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BIOMEDICAL IMPLANTS WITH SAR REDUCTION AND LINK OPTIMIZATION

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ABSTRACT

There exist a problem while using pacemakers and other implantable biomedical devices. Usually, those devices are powered with high quality and long lasting lithium batteries to power the circuits inside the implantable devices. But unfortunately, none of them works out for many years together. Hence the patients need to undergo surgeries to remove the device and replace its batteries to function it for some more time duration. In addition to this, aging is also a parameter to be considered valid in such type of biomedical implantable devices. Hence, replacing the battery or replacing any circuitry, naturally weakens the health of the already weakened body. Hence it is suggested and proposed in this work, to transfer the power to such devices from external source through wireless power transfer. A simulation model has been designed and tested to verify our proposed idea.

INTRODUCTION

WIRELESS POWER TRANSMISSION

Wireless power transmission is not a new idea. Nickola Tesla demonstrated transmission of electrical energy without wires in early 19th century. Tesla used electromagnetic induction systems. William C Brown demonstrated a micro wave powered model helicopter in 1964. This receives all the power needed for flight from a micro wave beam. In 1975 Bill Brown transmitted 30kW power over a distance of 1 mile at 84% efficiency without using cables. Researchers developed several technique for moving electricity over long distance without wires. Some exist only as theories or prototypes, but others are already in use.

Previous schemes for wireless power transmission included attempts by the late scientist Nikola Tesla and the Microwave power transmission. Both Tesla's design and the later microwave power were forms of radiative power transfer. Radiative transfer, used in wireless communication, is not particularly suitable for power transmission due to its low efficiency and radiative loss due to its Omni directional nature.

THEORETICAL BACKGROUND

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The principle of Evanescent Wave Coupling extends the principle of Electromagnetic induction. Electromagnetic induction works on the principle of a primary coil generating a predominantly magnetic field and a secondary coil being within that field so a current is induced within its coils. This causes the relatively short range due to the amount of power required to produce an electromagnetic field. Over greater distances the non-resonant induction method is inefficient and wastes much of the transmitted energy just to increase range. This is where the resonance comes in and helps the efficiency dramatically by "tunneling" the magnetic field to a receiver coil that resonates at the same frequency.

Theoretical analysis shows that by sending electromagnetic waves around in a highly angular waveguide1, evanescent waves are produced which carry no energy. If a proper resonant waveguide is brought near the transmitter, the evanescent waves can allow the energy to tunnel to the power drawing waveguide, where they can be rectified into DC power. Since the electromagnetic waves would tunnel, they would not propagate through the air to be absorbed or be dissipated, and would not disrupt electronic devices or cause physical injury.

METHODS OF WIRELESS POWER TRANSMISSION

- Inductive coupling
- Transformer coupling
- Radio and Microwave Energy Transfer
- Resonant Inductive Coupling

With inductive resonance, electromagnetic energy is only transferred to recipient devices that share the identical resonant frequencies as the energy source, so energy transfer efficiency is maintained, even when misalignment occurs.

NON-RADIAVE ENERGY TRANSFER IS SAFE FOR PEPOLE AND ANIMALS

WiTricity's technology is a non-radiative mode of energy transfer, relying instead on the magnetic near field. Magnetic fields interact very weakly with biological organisms people and animals and are scientifically regarded to be safe. Professor Sir John Pendry of Imperial College London, a world renowned physicist, explains: "The body really responds strongly to electric fields, which is why you can cook a chicken in a microwave. But it doesn't respond to magnetic fields. As far as we know the body has almost zero response to magnetic fields in terms of the amount of power it absorbs." Evidence of the safety of magnetic fields is illustrated by the widespread acceptance and safety of household magnetic induction cook tops. Through proprietary design of the WiTricity source, electric fields are almost completely contained within the source.

IMPLANTED PACEMAKER

Implantable biomedical sensors and actuators are highly desired in modern medicine. In many cases, the implant's electrical power source profoundly determines its overall size and performance. The inductively coupled coil

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pair operating at the radio-frequency (RF) has been the primary method for wirelessly delivering electrical power to implants for the last three decades.

