiency hit 80% at 1kW output power with roughly 100V input voltage and 50V output voltage at a switching frequency of 85kHz.

Furthermore, the paper "Wireless Power Transfer Using a Five-Phase Wound-Rotor Induction Machine for Speed-Controlled Rotary Platforms" by Rizzoli *et al.,* [107] presents a wireless power transmission mechanism to a revolving platform. The system comprises of a stationary transmitter and a revolving receiver, which is a wound-rotor induction machine with five phases. The machine can vary its speed based on the wireless power received, allowing it to maintain a steady pace even when the power transfer varies. The typical answer for this approach is to employ slip-ring contacts. They do, however, get worse with age, necessitating a regular care plan. The device's practical potential is demonstrated through experimental tests on a scaled prototype. The results indicate that the system can wirelessly transfer electricity to the spinning platform while keeping a steady speed. The system achieved an efficiency of more than 80%, and the authors believe that this might be enhanced further with system design optimization. Next, Meng *et al.,* [108] Helmholtz-like three-coil wireless power transfer system is a kind of wireless power transfer system that employs three coils to transfer power from a transmitter coil to a receiver coil. The technique was developed primarily for use in gastrointestinal robotics, where a wireless power transfer system is required to power the robot without the usage of batteries. However, the main limitations of WPT systems in such applications are low power transfer efficiency (PTE) (most studies show it to be less than 3%) and poor power received stability. The study explains the system's optimization and analysis, with an emphasis on increasing power transfer efficiency and assuring the robot and patient's safety. To maximise power transmission efficiency, the physical characteristics of the coils, such as radius, number of turns, and location, are adjusted throughout the optimization process. A prototype estimated the gastrointestinal robot operating condition and was implemented for an experimental test to validate the suggested design. The experimental findings show that the proposed three-coil WPT system with 9 turns load coil and 40 turns reception coil achieves a PTE of 4.32% and a PDL of 541.5 mW. Furthermore, the novel Helmholtz-like load coil achieved a best PTE of 6.45% and a PDL of 845 mW. The results of the research indicate that the improved three-coil WPT system can transmit power with up to 85% efficiency, which is greater than the efficiency of traditional two-coil WPT systems.

In addition, multiple isolated power supplies are required to run many gate drivers of series coupled insulated gate bipolar transistors (IGBTs) in a high-voltage application. This research has been conducted by Cheng *et al.,* [109] proposed a unique wireless power transfer (WPT) technology based on repeater coils to address these issues. Repeater coils are used to increase the power transfer capability for long range. The primary coil is normally located within the power supply unit (PSU) and is linked to a power source, such as an AC power supply. The secondary coil is linked to the load, which in this case is the gate drivers of the IGBTs and is situated near to the primary coil. Each receiving circuit in the experiment has a load power of 3W, which is sufficient to drive an IGBT. The efficiency for this system is 91% and was recorded. Other than that, inductively coupled wireless power transfer (WPT) systems are widely used to charge mobile device and electric vehicle batteries. The WPT system's performance is highly sensitive to the intensity of electromagnetic coupling between the coils, compensatory topologies, loads, and airgap fluctuation. D. Kim *et al.,* [110] study seeks to give a thorough characteristic analysis for the design of a WPT system using a numerical simulation tool. The FEKO electromagnetic field solver is primarily used to investigate high-frequency devices. The simulated S-parameter was used to calculate the self and mutual inductance of wireless transfer windings across various airgaps in this work. The development of the magnetic coupling and the distribution of the magnetic fields between the coils in the series-parallel model were further investigated using near-field analysis to determine the WPT system's efficient performance. Finally, it was established that the FEKO simulation results agreed well with the practical measurements. When a 10 V input voltage is applied to the prototype's transmission unit, a power of 5.31 W is provided with a transferring efficiency of 97.79% in FEKO. The actual measurements showed a transferring efficiency of 95.68%, with an error margin of 8.4%.

Furthermore, [111] this study carried out an investigation on “Three Phase Coil based Optimized Wireless Charging System for Electric Vehicles”. This study describes an optimised three-phase coil-based wireless charging system for electric automobiles. A three-phase coil, a power electronic converter, a battery charger, and a control circuit comprise the system. The objective of this research is to make charging electric vehicles easier by removing the need for wires and plug-in chargers. The use of three-phase coils in the charging system enhances power transfer efficiency by eliminating losses caused by skin and proximity effects in the coil. The optimised wireless charging technology can supply high power levels, allowing electric vehicles to be charged quickly. A communication system between the charging station and the vehicle is also included in the proposed technology to communicate information about the battery's status and the charging process. This enables the charging system to adapt to the vehicle's individual demands and optimise the charging process for optimal efficiency. This suggested work achieves a peak efficiency of 89% at 3 W of output power. Below 3.2 W, the transmitter will turn off and remain turned on otherwise. Overall, the Three Phase Coil based Improved Wireless Charging System for Electric Vehicles provides a promising option for the development of electric vehicle charging by offering EV owners with a simple, efficient, and safe charging environment. Additionally, a study on "Coil Parameter Analysis in Wireless Electric Vehicle Charging" [112] discusses the significance of coil characteristics in wireless electric vehicle charging (WEVC) systems. The article investigates the influence of coil characteristics such as number of turns, diameter, and length on WEVC system performance. The research provides a thorough examination of the impact of coil parameters on the Q factor and efficiency of a WEVC system. The author investigates the effects of coil diameter, length, and number of turns on the Q factor and system efficiency using simulations and mathematical models. The analytical findings suggest that the coil diameter and length have a substantial impact on the Q factor and system efficiency, whereas the number of turns has a very minor influence. Finally, the paper emphasises the significance of coil parameters in the design of WEVC systems and provides insights into the optimal coil diameter and length values. The paper's research can assist designers and engineers in optimising the performance of WEVC systems by selecting the appropriate coil settings.

Inductive wireless power transmission systems are widely employed in a variety of applications, including wireless charging of mobile devices, electric cars, and medical implants. However, one of the limitations of inductive wireless power transfer systems is their limited horizontal transmission range. To solve this constraint, researchers studied the use of passive resonators to improve the transmission range of inductive wireless power transfer devices. This study employed passive elliptical resonators to improve the horizontal transmission range of an inductive wireless power transfer system [113]. The resonators were intended to resonate at the same frequency as the transmitter coil and were positioned between the transmitter and reception coils. The resonators' elliptical shape was chosen because it provides for a bigger surface area than circular resonators, resulting in a stronger magnetic field. The resonators were also built with a high-quality factor (Q factor), which reflects the resonator's capacity to retain energy. A high Q factor indicates that the resonator can store energy for a longer period, resulting in a stronger magnetic field. The experimental coil type provided here is a single layer spiral with a double split track. A PIC18F microcontroller is employed at the transmitter to drive the H-bridge inverter at 200 kHz. The results of the research indicated that using passive elliptical resonators extended the horizontal transmission range of the inductive wireless power transfer system significantly. Researchers were able to obtain a 50% improvement in gearbox range over a system without resonators. Next, Elngar *et al.,* [114] has carried out a research on "Wireless Power Transfer for Stationary and Dynamic Charging Systems for Electric Vehicles Using MATLAB/SIMULINK" looks at the feasibility and efficiency of wireless power transfer (WPT) systems for electric cars (EVs). The goal of the research is to create a simulation model of WPT systems using MATLAB/SIMULINK to evaluate the system's performance and efficiency. The WPT system simulation model is created with MATLAB/SIMULINK, which enables the evaluation of the system's performance under various operating situations. The simulation findings demonstrate that the WPT system can wirelessly transmit power to an EV in both stationary and dynamic charging circumstances. Future WEVCS opportunities, such as "vehicle-to-grid (V2G)" and "in-wheel" wireless charging systems WCS, are also investigated and qualitatively compared to other advanced methods. Firstly, the author compared the wireless V2G system and plug-in V2G analysis. For wireless V2G, the operating frequency is between 81.9 kHz- 90 kHz while for the plug-in version is between 16 kHz – 10 kHz. The power transfer efficiency (PTE) for both systems has been recorded more than 90%. Moving forward, the author also compared the in-wheel WCS and via-wheel WCS. The operating frequency for in-wheel WCS is 100kHz and for the via-wheel WCS is 50 kHz – 55 kHz. The total power transfer for both in-wheel WCS and via wheel WCS are 100W and 60 W respectively while the PTE recorded are more than 80% for in-wheel WCS and 70% - 78% for via-wheel WCS. Finally, the study demonstrates the feasibility and effectiveness of wireless power transfer systems for EVs, and the simulation model created with MATLAB/SIMULINK is a useful tool for evaluating and optimising the performance of these systems.

