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UWB Antenna for Biomedical Application

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ABSTRACT: Wireless capsule endoscopy provides visualization of the GI tract by transmitting images wirelessly from a disposable capsule to a data recorder worn by the patient. The first capsule model for the small intestine was developed by Given Imaging and approved in Western countries and approved by the Food and Drug Administration (FDA) in 2001. Over subsequent years, this technology has been refined to provide superior resolution, increased battery life, and capabilities to view different parts of the GI tract. Before the introduction of capsule endoscopy (CE) and double-balloon endoscopy (DBE) , there was no effective modality for the evaluation and management of patients with obscure GI bleeding. Obscure GI bleeding is defined as bleeding of unknown origin that persists or recurs after a negative initial or primary endoscopy (colonoscopy or upper endoscopy) result. The first capsule endoscope model, which is now regarded as a first-line tool for the detection of abnormalities of the small bowel, was the PillCam SB. Our project aims to increase the speed of transmission and optimise the antenna to work within the permissible SAR limits as specified by the FCC.

Keywords: Ultra-Wideband (UWB), compact antenna, Endoscopy.

I. INTRODUCTION

Ultra-wideband (UWB) systems offer large bandwidth that facilitates a wide range of wireless applications. The Federal Communication Commission (FCC) assigned a frequency band for UWB systems in the range of 3.1 GHz to 10.6 GHz in February 2002. The EIRP (Equivalent Isotropic Radiated Power) has a maximum mean of -41.3 dBm/MHz. Due to its exceptional benefits, such as the ability to deliver high speed data rates at close transmission ranges with minimal power consumption, UWB technology has a very bright future. Researchers' focus has been drawn to the UWB antenna design because of this. Achieving impedance matching and radiation stability over the broad operational spectrum is the actual challenge in constructing a UWB antenna. Wireless capsule endoscopy (WCE) is a non-invasive technique for visualizing the entire gastrointestinal (GI) tract, where the traditional endoscopy cannot reach the inside of the small intestine [1]. Moreover, the traditional endoscopy having a long and malleable tube with a video camera passes through the human throat to rectum which causes pain and discomfort. Doctors recommend a capsule endoscopy instead of a traditional one, to find the cause of GI bleeding, to diagnose the inflammatory bowel diseases, cancer, celiac disease etc. [2].

II. ANTENNA DESIGN

Copper was used to make the patch. The conducting patch is a 2.5mm-radius circular patch. As depicted in Fig. 1, a plus (+) form slot is added at the patch's centre. To increase the bandwidth and optimise the resonant frequency, the slot has a split ring slot surrounding it. The slot causes a decrease in Q-factor and a rise in inductance, respectively. The negative relationship between Q factor and bandwidth results in increased bandwidth. Additionally, two square slots were added to the patch's edge in order to create a single feed circularly polarised antenna. The geometrical dimensions of the patch are C1 = 2.5mm, C2 = 1.5mm, C3 = 1.3mm, S1 = 1mm, S2 = 0.5mm, Ls = Ws = 0.8mm, thickness = 0.25mm. The parameters Ws and Ls were used to optimize the axial ratio. The antenna is fed through a waveguide port. A feed line with a matching section of width 1.6 mm is used to feed the circular patch. The geometrical dimensions of the feed line are F1 = 1.8mm, F2 = 1.8mm, M = 3.2mm, thickness = 0.25. The patch design can be seen in Fig. 1.

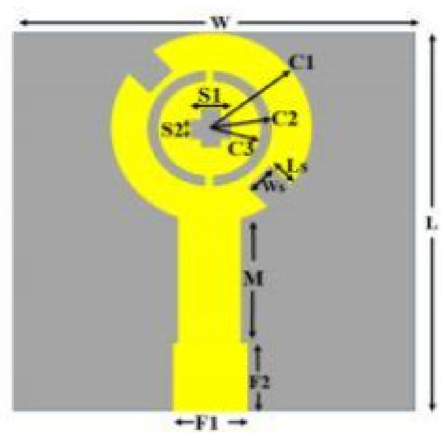

Fig. 1. Microstrip Patch.