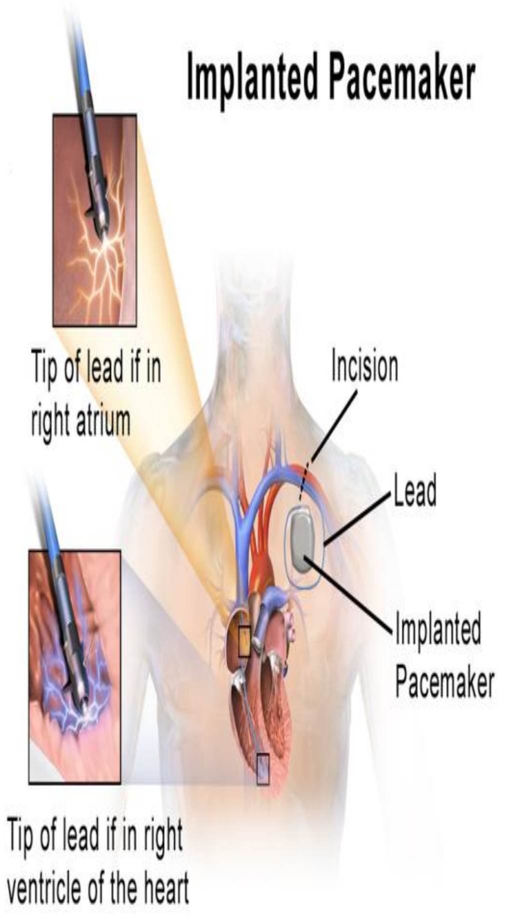

Fig 1. Location and implementation of pacemaker

However, RF radiation hazard and tissue absorption are the concerns in the RF wireless power transfer technology (RF-WPTT). Implants, such as the interventional orthopedic implants and the mechanical pump based cardio implants, require high power, to operate, and therefore cannot be powered by a non-rechargeable battery. Although life-saving, implant technology is severely restricted by the battery size, the available power, and the costs associated with its limited life-span. Thus, there is an imminent need for a wireless power transfer technology (WPTT) that is capable of delivering significant amounts of electrical power to implants in a safe and noninvasive manner. Aging or heart disease damages your sinus node's ability to set the correct pace for your heartbeat. Such damage can cause slower than normal heartbeats or long pauses between heartbeats. The damage also can cause your heart to switch between slow and fast rhythms. This condition is called sick sinus syndrome.

This can cause symptoms such as fatigue (tiredness), shortness of breath, or fainting. Severe arrhythmias can damage the body's vital organs and may even cause loss of consciousness or death. A pacemaker can relieve some arrhythmia symptoms, such as fatigue and fainting. A pacemaker also can help a person who has abnormal heart rhythms resume a more active lifestyle. The most common reasons are bradycardia and block. Bradycardia is a heartbeat that is slower than normal.

Heart block is a disorder that occurs if an electrical signal is slowed or disrupted as it moves through the heart. Heart block can happen as a result of aging, damage to the heart or other conditions that disrupt the heart's electrical activity. Some nerve and muscle disorders also can cause heart block, including muscular dystrophy.

Pacemaker Work

A pacemaker consists of a battery, a computerized generator, and wires with

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sensors at their tips. (The sensors are called electrodes.) The battery powers the generator, and both are surrounded by a thin metal box. The wires connect the generator to the heart. A pacemaker helps monitor and control your heartbeat. The electrodes detect your heart's electrical activity and send data through the wires to the computer in the generator. If your heart rhythm is abnormal, the computer will direct the generator to send electrode.

Pacemaker Surgery

Pacemaker surgery generally is safe. If problems do occur, they may include:

- Swelling, bleeding, bruising, or infection in the area where the pacemaker was placed
- Blood vessel or nerve damage
- A collapsed lung
- A bad reaction to the medicine used during the procedure

Artificial cardiac pacemaker

A pacemaker (or artificial pacemaker, so as not to be confused with the heart's natural pacemaker) is a medical device which uses electrical impulses, delivered by electrodes contracting the heart muscles, to regulate the beating of the heart. The primary purpose of a pacemaker is to maintain an adequate heart rate, either because the heart's natural pacemaker is not fast enough, or because there is a block in the heart's electrical conduction system. Modern pacemakers are externally programmable and allow a cardiologist to select the optimum pacing modes for individual patients. Some combine a pacemaker and defibrillator in a single implantable device. Others have multiple electrodes stimulating differing positions within the heart to improve synchronization of the lower chambers (ventricles) of the heart.

