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Implantable Fractal Antenna for Biomedical Application

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ABSTRACT

Smart implants are implantable devices that provide not only therapeutic benefits but also have diagnostic capabilities. The integration of smart implants into daily clinical practice has the potential for massive cost savings to the health care system. Applications for smart orthopaedic implants have been identified for knee arthroplasty, hip arthroplasty, spine fusion, fracture fixation and others. To date, smart orthopaedic implants have been used to measure physical parameters from inside the body, including pressure, force, strain, displacement, proximity temperature and pus formation . The measurement of physical stimuli is achieved through integration of application- specific technology with the implant. Data from smart implants have led to refinements in implant design, surgical technique and strategies for postoperative care and rehabilitation. In spite of decades of research, with very few exceptions, smart implants have not yet become a part of daily clinical practice. This is largely because integration of current sensor technology necessitates significant modification to the implants. While the technology underlying smart implants has matured significantly over the last several decades, there are still significant technical challenges that need to be overcome before smart implants become part of mainstream health care. Sensors for next-generation smart implants will be small, simple, robust and inexpensive and will necessitate little to no modification to existing implant designs. With rapidly advancing technology, the widespread implementation of smart implants is near. In this paper, we have presented a design of microstrip patch antenna using square shape]. In the present work, a combined square fractal antenna has been designed to operate between 2-8GHz around the resonant frequency of 0.5575GHz in order to detect the infected tissues around the bone.

Keywords: Smart implant, sensor, strain gage, force, knee, hip, spine, fracture, pus formation.

1.INTRODUCTION

An antenna is an electrical device which converts electric power into radio waves, and vice versa. They are used in systems such as radio broadcasting, broadcast television, two -way radio, communications receivers, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, and medical applications. In recent days implantable antenna plays a main role in the detection of the disease and an evolving technology in medical field. During surgery to fix a fracture, the doctor cuts through skin and soft tissues to reach the broken bone. The risk for developing an infection in this setting is quite low, usually less than 1% in healthy individuals, although this varies depending on the injury and the operation performed. The antibiotics are given to the patients to minimize the risk factor.Less commonly, an infection can occur at the surgical site even long after the injury has healed. The bacteria that causes the infection is found and the implant isused to detect the pus. Deep infections that develop pus pockets are called abscess es.[2] The Streptococcus is the most common bacterium disease that causes cellulitis.. These infections can become very life threatening.

2. WORKING PRINCIPLE

Smart implants can also provide continuous monitoring of critical intracorporal parameters, the data

from which can be used to guide treatments in real time. The integration of smart implants into daily clinical practice has the potential for massive cost savings to the health care system by minimizing expensive complications, reduces the recovery times, decreasing lost work days after surgery[3] and reducing readmissions and revision procedures. Smart implant research proves the importance of knowledge for the development of next-generation implants and surgical techniques.[9]

While the technology underlying smart implants, including sensing, power transfer, energy storage and wireless communications, has matured significantly over the last several decades, there are still some technical challenges that need to be overcome before smart implants become part of health care.

In all smart implant applications, the implant is the vehicle that carries the diagnostic technology into the body[8]. Due to the relatively large physical size of many orthopedic implants, the bulk provides an opportunity for between implant and sensing technology. Physically large implants providing implants itself by sensing and integeration technology.

There are some essential parameters for design of rectangular microstrip patch antenna. The dielectric constant of the substrate material is an important design parameter[4].The dielectric material the means to incorporate sensors, signal conditioning electronics and telemetry into the implant itself or on its surface. Because of the availability for integration of sensing technology, there has been much innovation and development in smart orthopedic implant symbiosis between implant technology. Physically large implants provide the means to incorporate sensors,The use of diamond shape implantable antenna in the field of orthopedic has evolving faster than other fields in medicine .It is helpful for the doctors to diagnose the infected area.

3. ANTENNA DESIGN

The propounded antenna is designed on 1.6mm thick FR4 glass proxy substrate with dielectric constant Er of 4.4 and is fed by micro strip line. The basic shape of proposed antenna consist of square patch of each side length 20mm has been mounted on the ground plane substrate of length = 20mm and width =1.6mm.

