Original Research Paper

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Engineering

DUROID SUBSTRATE MICROSTRIP PATCH ANTENNA DESIGN FOR WIRELESS CAPSULE ENDOSCOPY

Ms.P.Kokila	Assistant Professor, Department of ECE, Nandha Engineering College.
Ms.V.Logeswari	Assistant Professor, Department of ECE, Nandha Engineering College.
Yamuna Devi K*	Final year Student, Department of ECE, Nandha Engineering College. *Corresponding Author
Mythurikadevi S	Final year Student, Department of ECE, Nandha Engineering College.
Lithanya P	Final year Student, Department of ECE, Nandha Engineering College.

ABSTRACT Wireless network is the fast-growing technology. The world is moving towards the wireless technology and it is used each and everywhere. Wireless network is used in many ways and one of the applications is medical application. In wireless technology, Antennas play an important role in data transmission. Antennas are electronic eyes and ears of humans in the modern world. There are many applications of antenna in medical field. One of the applications is data transmission in wireless capsule endoscopy. Wireless capsule endoscopy is the advancement of wired endoscopy. Wireless capsule endoscopy is used to diagnose the problems in the gastro intestinal tract, stomach and intestines which cannot be identified from outer observation or through x-rays or any other tests. The doctors watch the travel of capsule in the display and diagnose the problems which will be easier for the treatment. The types of antennas in medical field are Ingestible antennas, On body wearable Antennas, Implantable antennas, Antenna for MRI, Microwave Imaging, Thermal Ablation. For wireless data transmission in wireless capsule endoscopy, Microstrip patch (MSP) antenna is designed using Duroid as substrate in the frequency of 2.45 GHz with efficiency of 88% and gain of 4.86 dB. Microstrip patch antenna is selected as it is smaller in size which is most important characteristic of capsule endoscopy. In MSP antenna, copper is used for ground and patch, Duroid is used as the dielectric medium for the substrate as it gives higher efficiency, higher gain and higher directivity.

KEYWORDS : Microstrip patch antenna, Wireless Capsule Endoscopy, Duroid, efficiency

1. INTRODUCTION:

In communication, Wireless technology plays a vital role. Wireless technology is more convenient to use than wired technology. Wireless technology is used in many applications such as medical application, cell phones wi-fi, security systems, walkie talkies, satellite communication. Wireless capsule endoscopy (WCE) is an important application of wireless technology in medical field. Wireless capsule endoscopy is used to identify the problems that aroused in digestive track. Capsule endoscopy is used for the patient where the problems cannot be identified by the wired endoscopy. In wired endoscopy long flexible tube with video camera is used to track the digestive area and the video is displayed in the monitor for the identification of problem for the doctor. In capsule endoscopy the patient swallows a tiny capsule that contains a small camera antenna inside it. The camera is used to take images and the antenna is used to transmit the images to the recorder that worn around the waist of the patient. Later, the images can be downloaded from the recorder and the problems can be diagnosed. The capsule in the patient's is flushed in the toilet and there is no need of retrieving the capsule. In capsule endoscopy, Gastrointestinal bleeding, celiac disease, alternative colitis can be diagnosed. Wireless capsule endoscopy is better and convenient than wired endoscopy for both the patient and doctor.

There are many types of antennas used in Wireless capsule endoscopy. In this paper, an MSP antenna is designed with Duroid as substrate for wireless capsule endoscopy in the frequency of 2.45 GHz. The MSP antenna is used at microwave frequencies. MSP antenna is used here as it is a kind of internal antenna smaller in size and light in weight which helps to reduce the size of the capsule. When the size of the capsule is smaller it is easier for the patient to swallow the capsule and the capsule can travel through the digestive track without any disturbance. The microstrip patches has various shapes such as rectangular, Square, triangular. Here, MSP antenna is designed in rectangular shape which are easily etched and fit in the capsule easily. The MSP antenna is compact in size which can provide the size betterment of the antenna for the patient's convenience. MSP antennas have the capacity to supporting multiple frequency bands.

The aim of the paper is to design the MSP antenna with Duroid as the dielectric medium in the substrate for wireless capsule endoscopy. The purpose to use Duroid as the substrate is the higher efficiency,higher gain and higher directivity which improves the performance of the antenna in capsule. The organization of the paper is as follows. The second part of the paper describes the design of MSP antenna. The third part of the paper describes the result and discussion of MSP antenna. The final part of the paper describes the conclusion of the proposed work.