Once the pacemaker is implanted, it is periodically checked to ensure the device is operational and performing appropriately. Depending on the frequency set by the following physician, the device can be checked as often as is necessary. Routine pacemaker checks are typically done in-office every six (6) months, though will vary depesnding upon patient/device status and remote monitoring availability.

EXISTING SYSTEM

13.56 MHz wireless power transfer system with a reconfigurable resonant regulating rectifier and wireless power control for biomedical implants is presented. A local PWM loop at the secondary side controls the duty cycle of mode-switching of the rectifier between the modes.

The primary transmitter and the secondary R rectifier are fabricated in 0.35 µm CMOS process with the digital control circuits implemented using FPGA. The measured maximum received power and receiver efficiency are 102 mW and92.6%, respectively. For load transients, the overshoot and the undershoot are approximately 110 mV and the settling times are less than 130 µs. Implantable medical devices, reconfigurable resonant regulating rectifier, wireless power control, Wireless power Transfers are used. The wireless power transfer has been widely used in implantable medical devices (IMDs) such as retinal prostheses and

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neural recording to eliminate the use of the bulky battery. Real-time power transfer in the range of 10 mW to 100 mW is required for different types of implants.

For near-skin IMDs, WPT is based on inductive near-field coupling due to its high efficiency .The basic WPT system consists of an external device and an internal implant. The measured receiver efficiency (the ratio of to the input power of the rectifier) for different ranging from10 to 100 mW is summarized in the power over head of the PWM controller is included. In light load, the switching loss of the active diodes degrades the efficiency. In heavy load, the conduction loss of the active diodes degrades the efficiency. At mW, the maximum efficiency of 92.6% is achieved. At a coil distance of 0.3 cm and mW, the maximum total power transfer efficiency including the losses in the wireless power transfer.

BLOCK DIAGRAM FOR WIRELESS POWER TRANSFER SYSTEM

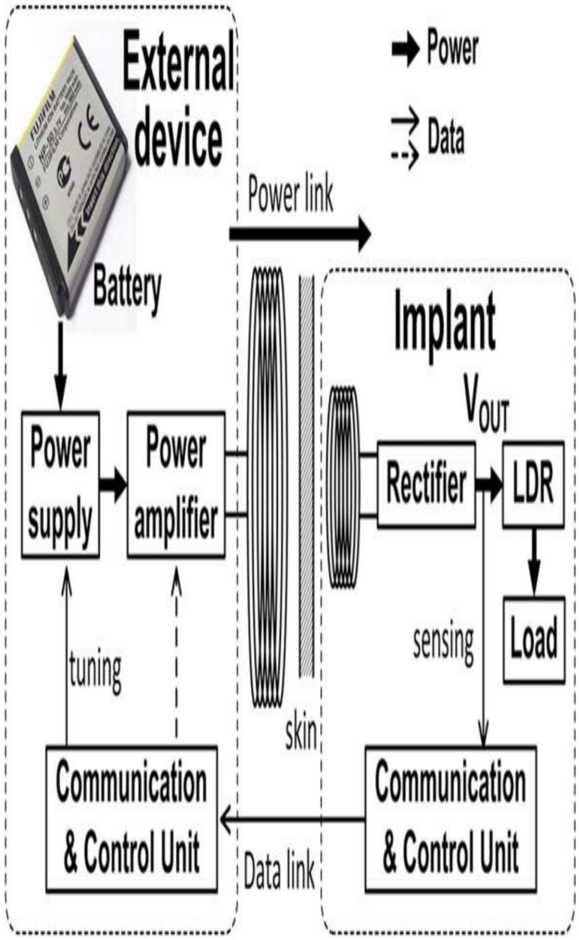

Fig 2. Wireless Power Transfer System of Implants

The power is transferred through two coupled coils: a primary coil and a secondary coil.. Wireless power transfer (WPT) system for IMDs.In the external device, the battery voltage is regulated by theDC supply module, which powers up the power amplifier (PA)that drives the primary coil to generate AC magnetic fluxes. In the implanted device, the coupled AC power is rectified into DC power, usually cascaded with a low dropout regulator(LDR) to generated regulated voltage for the load. In actual IMD applications, the coil coupling varies