Additionally, Kao *et al.,* [115] invented the Adaptive Bidirectional Inductive Power and Data Transmission System (ABIPDTS). It is a wireless power and data transfer technology that use inductive coupling. The ABIPDTS system provides a bidirectional communication protocol, allowing data to be exchanged between the transmitter and receiver. It also contains adaptive tuning, which modifies the frequency of the broadcast signal to optimise power and data transmission based on the receiving device's parameters. The versatility of the ABIPDTS system to adapt to changes in the environment is one of its distinguishing qualities. The system continually monitors the wireless link and adjusts the transmission settings in real time to account for changes in the distance between the transmitter and receiver coils, as well as the presence of other objects that may disrupt with the magnetic field. The system operated with 83kHz of operating frequency and 80 W of output power. Under high voltage and large conduction coil misalignment, the suggested technique may improve system efficiency by more than 7.5%. Wireless charging for electric cars, implanted medical devices, and wireless sensors for the Internet of Things (IoT) are all possible uses for ABIPDTS method. Its adaptive tuning and bidirectional communication features make it a viable wireless power and data transmission device. Moreover, [116] has carried out a study on “A novel design of partially magnetized pavement for wireless power transfer to electric vehicles with improved efficiency and cost saving”. The suggested solution includes employing partly magnetised pavement to provide wireless power to electric automobiles. The pavement consists of a series of magnetised segments implanted in the highway surface. The electric car is outfitted with a receiver coil, which is located beneath the vehicle and is used to collect energy from the pavement. Compared to standard wireless power transfer systems, the design has significant benefits. First, the partly magnetised pavement allows for more efficient power transfer, decreasing energy losses and enhancing total system efficiency. Second, using pavement as a power source eliminates the need for expensive and cumbersome charging equipment, lowering the system's cost and complexity. Furthermore, the design is adaptable in terms of the amount and positioning of magnetised segments, allowing for customisation based on the unique requirements of a given highway. The system may also function in bad weather, such as rain or snow, without reducing performance. The findings demonstrated that partly magnetised pavement outperformed conventional pavement for wireless power transmission, providing a 1.5%-13.3% gain in charging efficiency. If the embedment depth of the transmitter coil is 0.1 m, the wireless charging efficiency may be increased by 1.5%, from 70% to 71.5%. If the pavement layer above the transmitter coil thickens to 0.4 m, this efficiency boost can be upped to 12%. Based on the exact efficiency increase and the daily charging hours of the WPT system, the specific power cost savings for a one mile partly magnetized pavement stretch might vary from $0.2-14 million.

In addition, ÇİÇEK *et al.,* [117] research on “The modelling, simulation, and implementation of wireless power transfer for an electric vehicle charging station” has present a technique for wirelessly transmitting electric power from a charging station to an electric car. The article provides a thorough examination of the theoretical and practical elements of wireless power transfer, including the fundamental concepts of wireless power transfer, the design of a wireless power transfer system, and system modelling and simulation. The research also covers the development of a wireless power transmission system based on resonant magnetic coupling. A charging station and an electric car outfitted with a wireless power receiver comprise the proposed system. The charging station is powered by an external source and creates an oscillating magnetic field that is used to wirelessly transmit energy to the electric vehicle. The simulation results show that the proposed wireless power transfer system is efficient, with a high-power transmission efficiency of more than 90%. The system is also demonstrated to be durable, with low fluctuations in power transfer efficiency under various operating circumstances. Research demonstrated the optimal distance between the coils. The WPT system prototype is then developed, and experimental experiments are conducted at 86 kHz and 10 W. According to the experimental results, the maximum efficiency of the WPT system in the optimum condition of topology is 75%. The suggested approach has the potential to transform the charging of electric vehicles by providing a more convenient and efficient technique. Furthermore, Prosen *et al.,* [118] work "On-Line Foreign Object Detection Using Double DD Coils in an Inductive Wireless Power Transfer System" describes a technique for identifying foreign objects using double DD coils in an inductive wireless power transmission method. The paper proposes using double DD coils to detect foreign objects in the system. The double DD coils are made up of two identical coils that are perpendicular to one other and have two winding sections each. The coils are linked in series on the same circuit board. Any external item in the system will produce a change in the mutual inductance between the coils when the coils are activated with a high-frequency signal. This difference can be noticed and applied to set off an alert or shut down the system. The study gives experimental findings demonstrating the efficacy of the double DD coil approach for detecting alien objects. The studies were carried out on a 13.56 MHz WPT system, and numerous foreign items were brought into the system to put the detection mechanism to the test. The system was operated with 15 V and 2 A with 87 kHz of operating frequency. The distance between the transmitted and the receiver pads was modified in 2 mm increments from 15.3 mm to 75.3 mm. Overall, the research describes a unique and successful approach for detecting foreign items in inductive WPT systems employing double DD coils. The innovation has the potential to increase WPT system safety and dependability in a variety of situations.

The paper "Thermal Evaluation of an Inductive Power Transfer Pad for Charging Electric Vehicles" by S. Kim *et al.,* [119] offers research findings on the thermal performance of an inductive power transfer (IPT) pad used for charging electric automobiles. The IPT pad is a wireless charging method that employs magnetic fields to transmit electricity from the charging pad to the vehicle's battery.

The research looks at the thermal behaviour of the IPT pad under various charging settings, such as varied power levels and charging times. According to the study's findings, the IPT pad creates heat throughout the charging process, and the temperature of the pad rises as charging time and power level rise. 10 kW of output power was successfully transferred with 93.5% of system efficiency. The losses in the IPT system's other components are measured experimentally verified. When the expected power losses are added together, the overall efficiency of the IPT system is predicted to be 94.2%. The magnetics accounted for the bulk of the simulated losses, accounting for 2.9% and 0.7%, respectively. Overall, the study gives useful insights into the thermal behaviour of IPT pads as well as ideas for enhancing their thermal performance, which can lead to more efficient and dependable charging of electric vehicles. Next, [120] this paper carried out a study titled "A study on renewed perspectives of electrified road for wireless power transfer of electric vehicles". The research explores new views of electrified highways for electric car wireless power transmission. The electrified road technology is a long-term solution for charging electric vehicles and eliminates the need for large, expensive batteries. The study also examines the present state of electrified highways in various nations, as well as their technical and economic viability. One of the primary advantages of electrified highways is the ability to increase the range of electric cars, which may charge continually while driving. Furthermore, electrified highways might eliminate the need for regular charging stations, that can be expensive to establish and manage. Nevertheless, implementing electrified roadways presents various problems, including significant infrastructure construction costs, the requirement for a standardized charging method, and the possible impact on the environment and animals. To maintain constant speed on a highway, the needed power transmission on eRoad with a wireless system is projected to be 20 kW-40 kW for passenger cars, and 100 kW and 180 kW for big trucks and buses, respectively. The overall prices of the test tracks ranged from $1-1.5 million per lane-mile for low power capacity (20-50 kW) to $4-6 million per lane-mile for high power capacity (200 kW) [121]. The results of these test reveal that the practicality of eRoad was demonstrated, with charging efficiency ranging from 70 to 95% depending on the air gap and coil/ferrite configuration.

Inductive Wireless Power Transfer (IPT) has many applications, including electric vehicle (EV) charging. Thongpron *et al.,* [122] has developed a 10 kW IPT prototype for EV charging. The prototype employs a resonant converter to match the impedance of the transmitting and receiving coils, improving power transfer efficiency. A feedback control mechanism is also used in the prototype to maintain a consistent output voltage and current, ensuring safe and dependable charging. The outcomes showed that when the prototype IPT system was applied to the resistive tungsten halogen load at 369.4 V DC input voltage and 32.33 A DC input current during the first stage of the study, the DC output voltage and currents were 362.4 V and 29.67 A, respectively, while the highest DC output power and dc-to-dc effectiveness associated to 10.75 kW and 90.00%, accordingly. Next, Barsari *et al.,* [123] study on Inductive Coupler Array for In-Motion Wireless Charging of Electric cars is a technology which enables electric cars to be charged wirelessly while in motion. The system operates by placing several inductive couplers in the road and connecting them to an electrical power source. One of the primary benefits of the Inductive Coupler Array is its capacity to charge numerous vehicles at the same time. As the couplers are organized in an array, numerous cars can drive over them at the same time. Furthermore, the system is weather-resistant, making it suited for usage in all sorts of weather situations. The method has various possible uses, including utilization in public transportation systems such as buses and trams, as well as private automobiles. It might potentially be employed in freight transportation, with electric trucks being wirelessly charged while travelling on roads. As coupling declines by around 50%, the efficiency of the push-pull driven coupler array (PPCA) observed was 80%. The circuit layout is proven using a three-coupler primary array capable of delivering up to 3.3 kW to two independent secondary loads. Enabling vehicles to charge while they are moving has the potential to make electric vehicles more practical and convenient for daily use. Lastly, Kim *et al.,* has conducted research on “Development of 1 MW Inductive Power Transfer System for a High-Speed Train” [124]. The study focused on the 1MW high power IPT system based on the inverter's delivering power. In contrast to the previous research, the system supplies propulsion power to the train in actual time without the need of a charger for batteries, and for efficient system design, a 60kHz operating frequency was employed instead of the standard 20kHz for high-powered operation. The results of a resistive load rated power test with a 128 m transmitter showed an efficiency of 82.7% with output power of 818 kW to input power of 989 kW. The IPT was applied to a real vehicle, the output voltage and current of the pick-up were recorded, and a high-speed train successfully ran at 10 km/h.