2. DESIGNING OF MSP ANTENNA:

DESIGN EQUATION:

I) Peak Gain:

$G = k\,D$ (1)

where k is antenna efficiency ($0 \le k \le 1$)

ii) Radiation Intensity:

$U_{av} = \frac{Pr}{4\pi}$ (2)

where Pr is Radiated Power

iii) Width of patch:

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (3)$$

iv) Effective dielectric constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}$$

where ε_r is relative dielectric constant of the material
h is the height of the substrate
W is the width of the patch

v) Length of the patch:

$$\Delta L = h0.412\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (5)$$

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (6)$$

DESIGN OF MICROSTRIP PATCH ANTENNA:

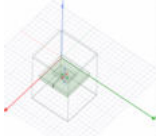

Figure 1: Design of MSP antenna

The MSP antenna is designed using Ansys HFSS (High Frequency Structure Simulator) from above design equations. The MSP antenna used here is designed in the frequency of 2.45 GHz. Here, copper is used for ground and patch. When the frequency is increased, the radiation will be high which is very harmful to the human body. So, the frequency of the antenna cannot be increased. The frequency is indirectly proportional to size of the antenna. When the frequency is decreased, the size of the antenna is increased. So that the capsule size will also be increased which leads to difficulty in travelling of capsule through intestine. The standard size of the capsule is 30mm X 10mm and it is the same used here.

3. RESULT & DISCUSSION

There are many dielectric mediums used in substrate in MSP antenna such as FR4 Epoxy, Vacuum, Bakelite, Rogers R04003, Taconic TLC, Duroid. The parameters of these dielectric medium have been analysed. Particularly, peak directivity, peak gain, radiated power, accepted power, radiation efficiency of dielectric medium has been analysed.

The results of these dielectric medium are shown below:

RESULTS OF DIELECTRIC MEDIUM USED IN SUBSTRATE:

GAIN:

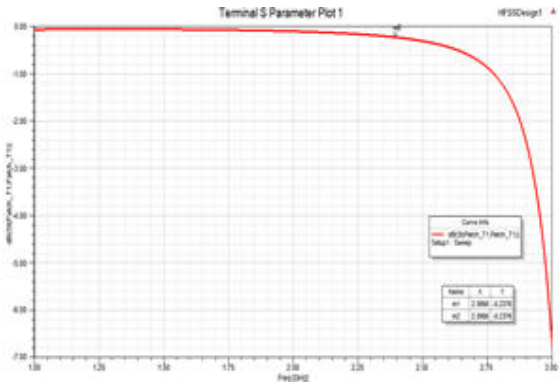

Figure 2

Figure 2 shows the gain of MSP antenna with duroid substrate. The gain value is high at 2.45GHz and the gain decreases when the frequency increases. So, the MSP Antenna is designed in the frequency of 2.45GHz.

The value of peak gain is 4.8596 in the frequency of 2.45GHz which is the higher gain value compared to other dielectric mediums.

DIRECTIVITY:

The value of peak directivity of MSP antenna which is designed using Duroid substrate is 5.4676 in the designed frequency which is higher directivity value compared to other dielectric mediums.

RADIATED POWER:

Normally the radiated power of an antenna should be very low to increase the efficiency of an antenna. Here, the value of measured radiated power for Duroid substrate MSP antenna is 0.0004 which is lower radiated power compared to other dielectric mediums.

ACCEPTED POWER:

The value of accepted power of Duroid substrate MSP antenna designed in the frequency of 2.45 GHz is 0.0005.

RADIATION EFFICIENCY:

The main purpose of designing an antenna is to increase the efficiency and also to improve performance of an antenna. The value of antenna efficiency is 0.8888 .

Duroid substrate has the high directivity of 5.4676, high gain of 4.8596 dB, high efficiency of 0.8888 and has lower radiated power and lower accepted power. Vacuum also has high efficiency, low radiated power and low accepted power than Duroid but vacuum cannot be used as dielectric medium in substrate. Duroid has high directivity, high gain and high efficiency compared to other substrates in MSP antenna. Hence, Duroid is used as the dielectric medium for substrate in MSP antenna for wireless capsule endoscopy for the better performance of the capsule.

4. CONCLUSION:

In capsule endoscopy the size of capsule must be small which is very important characteristics of capsule endoscopy so that it is easy to swallow and travel through the intestine. In capsule endoscopy, many antennas are used to transmit and receive the signals. MSP antenna is used here to transmit and receive as it is smaller in size which decreases the size of the capsule and it is very efficient. The substrates used in MSP antenna such as FR4 Epoxy, Vacuum, Bakelite, Rogers R04003, Taconic TLC, Duroid has been analysed. After the analysis and from the above results, here Duroid is used as dielectric medium in substrate as it has high efficiency, high gain and high directivity. Hence, if Duroid is used as dielectric medium in substrate in MSP antenna designed in the frequency of 2.45GHz, it increases the performance of the wireless capsule endoscopy.

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