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with the distance and the alignment between the coils. The load may change with time depending on the application. Both coupling and load variations make the output voltage of the rectifier unsteady. If there is no power control, the worst case scenario has to be designed for when the coupling distance is large, and use a high-enough transmission power to maintain higher than the minimum required value. However, for cases with better coupling conditions, will then be much higher than , and a large voltage drop across the LDR means poor receiver efficiency, with unnecessary power transmitted and absorbed by the body tissue, which accompanied by non-preferable heat dissipation, and leave a lower margin to reach the human tissue specific absorption rate (SAR) .

To implement power control, in addition to the forward power link, a separate reverse data link is required to Regulate. Is sensed and sent back to the external device through a wireless uplink communication channel. The external device will then adjust the transmission power accordingly based on the received data. The speed of this global control loop depends on the data rate of the uplink channel. In a high carrier frequency is used to achieve a fast data uplink; however, an additional pair of data coils is needed. The present works suffers from the following.

1. RF radiation hazard and tissue absorption due to high frequency transmission range.
2. SAR is high which affects the human tissues
3. Requires an accurate impedance matching network.
4. Sensitive to operating environments between the receiving coil and the load affects the efficiency of power delivery.

PROPOSED SYSTEM

Our proposed design will significantly improve the power delivery efficiency by optimizing the operating frequency, coil size and coil distance. A novel low-frequency wireless power transfer technology of nearly 60-KHz is used which provides a non-radiative power link between the implant and the transmitter. Because of the low operating frequency, RF radiation hazard and tissue absorption are largely avoided, and the power delivery efficiency from the receiving coil to the load is independent of the operating environment. Also, there is little power loss observed in the receiving coil of implant.

PROPOSED BLOCK DIAGRAM

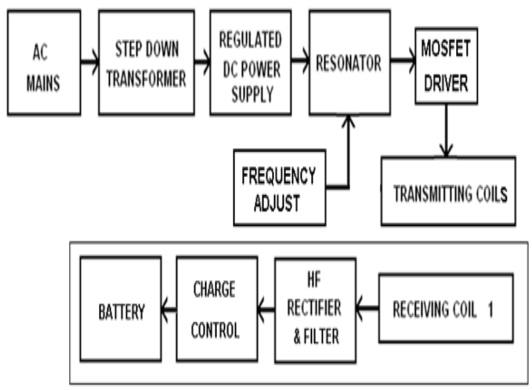

Fig 3 Block Diagram of the System

FUNCTIONAL CIRCUIT DIAGRAM

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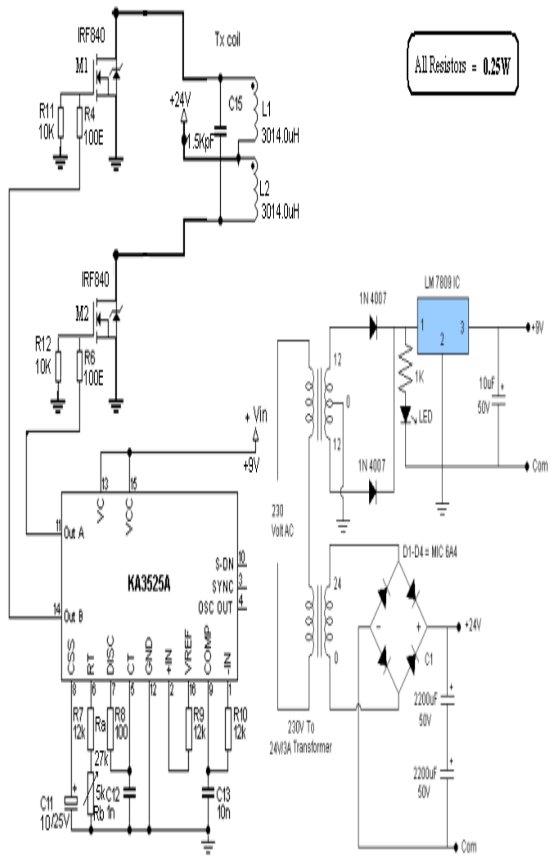