Table 1 and 2 summarize the results for the selected for both APT system and IPT system that has been review previously.

Synopsis of APT and IPT applications

There are number of research conducted in the field of AET and IPT. This research covers several application areas including medical, AUV, UAUV, Wall through power, aerospace and even in holograms. Both experimental and simulation modelling were used to design this research.

Medical applications:

High power in the receiving end is not required for medical appliances, to be specific for implantable devices. In fact, most of the application requires only mW to even µW level of received power. Therefore, most of the existing works focus on the reliability of the system, rather than the output power or efficiency. Hence, over 90% efficiency can be achieved (94.5% at 0.01 cm with 2.7 MHz operating frequency) using APT. Indeed, over-MHz range frequencies (40 kHz - 13.56 MHz) are preferred for medical applications using APT despite some with kHz frequencies. As can be seen from Table 1.

IPT is still in the experimental phase for implants compared to APT. IPT can achieve higher efficiency as well, over 90%. However, the energy density restrictions will limit the overall output power and will be within mW range as well.

Electric vehicles:

APT is strictly not suitable for wireless power for electric vehicles. As is requires over kW range with high efficiency. IPT, on the other hand, is well established in this interest. IPT can deliver high efficiency with high power up to 818 kW with 82.7% of efficiency at a 5 cm receiving distance. Table 2 depicts the improvements of IPT. Table 3 and 4 presents the summary of this review. Figure 1 and figure 2 shows several proposed APT and IPT systems.

Table 1
Selected APT system discussed in this paper

References	Operating frequency	Gaps (cm)	Operating power	Efficiency, %	Applications	Experiment
[67]	600 kHz – 1200 kHz	0 - 5	7 kPa	-	Medical	Simulation comsol
[68]	13.56 MHz	-	55 mW	59	Medical	Experimental
[69]	40 kHz	4	0.318 mW	69.4	Medical	Experimental
[1]	pMUT – 88 kHz	pMUT – 11 COTS - 3	pMUT – 417.7 mW	pMUT – 10.29	Medical	Experimental

	COTS – 628 kHz		COTS – 417.7 mW	COTS – 4.82		
[70]	915 MHz	120	8.2 dBm	87.2	Communication	Experimental
[71]	268 kHz	0.12	3.2 W	80	Wall through	Experimental
[72]	2.7 MHz	0.01	2.84 mW	94.5	Medical	Experimental (not confirmed)
[73]	5 Hz - 3 MHz	7.4	51.5 mW	75	Medical	Experimental
[74]	6.78 MHz	0.4	1.8 W	10	Medical	Experimental
[75]	1 MHz – 1.5 MHz	0 – 0.6	-	56	Medical	Simulation
[78]	100 kHz – 1.5 MHz	-	~ 3 µW	80	Medical	Experimental
[77]	40 kHz – 200 kHz	24	6 × 10-4 µW/cm^2	-	Medical	Experimental
[76]	3.5 MHz	0.1	-	>50	Medical	Experimental
[79]	1 MHz	11.57	0.64 MPa	50	Wall through	Simulation
[81]	100 kHz	6.2 – 18.6	55 W – 550 W	80	Medical	Experimental
[80]	3.6 MHz	1.85	9.43 mW	2.66	Medical	Experimental
[87]	16 kHz	-	-	-	System improvement	Numerical simulation
[90]	100 kHz	10	39.5 mW	65.2	Aerospace applications	Experimental
[83]	2.3 MHz	6	23.4 W	95.66	Holograms	Experimental
[84]	18 kHz – 34 kHz	4000	80 W	50	AUV	Simulation OMNeT++
[88]	3 kHz	1000	1.2 W	75	Underwater	Simulation
[89]	76 kHz	0.5	120 W	96	AUV	Experimental
[82]	192 kHz	10	1900 bps	40	AUV	Experimental
[86]	40 kHz	6	8 mW	4	Medium through EM-shielded cases	Simulation COMSOL
[85]	433 MHz	10 - 20	7.7 kW	38.5	Electric vehicles	Experimental

Table 2
Selected IPT system discussed in this paper

References	Operating frequency	Gaps, cm	Operating power	Efficiency, %	Applications	Experiment
[92]	945 kHz	2 - 15	-	73	System improvement	Experimental
[93]	88 kHz	20	20 kW	95.6	Electric vehicles	Experimental
[94]	415 MHz, 915 MHz and 1300 MHz	1.5 - 11	0.43 W/kg, 0.58 W/kg and 0.654 W/kg	72.26 at 1.5 cm	Medical	Experimental
[96]	147 kHz	15	40 W	~50	System improvement	Experimental
[97]	150 kHz	20	7.7 kW	38.5	Electric vehicles	Experimental
[99]	12 MHz	-	306 nW	-	Medical	Simulation
[95]	250 Hz	209	392 uW	99.8	Medical	Experimental

[100]	85 kHz	7	200 W	95	System improvement	Experimental
[101]	85 kHz	20	11 kW	82.9	Electric vehicles	Simulation
[102]	20 kHz	60	-	44	Wireless charging	Experimental
[103]	85 kHz	5	300 W	>71	Wireless charging	Experimental
[107]	100 Hz	-	100 W	53	Automation applications	Experimental
[109]	200 kHz	36	3 W	89.1	System improvement	Experimental
[108]	220 kHz	-	845 mW	81.69	Medical	Experimental
[104]	140 kHz	100	-	75	Wireless charging	Experimental
[106]	85 kHz	4	1 kW	80	Electric vehicles	Experimental
[110]	20 kHz	10	5.31 W	97.79	System improvement	Simulation
[105]	20 kHz	20	10.64 kW	93.2	Electric vehicles	Experimental
[111]	4 MHz	5.8 - 8	3 W	89	Electric vehicles	Experimental
[113]	200 kHz	6, 12 and 18	-	60, 60 and 53	System improvement	Experimental
[114]	100 kHz	Low – medium	100 W	>80	Electric vehicles	Simulation
	50 kHz – 55 kHz	High	60 W	70 - 78		Simulation
[115]	83 kHz	2	800 W	65	System improvement	Experimental
[123]	83 kHz	~6	3.3 kW	91.41	Electric vehicles	
[116]	75 kHz	50	20 kW	71.5	Electric vehicles	Experimental
[117]	86 kHz	1.5 - 2	10 W	75	Electric vehicles	Experimental
[118]	87 kHz	75.3	5.184 W	17.28	Foreign object detection	Experimental
[119]	81.2 kHz	22	9.42 kW	94.2	Electric vehicles	Experimental
[122]	20 kHz	16	10.75 kW	90	Electric vehicles	Experimental
[123]	83 kHz	20	3.3 kW	80	Electric vehicles	Experimental
[124]	60 kHz	5 cm	818 kW	82.7	High Speed Train	Experimental

Table 3
Summary of the review for AWPT

AWPT type	Frequency (min – max)	Gaps (cm) (max)	Efficiency (%)	Output Power (max)
Medical	5 Hz – 13.56 MHz	18.6	94.5	550 W
Communication	915 MHz	120	87.2	8.2 dBm

Wall-through	40 kHz - 1 MHz	6	80	3.2 W
System improvement	16 kHz	-	-	-
Aerospace applications	100 kHz	10	65.2	39.2mW
Holograms	2.3 MHz	6	95.66	23.4 W
AUV	18 kHz – 192 kHz	4000	96	120 W
Underwater applications	3 kHz	1000	75	1.2 W
EV	433 MHz	20	38.5	7.7 kW

Table 4
Summary of the review for IPT

IPT type	Frequency (min – max)	Gaps (cm) (max)	Efficiency (%) (max)	Output power (max)
System improvement	20 kHz – 945 kHz	36	97.79	800 W
EV	20 kHz – 4 MHz	50	94.2	818 kW
Medical	250 Hz – 1300 MHz	93	99.8	844.9 mW
Wireless charging	20 kHz – 140 kHz	100	75	300 W
Automation app	100 Hz	-	53	150 W
Foreign object detection	87 kHz	75.3	17.28	5.18

4. Conclusions

We can conclude from the aforementioned review is that WPT is widely used in wireless powering through walls, biomedical implants, charging electric automobiles, and many more applications. Both safety considerations and system performance of the WPT is the main point for recent developments. As such, APT is more suitable for the in vivo applications, i.e., medical implants, where safety concerns are more important. In comparison, IPTs are recommended for high power transfer within small gap between the transmitter and the receiver. In developments, APT has already surpassed the power range of 1kW and reached 88% efficiency and can deliver power to an adequate 400 mm depth for deep tissue implants. Even so, the system still can be improved in terms of efficiency. So far, APT systems have recorded the highest system efficiency of 96.75%. In contrast, IPT is well suited for high power transfer and to be specific electric is the primary application. In fact, several literature support IPT application for KW or even close to MW range power transfer with an attractive 82.7% efficiencies. However, IPT can achieve over 99% efficiencies for some specific applications.