Copper is also present in the soil. To enhance the radiation property, use the ground plane. Top corners of the ground are cut off to increase bandwidth, and notches are added to the top centre of the ground to improve impedance matching and increase bandwidth. The ground's geometrical measurements are as follows: thickness = 0.25mm, A = 3mm, B = 1mm, C = 2.8283mm.

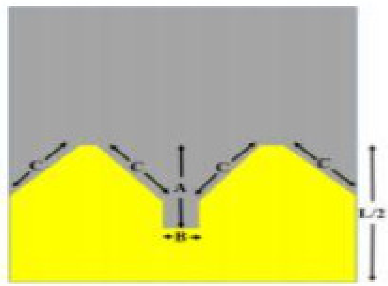

Fig. 2. Ground Plane.

III. GI TRACT MODEL

Food that has been consumed passes through the GI Tract on its way from the mouth to the digestive system and finally to the anus. The mouth, oesophagus, stomach, small intestine, large intestine, rectum, and anus are all parts of the tract. Models of the aforementioned organs are created here for capsule endoscopy in order to recreate the full procedure in the proper setting. The models of the organs have specific dimensions. As seen in Figure 3, the stomach was constructed as a sphere with a 20 mm radius, and the esophagus was made as a circular cylinder with radius. The small intestine was a 10-mm-radius, 80-mm-long cylinder, while the large intestine was a 40-mm x 70 mm x 40 mm box.

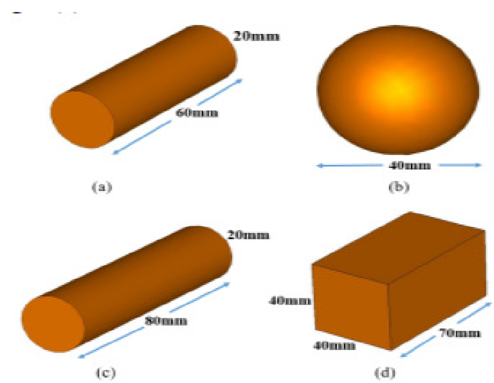

Fig. 3. Properties of the gastrointestinal organs used for the simulation. (a) Esophagus, (b) Stomach, (c) Small Intestine, and (d) Large Intestine.

Table 1: Parameters for Different Body Parts.

Tissue	Relative Permittivity	Conductivity(S/m)	Loss Tangent
Esophagus	57.89	5.16	0.32
Stomach	57.89	5.16	0.32
Small Intestine	49.98	5.75	0.41
Large Intestine	46.4	4.7	0.36
Muscle	49.54	4.04	0.29
Fat	5.03	0.24	0.17
Skin	35.77	3.06	0.31

IV. SIMULATION RESULTS

Fig. 5 shows the radiation pattern and gain. At first the simple circular patch is designed. The simple circular patch was designed as per the design specification a circular patch with a substrate, feed line and ground which is shown in the Fig. 1 and 2. and after simulation S_{11} plot and radiation pattern was observed as shown in Figure 4. Figure 5 shows the radiation pattern and gain.

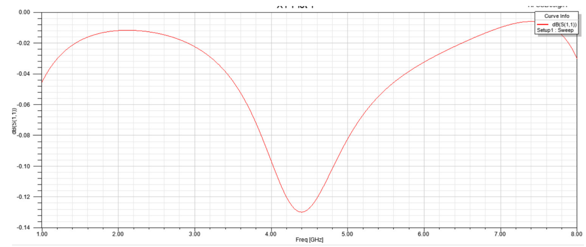

Fig. 4. Simple Circular Patch S11.

Fig. 5. Simple Circular Patch Radiation Pattern.

V. CONCLUSION

This paper explains the working of the capsule endoscopy and the process of finding out how the antenna works in different conditions due to being ingested in the human body. In HFSS, the patch of the antenna was placed within different shaped models representing the organs in the GI tract and the different layers of human tissues such as muscle. During the simulation of the patch, some results showed that simulations as expected for biomedical application.

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