Fig. 4 Transmitter Unit

The transmitter unit. In the transmitter section the step down transformer is used. The transformer is reduced the primary voltage. Its output is given to regulated power supply. The regulated power supply is used to convert the AC voltage to DC regulating voltage. This DC voltage is given to the resonator. The resonator is oscillating the high frequency components by using MOSFET and LC tank circuit. The transmitter coil is induced electrical energy at desired resonant frequency.

3.3.3.2 Receiver Unit

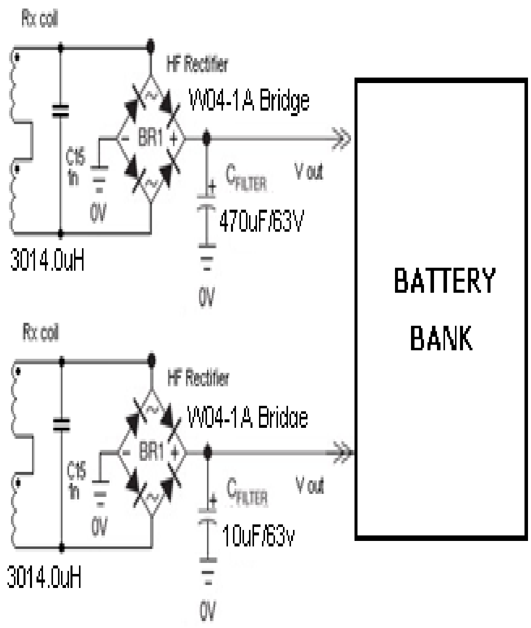

Figure 5 Receiver Unit

The receiver units. The receiving coil is received the electrical energy from the transmitting coil. There are two hf rectifier are used .When the resonance frequency is identically the transmitting coil transmits the energy, otherwise not transmitting the energy from the transmitter. In receiver section, the transmitting frequency is observed by the coil and it converts the resonant frequency into voltage.

4.1.4 WIRELESS POWER CALCULATIONS

4.1.4.1 Frequency Calculation Of Transmitter & Receiver

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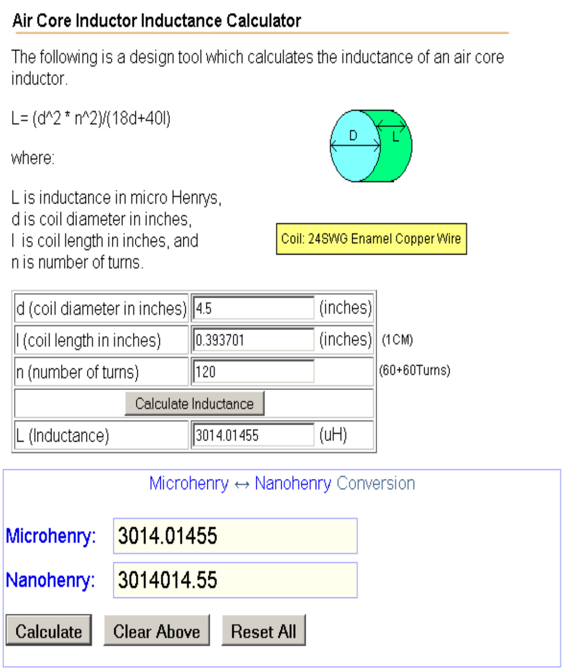

Fig.6 Inductance Calculation of Transmitter

The inductance type transmitter contsits of three parts coil a movable magnetic core and a pressure sensing the effective protection of a klystron in a high power transmitter requires the diversion of all stored energy.the indt148 is designed for any type of inductance.

SIMULATION AND RESULTS

PSIM achieves fast simulation while retaining excellent simulation accuracy. This makes it particularly efficient is simulating converter system of any size and performing multiple cycle.