This review suggested that the combination of APT and IPT can be beneficial in many ways, from enhancing safety to efficiency. As such, a hybrid novel power delivering system is the future agenda of this work.

Acknowledgement
This work is partially supported by Universiti Malaysia Terengganu, under fundamental research grant scheme (Ref: FRGS/1/2019/TK04/UMT/03/1), Ministry of Higher Education, Government of Malaysia.

References

[1] Basaeri, Hamid, Yuechuan Yu, Darrin Young, and Shad Roundy. "Acoustic power transfer for biomedical implants using piezoelectric receivers: effects of misalignment and misorientation." Journal of Micromechanics and Microengineering 29, no. 8 (2019): 084004. https://doi.org/10.1088/1361-6439/ab257f

[2] Beh, Hui Zhi Zak, Grant A. Covic, and John T. Boys. "Wireless fleet charging system for electric bicycles." IEEE journal of emerging and selected topics in power electronics 3, no. 1 (2014): 75-86. https://doi.org/10.1109/JESTPE.2014.2319104

[3] El-Shahat, Adel, Erhuvwu Ayisire, Yan Wu, Mosfequr Rahman, and Dylan Nelms. "Electric vehicles wireless power transfer state-of-the-art." Energy Procedia 162 (2019): 24-37. https://doi.org/10.1016/j.egypro.2019.04.004

[4] Mai, Ruikun, Yang Chen, Yong Li, Youyuan Zhang, Guangzhong Cao, and Zhengyou He. "Inductive power transfer for massive electric bicycles charging based on hybrid topology switching with a single inverter." IEEE Transactions on Power Electronics 32, no. 8 (2017): 5897-5906. https://doi.org/10.1109/TPEL.2017.2654360

[5] Tesla, Nikola. "Experiments with alternate currents of very high frequency and their application to methods of artificial illumination." Trans. Am. Inst. Electr. Eng 8, no. 1 (1891): 266-319. https://doi.org/10.1109/t-aiee.1891.5570149

[6] House, William F. "Cochlear implants." Annals of Otology, Rhinology & Laryngology 85, no. 3_suppl (1976): 3-3. https://doi.org/10.1177/00034894760850S303

[7] Ko, Wen H., Sheau P. Liang, and Cliff DF Fung. "Design of radio-frequency powered coils for implant instruments." Medical and Biological Engineering and Computing 15 (1977): 634-640. https://doi.org/10.1007/BF02457921

[8] Gozalvez, Javier. "Advances in wireless power transfer [Mobile Radio]." IEEE Vehicular Technology Magazine 10, no. 4 (2015): 14-32. https://doi.org/10.1109/MVT.2015.2484140

[9] Awal, Md Rabiul, Muzammil Jusoh, Thennarasan Sabapathy, Muhammad Ramlee Kamarudin, and Rosemizi Abd Rahim. "State-of-the-art developments of acoustic energy transfer." International Journal of Antennas and Propagation 2016 (2016). https://doi.org/10.1155/2016/3072528

[10] Kawanabe, Hideyuki, Tamotsu Katane, Hideo Saotome, Osami Saito, and Kazuhito Kobayashi. "Power and information transmission to implanted medical device using ultrasonic." Japanese journal of applied physics 40, no. 5S (2001): 3865. https://doi.org/10.1143/JJAP.40.3865

[11] Elsässer, Klaus, and Hamid Saleem. "Low-frequency thermal noise in magnetized plasmas." Physica Scripta 53, no. 6 (1996): 720. https://doi.org/10.1088/0031-8949/53/6/014

[12] Mazzilli, Francesco, Michela Peisino, Rostand Mitouassiwou, Benjamin Cotté, Prakash Thoppay, Cyril Lafon, Patrick Favre, Eric Meurville, and Catherine Dehollain. "In-vitro platform to study ultrasound as source for wireless energy transfer and communication for implanted medical devices." In 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology, pp. 3751-3754. IEEE, 2010. https://doi.org/10.1109/IEMBS.2010.5627541

[13] Bao, Xiaoqi, Will Biederman, Stewart Sherrit, Mircea Badescu, Yoseph Bar-Cohen, Christopher Jones, Jack Aldrich, and Zensheu Chang. "High-power piezoelectric acoustic-electric power feedthru for metal walls." In Industrial and Commercial Applications of Smart Structures Technologies 2008, vol. 6930, pp. 291-298. SPIE, 2008. https://doi.org/10.1117/12.776473

[14] Maleki, Teimour, Ning Cao, Seung Hyun Song, Chinghai Kao, Song-Chu Ko, and Babak Ziaie. "An ultrasonically powered implantable micro-oxygen generator (IMOG)." IEEE transactions on Biomedical Engineering 58, no. 11 (2011): 3104-3111. https://doi.org/10.1109/TBME.2011.2163634

[15] Valdastri, Pietro, Ekawahyu Susilo, Thilo Forster, Christof Strohhofer, Arianna Menciassi, and Paolo Dario. "Wireless implantable electronic platform for chronic fluorescent-based biosensors." IEEE transactions on Biomedical Engineering 58, no. 6 (2011): 1846-1854. https://doi.org/10.1109/TBME.2011.2123098

[16] Arra, Satu, Jarkko Leskinen, Janne Heikkila, and Jukka Vanhala. "Ultrasonic power and data link for wireless implantable applications." In 2007 2nd International Symposium on Wireless Pervasive