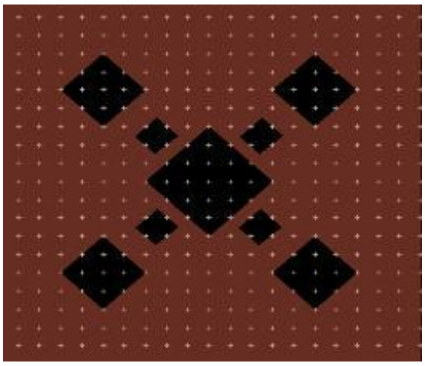
ANTENNA	DESIGN VALUE
Dielectric constant	4.4
Substrate height (mm)	20
Loss tangent	0.001
Length of patch(mm)	20
Width of patch(mm)	1.6
Length substrate(mm)	20

In the antenna design, substrate thickness is another important design parameter. Thick substrate increases the fringing field at the patch periphery like low dielectric constant and thus increases the radiated power. The height of dielectric substrate employed in this design of antenna is h=1.6mm.this design only. Lastly, the resonant frequency (fr) of the antenna must be selected appropriately. The frequency range used is from 2GHz – 8GHz and the design of antenna must be operated within this frequency range.The resonant frequency selected for this design is 0.5575 GHz.

The iteration is the procedure in which the same process is repeated for specified number of times.Here,the process of cutting square is repeated to obtain the proposed design of antenna. Here four iteration were done to increase the antenna parameters.

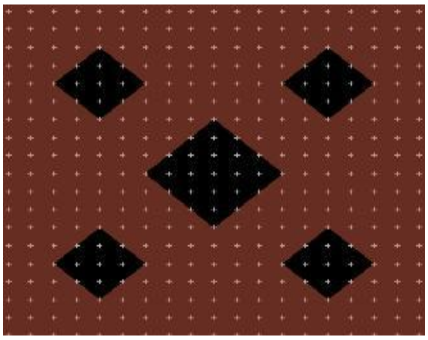
3.1 First iteration :

It is achieved by cutting square fractal slot is deploying square geometry of each side length 4mm in the center of the square patch as shown in fig.1. Return loss of -33.97db and VSWR of 1.067.

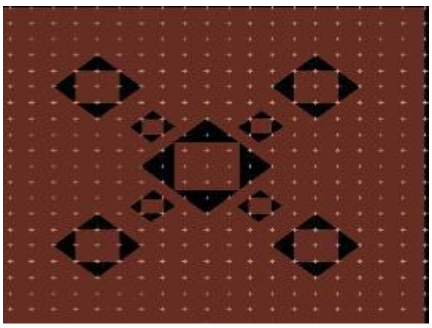


3.2 Second iteration :

Fig.2. shows the results of the second iteration of the proposed fractal antenna. In the centre one square fractal slot deploying square geometry each of side length 4mm is taken and similar four slots each of side length 2mm are taken on each corner of the central slot. A VSWR of 1.04 and return loss of -34.01 are available at the resonant frequency.

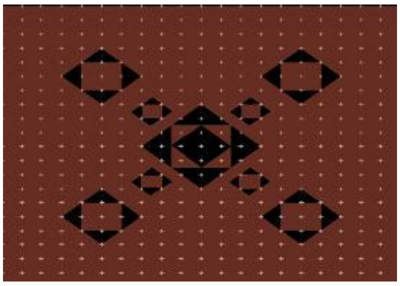


3.3 Third iteration: In this one central square fractal slot deploying square geometry is cut and similar structured fractal taken on each corner of the central slot with reduction in their sizes These fractal slots have dimension of each side equals L1=4mm, L2=2mm, L3=1mm. shown in fig.3.