SIMULATION CIRCUIT

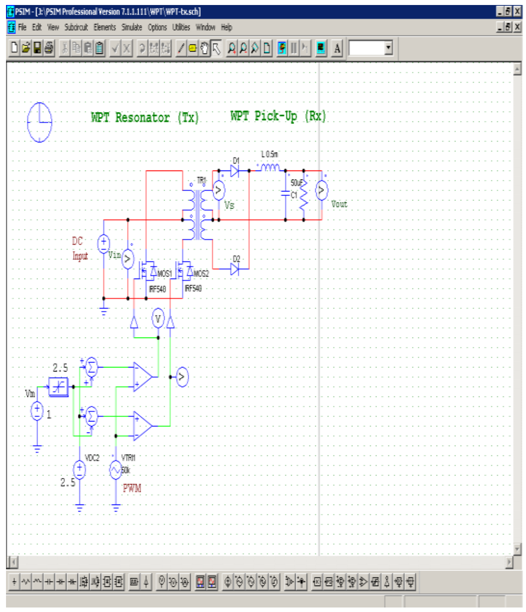

Fig.7. Simualtion model in PSIM

5.2 SIMULATION OUTPUT

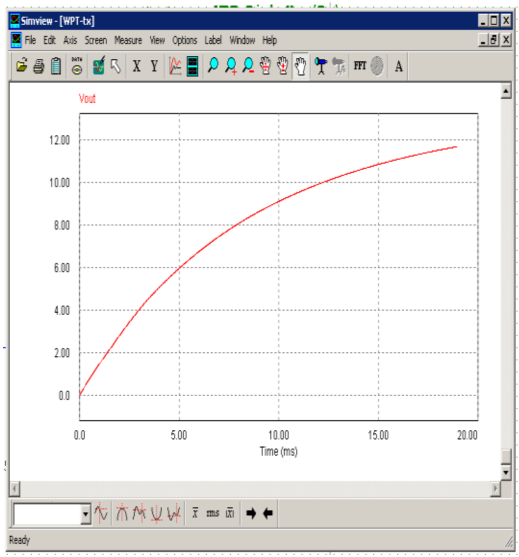

Fig.8. Capacitor voltage charging profile

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PWM

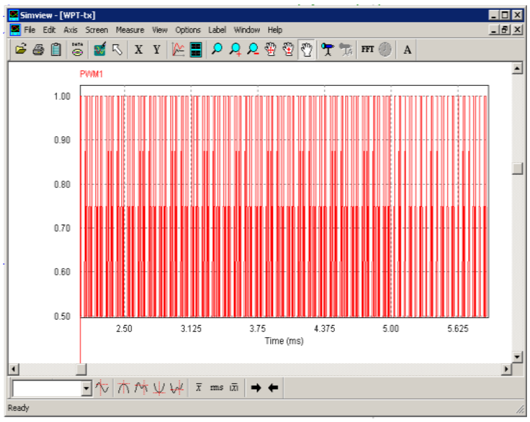

Fig.8. Capacitor voltage charging profile

CONCLUSION

Wireless power transfer thus allows a convenient, easy to use battery charging of and powering other electrical or electronic devices. No hassle with cables and plugs, just place the device on a pad and that's it. Such a system even has the potential to become a standard charging solution. By only adjusting the coupling coefficient between coils in transmitter can improve the system performance. The significant finding is that the technique shows the effectiveness with multiple receiving coils, which is very useful in practice, as well. It enables the industry to practically implement the high efficient wireless charging system for mobile consumer electronics devices in future. From an efficiency point of view, wireless resonant power transfer is feasible for general power applications only if transmitter and receiver coils are in close proximity to each other. Resonant power transfer in a larger space is not feasible due to the very low efficiency. A Resonant inductive power pad to charge battery operated devices along with powering some electronic devices is presented, which allows arbitrary positioning and local detection. Employing multiple carrier would help to effectively isolated many of the conflicting requirements is design of the wireless link with only one carrier. In a multicarrier system individual parameters of every carrier can be optimized for its associated function and requirements regardless of the other carrier on the other hand every individual carrier its dedicated coils or antennas which could potentially add to the implant size and complexity.

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