Computing. IEEE, 2007. https://doi.org/10.1109/ISWPC.2007.342668
[17] Shung, K. Kirk, and Michael Zippuro. "Ultrasonic transducers and arrays." IEEE Engineering in Medicine and Biology Magazine 15, no. 6 (1996): 20-30. https://doi.org/10.1109/51.544509
[18] Denisov, Alexey, and Eric Yeatman. "Ultrasonic vs. inductive power delivery for miniature biomedical implants." In 2010 International Conference on Body Sensor Networks, pp. 84-89. IEEE, 2010. https://doi.org/10.1109/BSN.2010.27
[19] Zhou, Gouqing, Chaokui Li, and Penggen Cheng. "Unmanned aerial vehicle (UAV) real-time video registration for forest fire monitoring." In Proceedings. 2005 IEEE International Geoscience and Remote Sensing Symposium, 2005. IGARSS'05., vol. 3, pp. 1803-1806. IEEE, 2005. https://doi.org/10.1109/IGARSS.2005.1526355
[20] Kumar, Vijay, and Nathan Michael. "Opportunities and challenges with autonomous micro aerial vehicles." The International Journal of Robotics Research 31, no. 11 (2012): 1279-1291. https://doi.org/10.1177/0278364912455954
[21] Abdilla, Analiza, Arthur Richards, and Stephen Burrow. "Power and endurance modelling of battery-powered rotorcraft." In 2015 IEEE/RSJ international conference on intelligent robots and systems (IROS), pp. 675-680. IEEE, 2015. https://doi.org/10.1109/IROS.2015.7353445
[22] Plaizier, Gregory M., Erik Andersen, Binh Truong, Xiang He, Shad Roundy, and Kam K. Leang. "Design, modeling, and analysis of inductive resonant coupling wireless power transfer for micro aerial vehicles (MAVs)." In 2018 IEEE International Conference on Robotics and Automation (ICRA), pp. 6104-6109. IEEE, 2018. https://doi.org/10.1109/ICRA.2018.8461162
[23] Benito, Juan Alberto, Guillermo Glez-de-Rivera, Javier Garrido, and Roberto Ponticelli. "Design considerations of a small UAV platform carrying medium payloads." In Design of Circuits and Integrated Systems, pp. 1-6. IEEE, 2014. https://doi.org/10.1109/DCIS.2014.7035583
[24] Hsu, Jr-Uei William, Aiguo Patrick Hu, and Akshya Swain. "A wireless power pickup based on directional tuning control of magnetic amplifier." IEEE Transactions on Industrial Electronics 56, no. 7 (2009): 2771-2781. https://doi.org/10.1109/TIE.2009.2020081
[25] Li, Yan-Ling, Yue Sun, and Xin Dai. "/spl mu/-synthesis for frequency uncertainty of the ICPT system." IEEE Transactions on Industrial Electronics 60, no. 1 (2011): 291-300. https://doi.org/10.1109/TIE.2011.2170394
[26] Mai, Ruikun, Liwen Lu, Yong Li, Tianren Lin, and Zhengyou He. "Circulating current reduction strategy for parallel-connected inverters based IPT systems." Energies 10, no. 3 (2017): 261. https://doi.org/10.3390/en10030261
[27] Vu, Tuan Anh, Van Chi Pham, Anh Vu Pham, and Christopher Gardner. "Wireless power transfer through metal using inductive link." International Journal of Power Electronics and Drive Systems (IJPEDS) 10, no. 4 (2019). http://doi.org/10.11591/ijpeds.v10.i4.pp1906-1913
[28] Fukuda, H., N. Kobayashi, K. Shizuno, S. Yoshida, M. Tanomura, and Y. Hama. "New concept of an electromagnetic usage for contactless communication and power transmission in the ocean." In 2013 IEEE International Underwater Technology Symposium (UT), pp. 1-4. IEEE, 2013. https://doi.org/10.1109/UT.2013.6519896
[29] Kim, Jae Hee, Byung-Song Lee, Jun-Ho Lee, Seung-Hwan Lee, Chan-Bae Park, Shin-Myung Jung, Soo-Gil Lee, Kyung-Pyo Yi, and Jeihoon Baek. "Development of 1-MW inductive power transfer system for a high-speed train." IEEE Transactions on Industrial Electronics 62, no. 10 (2015): 6242-6250. https://doi.org/10.1109/TIE.2015.2417122
[30] Li, Weihan, Han Zhao, Siqi Li, Junjun Deng, Tianze Kan, and Chunting Chris Mi. "Integrated ${LCC} $ compensation topology for wireless charger in electric and plug-in electric vehicles." IEEE Transactions on Industrial Electronics 62, no. 7 (2014): 4215-4225. https://doi.org/10.1109/TIE.2014.2384003
[31] Beh, Hui Zhi Zak, Grant A. Covic, and John T. Boys. "Investigation of magnetic couplers in bicycle kickstands for wireless charging of electric bicycles." IEEE Journal of Emerging and Selected Topics in Power Electronics 3, no. 1 (2014): 87-100. https://doi.org/10.1109/JESTPE.2014.2325866
[32] Boys, J. T., G. A. Covic, and A. Williamson Green. "Stability and control of inductively coupled power transfer systems." IEE Proceedings-Electric Power Applications 147, no. 1 (2000): 37-43.

https://doi.org/10.1049/ip-epa:20000017
[33] Woo, Kyung Il, Han Seok Park, Yun Hyun Cho, and Kyung Ho Kim. "Contactless energy transmission system for linear servo motor." IEEE Transactions on Magnetics 41, no. 5 (2005): 1596-1599. https://doi.org/10.1109/TMAG.2005.845025
[34] Wu, Hunter Hanzhuo, John T. Boys, and Grant Anthony Covic. "An AC processing pickup for IPT systems." IEEE Transactions on Power Electronics 25, no. 5 (2009): 1275-1284. https://doi.org/10.1109/TPEL.2009.2037002
[35] Kim, Chang-Gyun, Dong-Hyun Seo, Jung-Sik You, Jong-Hu Park, and Bo-Hyung Cho. "Design of a contactless battery charger for cellular phone." IEEE Transactions on Industrial Electronics 48, no. 6 (2001): 1238-1247. https://doi.org/10.1109/41.969404
[36] Zhong, W. X., Xun Liu, and SY Ron Hui. "A novel single-layer winding array and receiver coil structure for contactless battery charging systems with free-positioning and localized charging features." IEEE Transactions on Industrial Electronics 58, no. 9 (2010): 4136-4144. https://doi.org/10.1109/TIE.2010.2098379
[37] Si, Ping, Aiguo Patrick Hu, Simon Malpas, and David Budgett. "A frequency control method for regulating wireless power to implantable devices." IEEE transactions on biomedical circuits and systems 2, no. 1 (2008): 22-29. https://doi.org/10.1109/TBCAS.2008.918284
[38] Wang, Guoxing, Wentai Liu, Mohanasankar Sivaprakasam, and Gurhan Alper Kendir. "Design and analysis of an adaptive transcutaneous power telemetry for biomedical implants." IEEE Transactions on Circuits and Systems I: Regular Papers 52, no. 10 (2005): 2109-2117. https://doi.org/10.1109/TCSI.2005.852923
[39] Roes, Maurice GL, Jorge L. Duarte, Marcel AM Hendrix, and Elena A. Lomonova. "Acoustic energy transfer: A review." IEEE Transactions on Industrial Electronics 60, no. 1 (2012): 242-248. https://doi.org/10.1109/TIE.2012.2202362
[40] Zaid, Thoriq, Shakir Saat, Yusmarnita Yusop, and Norezmi Jamal. "Contactless energy transfer using acoustic approach-A review." In 2014 International conference on computer, communications, and control technology (I4CT), pp. 376-381. IEEE, 2014. https://doi.org/10.1109/I4CT.2014.6914209
[41] Vaiarello, Yannick, William Tatinian, Yves Leduc, Nicolas Veau, and Gilles Jacquemod. "Ultra-low-power radio microphone for cochlear implant application." IEEE Journal on Emerging and Selected Topics in Circuits and Systems 1, no. 4 (2011): 622-630. https://doi.org/10.1109/JETCAS.2011.2177930
[42] Graham, David J., Jeffrey A. Neasham, and Bayan S. Sharif. "Investigation of methods for data communication and power delivery through metals." IEEE Transactions on industrial electronics 58, no. 10 (2011): 4972-4980. https://doi.org/10.1109/TIE.2010.2103535
[43] Yang, Ding-Xin, Zheng Hu, Hong Zhao, Hai-Feng Hu, Yun-Zhe Sun, and Bao-Jian Hou. "Through-metal-wall power delivery and data transmission for enclosed sensors: A review." Sensors 15, no. 12 (2015): 31581-31605. https://doi.org/10.3390/s151229870
[44] Zangl, Hubert, Anton Fuchs, Thomas Bretterklieber, Michael J. Moser, and Gert Holler. "Wireless communication and power supply strategy for sensor applications within closed metal walls." IEEE Transactions on Instrumentation and Measurement 59, no. 6 (2010): 1686-1692. https://doi.org/10.1109/TIM.2009.2026602
[45] El-Ashmawy, Nessma Ibrahim, and A. M. M. Allam. "Dual Band U-Shaped Microstrip Antenna."
[46] Lin, Mark, Amrita Kumar, Xinlin Qing, Shawn J. Beard, Samuel S. Russell, James L. Walker, and Thomas K. Delay. "Monitoring the integrity of filament-wound structures using built-in sensor networks." In Smart Structures and Materials 2003: Industrial and Commercial Applications of Smart Structures Technologies, vol. 5054, pp. 222-229. SPIE, 2003. https://doi.org/10.1117/12.483877
[47] Lueke, Jonathan, and Walied A. Moussa. "MEMS-based power generation techniques for implantable biosensing applications." Sensors 11, no. 2 (2011): 1433-1460. https://doi.org/10.3390/s110201433
[48] Kurs, Andre, Aristeidis Karalis, Robert Moffatt, John D. Joannopoulos, Peter Fisher, and Marin Soljacic. "Wireless power transfer via strongly coupled magnetic resonances." science 317, no. 5834 (2007): 83-86. https://doi.org/10.1126/science.1143254
[49] Van Pham, Chi, Tuan Anh Vu, William Tran, Anh-Vu Pham, and Christopher S. Gardner. "Wireless energy