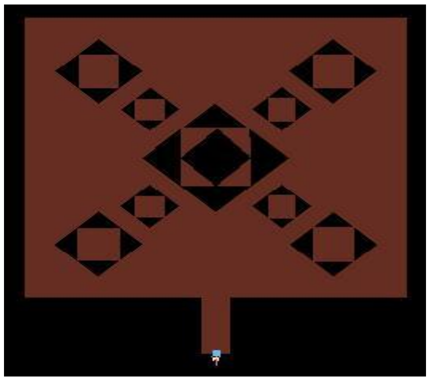


3.4 Fourth iteration :

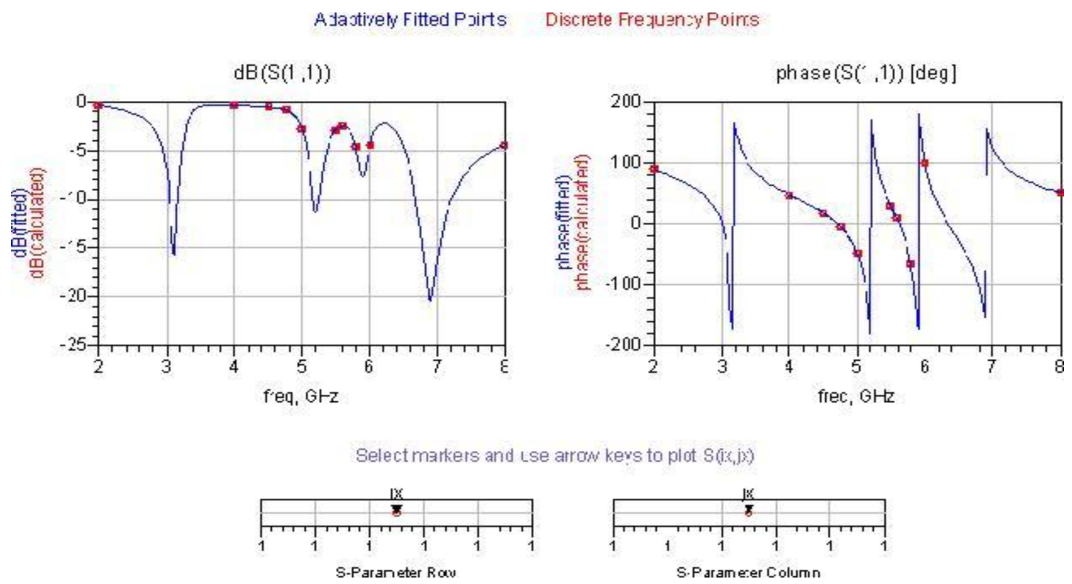
In the fourth iteration the square fractal with 1mm dimension of equal side is deployed in the square geometry which were having each of side length 4mm.



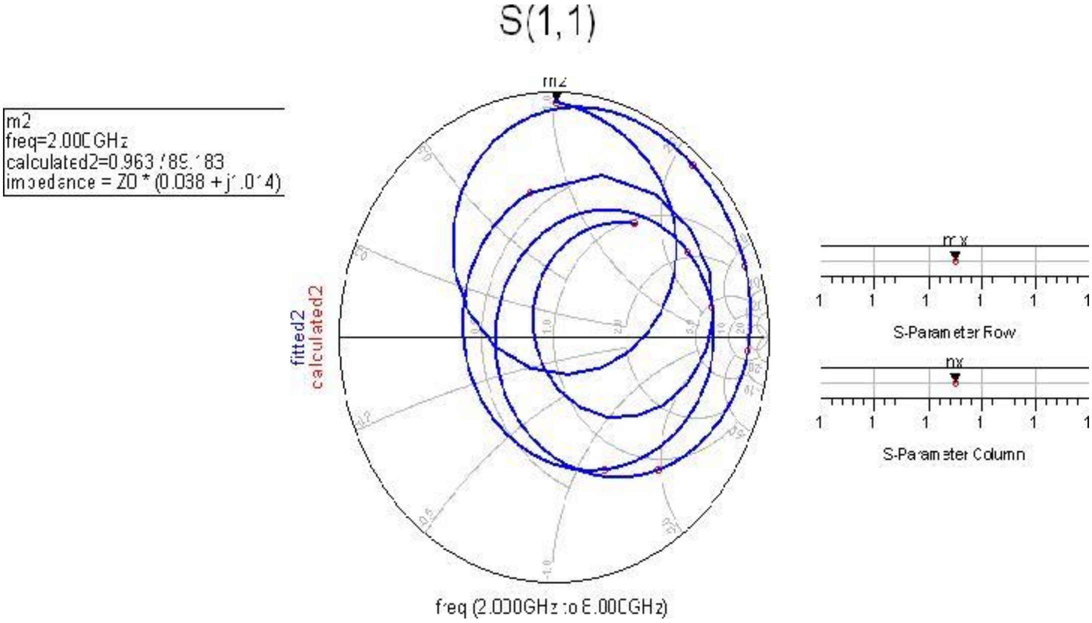
4. ANTENNA LAYOUT:



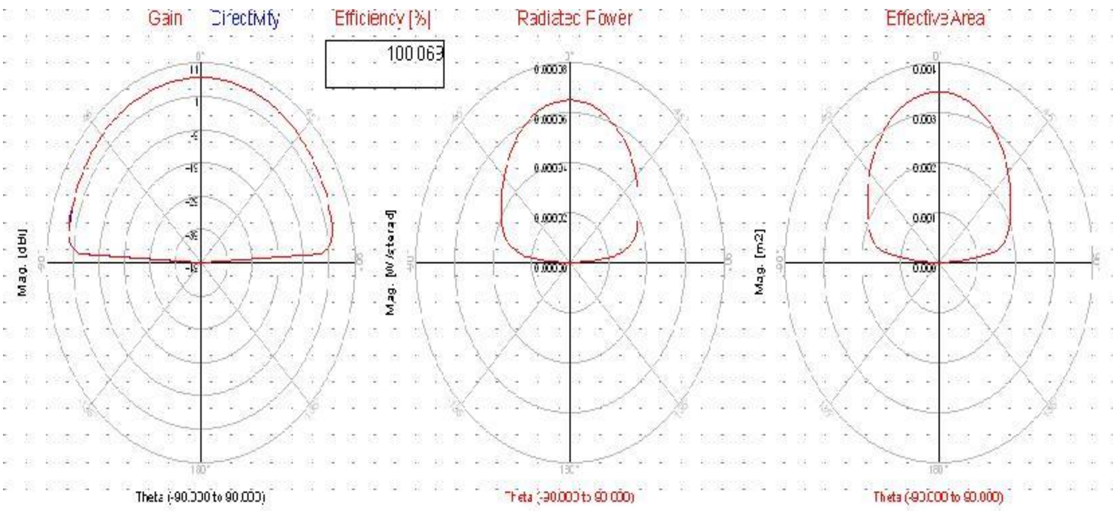
5. RETURN LOSS AND RESONANT FREQUENCY:



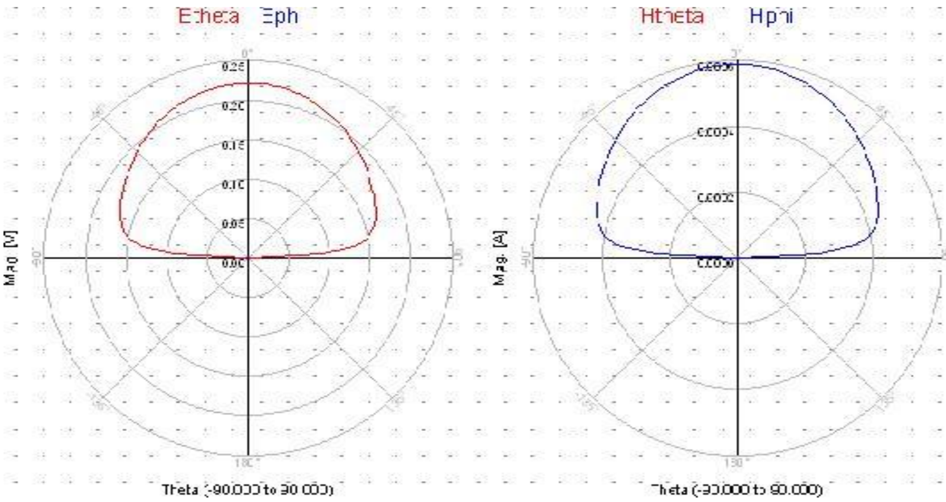
6.VSWR:



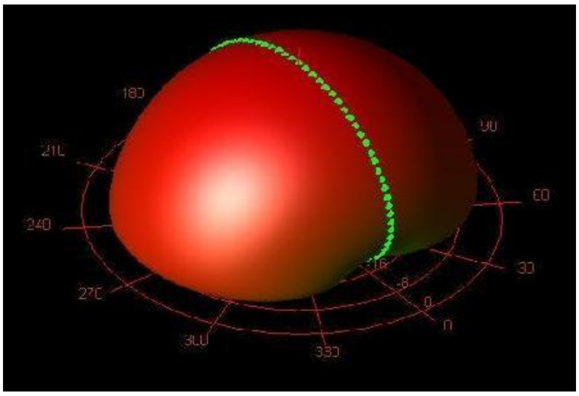
7.GAIN AND EFFICIENCY:



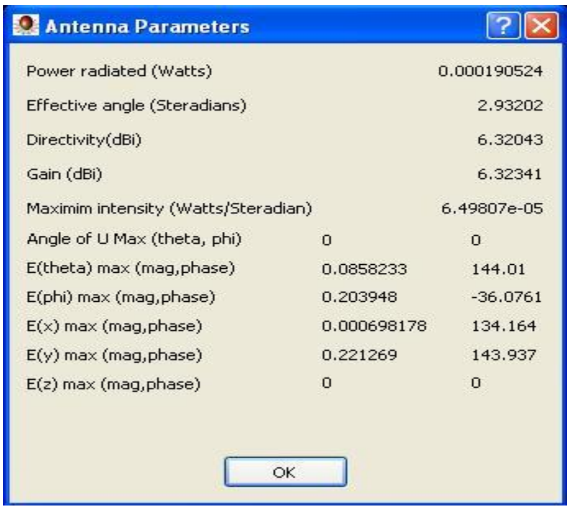
8. ABSOLUTE FIELDS:



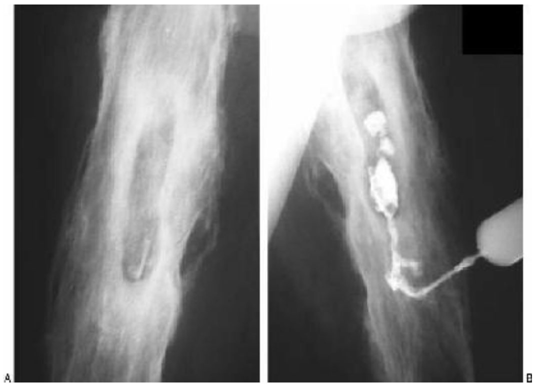
9.FAR FIELD:



10. ANTENNA PARAMETER:



11. PUS FORMATION



These specialty areas of medicine are similar to orthopedic surgery. For example, hand surgery is practiced by some plastic surgeons and spine surgery is practiced by most neurosurgeons. When the patient get injured by fracture he has to pay attention in all his activities. After the surgery if the patient feels any swelling or pain in the infected area that can be predicted by the implantable antenna. In terms of fracture healing, preclinical studies show that normal bone healing takes up to 10 weeks , with a 'hard callus stage' that is situated between 3 and 16 weeks[9].

In case of infection, this changes significantly have that S.epidermidis inoculation into a fracture gap in the rat can lead to non- union rates of 83–100% at 8 weeks .It could prove, in a similar approach, that IAFF was associated with weaker callus formation.[13] These observations, in combination with the fact that bacterial bone invasion and inflammation ('osteomyelitis') often occur within 2–10 weeks explain why treatment choices are often different compared to early onset infections where fracture healing may not have commenced, and bone involvement may still be minimal. Late infection (>10 weeks)[7]. Many patients with late infections can present with subtle symptoms, compromised functionality and stress dependent pain, localized swelling and erythema or a draining sinus tract, mostly lacking systemic manifestation. In patients presenting with compromised fnctionality and stress dependent pain, In terms of fracture healing, preclinical studies show that normal bone healing takes up to 10 weeks , with a 'hard callus stage' that is situated between 3 and 16 weeks[9]. In case of infection, this changes significantly have that S.epidermidis inoculation into a fracture gap in the rat can lead to non- union rates of 83–100% at 8 weeks .It could prove, in a similar approach, that IAFF was associated with weaker callus formation.[13]

12. OSTEOMYELITIS:

The rate of infection in the present study is 5.76%, which is much higher than accepted standard for postoperative wound infection, which should be less than 1%[5]. Our infection rate is comparable to another local study9 in which the infection rate was 5% and is much lower than another local study8 in which the infection rate was 7.8%.

Marston et al10 reported 5% superficial and 0.25% deep infection in 413 total hip replacements in ideal circumstances.[15]

According to some studies conducted in Pakistan, the overall superficial and deep infection rate is 7.8% and 10% respectively11 while we reported 1.92% superficial and 3.84 % deep infection.

The rate of postoperative wound infection without prophylactic antibiotic is high as compared to the use of prophylactic antibiotic[12].Our infection rate with prophylactic antibiotic is 5.7% that is comparable to another local study11 in which it is 6% but is higher as compared to another local study, 13 i.e., 3.97%.

13. CONCLUSION

Our infection rate was quite high and needs proper measures to control it because it had great financial burden on patient and on hospital resources and could lead to increased morbidity and mortality in patients. The antenna is simulated by using ADS Software. The results demonstrated a maximum patch size reduction by the proposed any type fractal antennas, without degrading antenna's performance, such as

the return loss and radiation pattern, VSWR. The basis of the maintenance of the antenna radiation patterns is the self-similarity and Centro- symmetry properties of the fractal shapes. The main advantages of the discussed method are: (i) miniaturization (ii) maintained radiation patterns (iii) wider and better operating frequency bandwidth,(iv) simple and easy to design. This paper presented a modified square shape antenna on substrate relative permittivity of 4.4 & thickness 1.6 mm.The variation of return loss with frequency, VSWR and Bandwidth for iteration I, II, III and IV for transmission line feed this geometry shows high self-similarity and symmetry.

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