harvesting system through metal for aerospace sensor." In 2018 IEEE Transportation Electrification Conference and Expo (ITEC), pp. 545-549. IEEE, 2018. https://doi.org/10.1109/ITEC.2018.8450098
[50] Covic, Grant A., and John T. Boys. "Inductive power transfer." Proceedings of the IEEE 101, no. 6 (2013): 1276-1289. https://doi.org/10.1109/JPROC.2013.2244536
[51] Seo, Young-Sik, Zachariah Hughes, Matt Hoang, Deena Isom, Minh Nguyen, Smitha Rao, and J-C. Chiao. "Investigation of wireless power transfer in through-wall applications." In 2012 Asia Pacific Microwave Conference Proceedings, pp. 403-405. IEEE, 2012. https://doi.org/10.1109/APMC.2012.6421612
[52] Budhia, Mickel, Grant A. Covic, and John T. Boys. "Design and optimization of circular magnetic structures for lumped inductive power transfer systems." IEEE Transactions on Power Electronics 26, no. 11 (2011): 3096-3108. https://doi.org/10.1109/TPEL.2011.2143730
[53] Nagatsuka, Yuichi, Shingo Noguchi, Yasuyoshi Kaneko, Shigeru Abe, Tomio Yasuda, Kazuhiko Ida, Akira Suzuki, and Ryoichi Yamanouchi. "Contactless power transfer system for electric vehicle battery charger." In The 25th World Battery, Hybrid and Fuel Cell Electric Vehicle Symposium & Exhibition, China. 2010.
[54] Villa, Juan Luis, Jesús Sallán, Andrés Llombart, and José Fco Sanz. "Design of a high frequency inductively coupled power transfer system for electric vehicle battery charge." Applied Energy 86, no. 3 (2009): 355-363. https://doi.org/10.1016/j.apenergy.2008.05.009
[55] Huh, Jin, Sung W. Lee, Woo Y. Lee, Gyu H. Cho, and Chun T. Rim. "Narrow-width inductive power transfer system for online electrical vehicles." IEEE Transactions on Power Electronics 26, no. 12 (2011): 3666-3679. https://doi.org/10.1109/TPEL.2011.2160972
[56] Pantic, Zeljko, Sanzhong Bai, and Srdjan M. Lukic. "Inductively coupled power transfer for continuously powered electric vehicles." In 2009 IEEE Vehicle Power and Propulsion Conference, pp. 1271-1278. IEEE, 2009. https://doi.org/10.1109/VPPC.2009.5289705
[57] Boys, John T., Grant AJ Elliott, and Grant A. Covic. "An appropriate magnetic coupling co-efficient for the design and comparison of ICPT pickups." IEEE Transactions on Power Electronics 22, no. 1 (2007): 333-335. https://doi.org/10.1109/TPEL.2006.887590
[58] Cochran, G. V. B., M. W. Johnson, M. P. Kadaba, F. Vosburgh, M. W. Ferguson-Pell, and V. R. Palmeiri. "Piezoelectric internal fixation devices: A new approach to electrical augmentation of osteogenesis." Journal of orthopaedic research 3, no. 4 (1985): 508-513. https://doi.org/10.1002/jor.1100030414
[59] Cochran, George VB, Murali P. Kadaba, and Vincent R. Palmieri. "External ultrasound can generate microampere direct currents in vivo from implanted piezoelectric materials." Journal of orthopaedic research 6, no. 1 (1988): 145-147. https://doi.org/10.1002/jor.1100060119
[60] Suzuki, Shin-nosuke, Shunsuke Kimura, Tamotsu Katane, Hideo Saotome, Osami Saito, and Kazuhito Kobayashi. "Power and interactive information transmission to implanted medical device using ultrasonic." Japanese journal of applied physics 41, no. 5S (2002): 3600. https://doi.org/10.1143/JJAP.41.3600
[61] Suzuki, Shin-nosuke, Tamotsu Katane, and Osami Saito. "Fundamental study of an electric power transmission system for implanted medical devices using magnetic and ultrasonic energy." Journal of Artificial Organs 6 (2003): 145-148. https://doi.org/10.1007/s10047-003-0209-9
[62] Hu, Yuantai, Xuesong Zhang, Jiashi Yang, and Qing Jiang. "Transmitting electric energy through a metal wall by acoustic waves using piezoelectric transducers." IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control 50, no. 7 (2003): 773-781. https://doi.org/10.1109/TUFFC.2003.1214497
[63] Sherrit, Stewart, Mircea Badescu, Xiaoqi Bao, Yoseph Bar-Cohen, and Zensheu Chang. "Efficient electromechanical network model for wireless acoustic-electric feed-throughs." In Smart Structures and Materials 2005: Smart Sensor Technology and Measurement Systems, vol. 5758, pp. 362-372. SPIE, 2005. https://doi.org/10.1117/12.598300
[64] Sherrit, Stewart, Benjamin Doty, Mircea Badescu, Xiaoqi Bao, Yoseph Bar-Cohen, Jack Aldrich, and Zensheu Chang. "Studies of acoustic-electric feed-throughs for power transmission through structures." In Smart Structures and Materials 2006: Industrial and Commercial Applications of Smart Structures Technologies, vol. 6171, pp. 8-15. SPIE, 2006. https://doi.org/10.1117/12.657736

[65] Nemoto, Tetsuya, Zenzo Isogai, Kazuharu Koide, Yasumi Itoh, Fumio Nogata, Akira Shimamoto, Dong-Ying Ju, and Hiroyuki Matsuura. "Evaluation of dermal segment on viscoelasticity measurement of skin by rheometer." In Health Monitoring of Structural and Biological Systems 2007, vol. 6532, pp. 660-667. SPIE, 2007. https://doi.org/10.1117/12.715636

[66] Sherrit, S., X. Bao, M. Badescu, J. Aldrich, Y. Bar-Cohen, W. Biederman, and Z. Chang. "1 kW power transmission using wireless acoustic-electric feedthrough (WAEF)." In Earth & Space 2008: Engineering, Science, Construction, and Operations in Challenging Environments, pp. 1-10. 2008. https://doi.org/10.1061/40988(323)120

[67] Siddiqui, Ariba, and Amber Khan. "Mechanism and optimization of acoustic power transfer systems." In 2019 International Conference on Power Electronics, Control and Automation (ICPECA), pp. 1-6. IEEE, 2019. https://doi.org/10.1109/ICPECA47973.2019.8975391

[68] Qian, Xin-Hong, Yi-Chung Wu, Tzu-Yi Yang, Cheng-Hsiang Cheng, Hsing-Chien Chu, Wan-Hsueh Cheng, Ting-Yang Yen et al. "Design and in vivo verification of a CMOS bone-guided cochlear implant microsystem." IEEE Transactions on Biomedical Engineering 66, no. 11 (2019): 3156-3167. https://doi.org/10.1109/TBME.2019.2901374

[69] Mahmood, Mustafa F., Saleem Latteef Mohammed, and Sadik Kamel Gharghan. "Ultrasound sensor-based wireless power transfer for low-power medical devices." Journal of Low Power Electronics and Applications 9, no. 3 (2019): 20. https://doi.org/10.3390/jlpea9030020

[70] Lin, Wei, and Richard W. Ziolkowski. "Electrically small Huygens antenna-based fully-integrated wireless power transfer and communication system." IEEE Access 7 (2019): 39762-39769. https://doi.org/10.1109/ACCESS.2019.2903545

[71] Freychet, O., S. Boisseau, F. Frassati, V. Josselin, P. Gasnier, N. Garraud, R. Gohier, D. Gibus, S. Brulais, and G. Despesse. "A versatile through-metal-wall acoustic power and data transfer solution." In 2019 19th International Conference on Micro and Nanotechnology for Power Generation and Energy Conversion Applications (PowerMEMS), pp. 1-6. IEEE, 2019. https://doi.org/10.1109/PowerMEMS49317.2019.92321100357

[72] Rashidi, Amin, Kjeld Laursen, Seyedsina Hosseini, Hai-Au Huynh, and Farshad Moradi. "An implantable ultrasonically powered system for optogenetic stimulation with power-efficient active rectifier and charge-reuse capability." IEEE Transactions on Biomedical Circuits and Systems 13, no. 6 (2019): 1362-1371. https://doi.org/10.1109/TBCAS.2019.2949154

[73] Bhargava, Aarushi, and Shima Shahab. "Acoustic-electroelastic modeling of piezoelectric disks in high-intensity focused ultrasound power transfer systems." Journal of Intelligent Material Systems and Structures 32, no. 11 (2021): 1215-1233. https://doi.org/10.1177/1045389X20975478

[74] Kim, Junho, Hyeok Kim, Dongwook Kim, Hun-Jun Park, Kiwon Ban, Seungyoung Ahn, and Sung-Min Park. "A wireless power transfer based implantable ECG monitoring device." Energies 13, no. 4 (2020): 905. https://doi.org/10.3390/en13040905

[75] Sedaghatkish, Amir, Mohsen Rezaeian, Hamidreza Heydari, Ali Mohammad Ranjbar, and M. Soltani. "Acoustic streaming and thermosensitive liposomes for drug delivery into hepatocellular carcinoma tumor adjacent to major hepatic veins; an acoustics–thermal–fluid-mass transport coupling model." International Journal of Thermal Sciences 158 (2020): 106540. https://doi.org/10.1016/j.ijthermalsci.2020.106540

[76] Groen, MH A., FJ B. Slieker, A. Vink, G. J. de Borst, M. V. Simons, E. S. Ebbini, P. A. Doevendans, C. E. V. B. Hazenberg, and R. van Es. "Safety and feasibility of arterial wall targeting with robot-assisted high intensity focused ultrasound: A preclinical study." International Journal of Hyperthermia 37, no. 1 (2020): 903-912. https://doi.org/10.1080/02656736.2020.1795278

[77] Yosra, Dammak, Dominique Certon, François Vander Meulon, Samuel Callé, Thien Hoang, Guillaume Ferin, and Bogdan Rosinski. "Contactless Acoustic Power Transmission through air/Skin interface: A feasibility study." In 2020 IEEE International Ultrasonics Symposium (IUS), pp. 1-3. IEEE, 2020. https://doi.org/10.1109/IUS46767.2020.9251451

[78] Shen, Konlin, and Michel M. Maharbiz. "Design of ceramic packages for ultrasonically coupled implantable medical devices." IEEE Transactions on Biomedical Engineering 67, no. 8 (2019): 2230-

2240. https://doi.org/10.1109/TBME.2019.2957732

[79] Meesala, Vamsi C., Muhammad R. Hajj, and Shima Shahab. "Analysis and prediction of shock formation in acoustic energy transfer systems." Journal of Applied Physics 128, no. 23 (2020). https://doi.org/10.1063/5.0026645

[80] Kim, Kyungmin, Seok Geun Jang, Hae Gyun Lim, Hyung Ham Kim, and Sung-Min Park. "Acoustic power transfer using self-focused transducers for miniaturized implantable neurostimulators." IEEE Access 9 (2021): 153850-153862. https://doi.org/10.1109/ACCESS.2021.3127875

[81] Pop, Flavius, Bernard Herrera, Cristian Cassella, and Matteo Rinaldi. "Modeling and optimization of directly modulated piezoelectric micromachined ultrasonic transducers." Sensors 21, no. 1 (2020): 157. https://doi.org/10.3390/s21010157

[82] Coccolo, Emanuele, Filippo Campagnaro, Davide Tronchin, Antonio Montanari, Roberto Francescon, Lorenzo Vangelista, and Michele Zorzi. "Underwater acoustic modem for a morphing distributed autonomous underwater vehicle (MODA)." In OCEANS 2022-Chennai, pp. 1-8. IEEE, 2022. https://doi.org/10.1109/OCEANSChennai45887.2022.9775308

[83] Bakhtiari-Nejad, Marjan. "Multi-focal transmission acoustic phase holograms in contactless ultrasonic power transfer systems." Sensors and Actuators A: Physical 340 (2022): 113551. https://doi.org/10.1016/j.sna.2022.113551

[84] Danielis, Peter, Helge Parzyjegla, Mostafa Assem Mohamed Ali, and Frank Sill Torres. "Simulation model for energy consumption and acoustic underwater communication of autonomous underwater vehicles." WMU Journal of Maritime Affairs (2021): 1-19. https://doi.org/10.1007/s13437-021-00253-z

[85] Yang, Zenan, Yin Wu, and Yanyi Liu. "A Wireless Acoustic Emission Sensor System with ACMD-IGWO-XGBoost Algorithm for Living Tree Moisture Content Diagnosis." Plants 12, no. 3 (2023): 601. https://doi.org/10.3390/plants12030601

[86] Kim, Hyun Soo, Sunghoon Hur, Dong-Gyu Lee, Joonchul Shin, Huimin Qiao, Seunguk Mun, Hoontaek Lee et al. "Ferroelectrically augmented contact electrification enables efficient acoustic energy transfer through liquid and solid media." Energy & Environmental Science 15, no. 3 (2022): 1243-1255. https://doi.org/10.1039/D1EE02623B

[87] Zhang, Jie, Jun Du, and Li-Rong Dai. "Sensor selection for relative acoustic transfer function steered linearly-constrained beamformers." IEEE/ACM Transactions on Audio, Speech, and Language Processing 29 (2021): 1220-1232. https://doi.org/10.1109/TASLP.2021.3064399

[88] Somani, NISHA A., and N. I. R. B. H. A. Y. Chaubey. "Experimental analysis of vector based forwarding and depth based routing protocols in underwater acoustic sensor network (Uw-Asns) by varying network size." Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/Journal of Tianjin University Science and Technology 55, no. 01 (2022): 137-148. https://doi.org/10.17605/OSF.IO/QDXFM

[89] Wang, Zhongda, Xiyou Chen, and Xin Jin. "A Wireless Power Transmission System With High Misalignment Tolerance and High Efficiency for Autonomous Underwater Vehicles." In Journal of Physics: Conference Series, vol. 2245, no. 1, p. 012007. IOP Publishing, 2022. https://doi.org/10.1088/1742-6596/2245/1/012007

[90] Grigg, Stephen, Rhys Pullin, Matthew Pearson, David Jenman, Robert Cooper, Andrew Parkins, and Carol Ann Featherston. "Development of a low-power wireless acoustic emission sensor node for aerospace applications." Structural Control and Health Monitoring 28, no. 4 (2021): e2701. https://doi.org/10.1002/stc.2701

[91] Choi, Su Y., Beom W. Gu, Sung W. Lee, Woo Y. Lee, Jin Huh, and Chun T. Rim. "Generalized active EMF cancel methods for wireless electric vehicles." IEEE Transactions on Power Electronics 29, no. 11 (2013): 5770-5783. https://doi.org/10.1109/TPEL.2013.2295094

[92] Lum, Kin Yun, and Tian Swee Tan. "Improved Transfer Efficiency of Wireless Power Transmission System featuring Coil-Size Disparity." Progress in Energy and Environment (2017): 9-16. https://orcid.org/0000-0003-3815-4390

[93] Deng, Qijun, Jiangtao Liu, Dariusz Czarkowski, Wenshan Hu, and Hong Zhou. "An inductive power transfer system supplied by a multiphase parallel inverter." IEEE Transactions on Industrial Electronics

64, no. 9 (2017): 7039-7048. https://doi.org/10.1109/TIE.2017.2686351
[94] Shadid, Reem, Mohammad Haerinia, Sayan Roy, and Sima Noghanian. "Hybrid inductive power transfer and wireless antenna system for biomedical implanted devices." Progress in Electromagnetics Research C 88 (2018): 77. https://doi.org/10.2528/PIERC18061604
[95] Rahman, Muhammad Fithratur, Yong Hun Jang, Sang Hyun Lee, and Illsoo Sohn. "Low-Power Wireless Communication for Wireless Power Transfer Device." In 2020 IEEE Wireless Power Transfer Conference (WPTC), pp. 369-372. IEEE, 2020. https://doi.org/10.1109/WPTC48563.2020.9295560
[96] Liu, Jiangtao, Qijun Deng, Dariusz Czarkowski, Marian K. Kazimierczuk, Hong Zhou, and Wenshan Hu. "Frequency optimization for inductive power transfer based on AC resistance evaluation in Litz-wire coil." IEEE Transactions on Power Electronics 34, no. 3 (2018): 2355-2363. https://doi.org/10.1109/TPEL.2018.2839626
[97] Zucca, Mauro, Oriano Bottauscio, Stuart Harmon, Roberta Guilizzoni, Florian Schilling, Matthias Schmidt, Peter Ankarson et al. "Metrology for inductive charging of electric vehicles (MICEV)." In 2019 AEIT International Conference of Electrical and Electronic Technologies for Automotive (AEIT AUTOMOTIVE), pp. 1-6. IEEE, 2019. https://doi.org/10.23919/EETA.2019.8804498
[98] Guidi, Giuseppe, Anastasios M. Lekkas, Jon Eivind Stranden, and Jon Are Suul. "Dynamic wireless charging of autonomous vehicles: Small-scale demonstration of inductive power transfer as an enabling technology for self-sufficient energy supply." IEEE Electrification Magazine 8, no. 1 (2020): 37-48. https://doi.org/10.1109/MELE.2019.2962888
[99] Kempi, Ilia, Nouman Ahmed, Andreas Hammer, Olaitan Olabode, Vishnu Unnikrishnan, Marko Kosunen, and Jussi Ryynänen. "Resilient flow control for wireless data streaming in inductively coupled medical implants." Microprocessors and microsystems 72 (2020): 102905. https://doi.org/10.1016/j.micpro.2019.102905
[100] Namadmalan, Alireza, Behzad Jaafari, Atif Iqbal, and Mohammed Al-Hitmi. "Design optimization of inductive power transfer systems considering bifurcation and equivalent AC resistance for spiral coils." IEEE Access 8 (2020): 141584-141593. https://doi.org/10.1109/ACCESS.2020.3013120
[101] Stoyka, Kateryna, Luca De Guglielmo, Giulia Di Capua, and Nicola Femia. "Transmitter Input Current Modeling in Electric Vehicles Dynamic Charging IPT Systems." In 2020 27th IEEE International Conference on Electronics, Circuits and Systems (ICECS), pp. 1-4. IEEE, 2020. https://doi.org/10.1109/ICECS49266.2020.9294963
[102] Song, Shuangcheng, Shuai Dong, and Qianfan Zhang. "Receiver current-stress mitigation for a dynamic wireless charging system employing constant resistance control." IEEE Transactions on Power Electronics 36, no. 4 (2020): 3883-3893. https://doi.org/10.1109/TPEL.2020.3019493
[103] Xia, Nenghong, Zhipeng Yuan, Yimin Zhu, and Yueyue Wang. "Integrated receiver with high misalignment tolerance used in dynamic wireless charging." IET Electric Power Applications 14, no. 10 (2020): 1918-1924. https://doi.org/10.1049/iet-epa.2019.0163
[104] Bouattour, Ghada, Mohamed Elhawy, Slim Naifar, Christian Viehweger, Houda Ben Jmaa Derbel, and Olfa Kanoun. "Multiplexed supply of a MISO wireless power transfer system for battery-free wireless sensors." Energies 13, no. 5 (2020): 1244. https://doi.org/10.3390/en13051244
[105] Song, Beibei, Shuai Dong, Yong Li, and Shumei Cui. "A dual-layer receiver with a low aspect ratio and a reduced output fluctuation for EV dynamic wireless charging." IEEE Transactions on Power Electronics 35, no. 10 (2020): 10338-10351. https://doi.org/10.1109/TPEL.2020.2978214
[106] Zhang, Yuanqing, Junjun Deng, Shuo Wang, Zhenpo Wang, and Yin Yang. "Multi-objective optimization of single-transmitter coupled multi-receiver IPT system for maglev trains." In 2020 IEEE Applied Power Electronics Conference and Exposition (APEC), pp. 1649-1654. IEEE, 2020. https://doi.org/10.1109/APEC39645.2020.9124214
[107] Rizzoli, Gabriele, Michele Mengoni, Angelo Tani, Giovanni Serra, Luca Zarri, and Domenico Casadei. "Wireless power transfer using a five-phase wound-rotor induction machine for speed-controlled rotary platforms." IEEE Transactions on Industrial Electronics 67, no. 8 (2019): 6237-6247. https://doi.org/10.1109/TIE.2019.2935988
[108] Meng, Yicun, Zhiwu Wang, Pingping Jiang, Wei Wang, Fanji Chen, and Guozheng Yan. "Optimization

and analysis of Helmholtz-like three-coil wireless power transfer system applied in gastrointestinal robots." Journal of Power Electronics 20 (2020): 1088-1098. https://doi.org/10.1007/s43236-020-00080-0
[109] Cheng, Chenwen, Chao Wang, Zhe Zhou, Weiguo Li, Zhanfeng Deng, and Chunting Chris Mi. "Repeater coil-based wireless power transfer system powering multiple gate drivers of series-connected IGBTs." IET Power Electronics 13, no. 9 (2020): 1722-1728. https://doi.org/10.1049/iet-pel.2019.0982
[110] Kim, Dowon, Adrian Sutinjo, and Ahmed Abu-Siada. "Near-Field Analysis and Design of Inductively-Coupled Wireless Power Transfer System in FEKO." Applied Computational Electromagnetics Society Journal 35 (2020): 82-82.
[111] Adam, Edriss Eisa Babikir, and A. Sathesh. "Three Phase Coil based Optimized Wireless Charging System for Electric Vehicles." IRO Journal on Sustainable Wireless Systems 3, no. 3 (2021): 182-195. http://dx.doi.org/10.36548/jsws.2021.3.005
[112] Ghimire, Kshitij. "Coil Parameter Analysis in Wireless Electric Vehicle Charging." WSEAS Transactions on International Journal of Electrical Engineering and Computer Science 4 (2022): 101-109. https://doi.org/10.37394/232027.2022.4.15
[113] Alexandru, Cristina A., and Dibin Zhu. "Extending the horizontal transmission range of an inductive wireless power transfer system using passive elliptical resonators." IET Power Electronics 14, no. 13 (2021): 2207-2218. https://doi.org/10.1049/pel2.12172
[114] Elngar, Ahmed, Gunawan Dewantoro, and Atyanta Nika Rumaksari. "A Study on Wireless Power Transfer for Stationary and Dynamic Charging Systems for Electric Vehicles Using MATLAB/SIMULINK." Journal of Applied Engineering & Technology (JAET) 5, no. 2 (2021): 10-33.
[115] Kao, Jia-Jing, Chun-Liang Lin, Yu-Chen Liu, Chih-Cheng Huang, and Hau-Shian Jian. "Adaptive bidirectional inductive power and data transmission system." IEEE Transactions on Power Electronics 36, no. 7 (2020): 7550-7563. https://doi.org/10.1109/TPEL.2020.3047069
[116] Guo, Lukai, and Hao Wang. "A novel design of partially magnetized pavement for wireless power transfer to electric vehicles with improved efficiency and cost saving." Energy Conversion and Management 252 (2022): 115080. https://doi.org/10.1016/j.enconman.2021.115080
[117] Çiçek, Mehmet, Mustafa Gençtürk, Selami Balci, and Kadir Sabanci. "The modelling, simulation, and implementation of wireless power transfer for an electric vehicle charging station." PhD diss., Murat Yakar, 2021. https://doi.org/10.31127/tuje.930933
[118] Prosen, Nataša, Miro Milanovič, and Jure Domajnko. "On-Line Foreign Object Detection Using Double DD Coils in an Inductive Wireless Power Transfer System." Sensors 22, no. 4 (2022): 1637. https://doi.org/10.3390/s22041637
[119] Kim, Seho, Maedeh Amirpour, Tharindu Dharmakeerthi, Vahid Zahiri Barsari, Grant Covic, Simon Bickerton, and Duleepa Thrimawithana. "Thermal evaluation of an inductive power transfer pad for charging electric vehicles." IEEE Transactions on Industrial Electronics 69, no. 1 (2021): 314-322. https://doi.org/10.1109/TIE.2021.3055186
[120] Soares, Laura, and Hao Wang. "A study on renewed perspectives of electrified road for wireless power transfer of electric vehicles." Renewable and Sustainable Energy Reviews 158 (2022): 112110. https://doi.org/10.1016/j.rser.2022.112110
[121] Guidi, Giuseppe, and Jon Are Suul. "Transient control of dynamic inductive EV charging and impact on energy efficiency when passing a roadside coil section." In 2018 IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (Wow), pp. 1-7. IEEE, 2018. https://doi.org/10.1109/WoW.2018.8450893
[122] Thongpron, Jutturit, Wuttikai Tammawan, Teerasak Somsak, Wiwat Tippachon, Kosol Oranpiroj, Ekkachai Chaidee, and Anon Namin. "A 10 kW Inductive Wireless Power Transfer Prototype for EV Charging in Thailand." ECTI Transactions on Electrical Engineering, Electronics, and Communications 20, no. 1 (2022): 83-95. https://doi.org/10.37936/ecti-eec.2022201.246108
[123] Barsari, Vahid Zahiri, Duleepa J. Thrimawithana, and Grant A. Covic. "An inductive coupler array for in-motion wireless charging of electric vehicles." IEEE Transactions on Power Electronics 36, no. 9 (2021): 9854-9863. https://doi.org/10.1109/TPEL.2021.3058666

[124] Kim, Jae Hee, Byung-Song Lee, Jun-Ho Lee, Seung-Hwan Lee, Chan-Bae Park, Shin-Myung Jung, Soo-Gil Lee, Kyung-Pyo Yi, and Jeihoon Baek. "Development of 1-MW inductive power transfer system for a high-speed train." IEEE Transactions on Industrial Electronics 62, no. 10 (2015): 6242-6250. https://doi.org/10.1109/TIE.2015.2417122