DESIGN OF CONFORMAL WIDEBAND ANTENNA FOR ADENOCARCINOMA IN WIRELESS CAPSULE ENDOSCOPY

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Abstract - *Wireless capsule endoscopy (WCE) can be considered as an example of ingenious technology since it represents an appealing alternative to traditional diagnostic techniques. This technology enables inspection of the digestive system without discomfort or need for sedation, thus preventing the risks of conventional endoscopy, and has the potential of encouraging patients to undergo gastrointestinal (GI) tract observations. In this paper, the novel small antenna solutions for a WCE system operating at the ISM band frequency of 2.4 GHz . The in-body capsule transmitter uses an ultra wideband conformal antenna with less size of dimensions as (3.8*3) mm. The ultra wideband characteristic enables the capsule antenna to tolerate the detuning effects due to electronic modules in the capsule and due to the proximity of various different tissues in stomach. The partial ground plane produce required frequency and high gain of -16.2 dB of return loss. Also, the parameters of the patch antenna is measured. Specific Absorption Rate is also evaluated.*

***Key Words*: Wireless Capsule Endoscopy(WCE), Conformal Antenna, Partial ground plane, Stomach cancer, Antenna parameters.**

1. INTRODUCTION

Wireless Capsule Endoscopy (WCE) is a technology designed to provide anatomically and diagnostically visualization of whole Gastro Intestinal (GI) Tract – esophagus, stomach and small intestine. Images are acquired with excellent resolution and higher than conventional endoscopes. This magnification approaches the concept of physiological endoscopy as the capsule moves passively along the GI tract is shown in figure 1.

For capsule endoscopy, first the intestines are cleaned with the use of laxatives and purges. Then, the capsule is swallowed by the patient and the capsule is travelled through the esophagus, stomach and small intestine. The capsule contains cameras, LED's, battery and a radio transmitter and takes photographs rapidly. The images are transmitted continuously by the radio transmitter to the small receiver wored by the patient while undergoing capsule endoscopy. Approximately, after 8 hours at the end of the endoscopy procedure, the recorded images are viewed by the physician. Thus, swallowed capsule is digested and excreted. There is no need to retrieve the capsule.

Fig. 1 Wireless Capsule Endosocopy

1.1 Conformal Antenna

In radio communication and avionics a conformal antenna or conformal array is a flat radio antenna which is designed to conform or follow some prescribed shape, for example a flat curving antenna which is mounted on or embedded in a curved surface. Conformal antennas were developed in the 1980s as avionics antennas integrated into the curving skin of military aircraft to reduce aerodynamic drag, replacing conventional antenna designs which project from the aircraft surface. Military aircraft and missiles are the largest application of conformal antennas, but they are also used in some civilian aircraft, military ships and land vehicles. As the cost of the required processing technology comes down, they are being considered for use in civilian applications such as train antennas, car radio antennas, and cellular base station antennas, to save space and also to make the antenna less visually intrusive by integrating it into existing objects.

1.2 How It Works

Conformal antennas are a form of phased array antenna. They are composed of an array of many identical small flat antenna elements, such as dipole, horn, or patch antennas, covering the surface. At each antenna the current from the transmitter passes through a phase shifter device which are all controlled by a microprocessor (computer). By controlling the phase of the feed current, the non-directional radio waves emitted by the individual antennas can be made to combine in front of the antenna by the process of interference, forming a strong beam (or beams) of radio waves pointed in any desired direction. In a receiving antenna the weak individual radio signals received by each antenna element are combined in the correct phase to enhance signals coming from a particular direction, so the antenna can be made sensitive to the signal from a particular station and reject interfering signals from other directions.

2. ANTENNA DESIGN

The proposed antenna is a conformal wideband antenna patterned with thickness of 1.6mm flexible substrate Rogers, which allows bending and wrapping around the capsule. The proposed antenna design is shown in figure 2. The conformal patch antenna is a form of phased array antenna, covering the surface. At the antenna, the current from the transmitter passes through the phase array antennas which are controlled by the microprocessor. By controlling, the unnecessary radiations emitted by the other antennas are combined by the process of interference at the transmitter. At the receiver, the weak signals of radiations are combined and sensed in correct phase and avoid the interference signals. The conformal patch antenna is designed to analyze the stomach cancer.

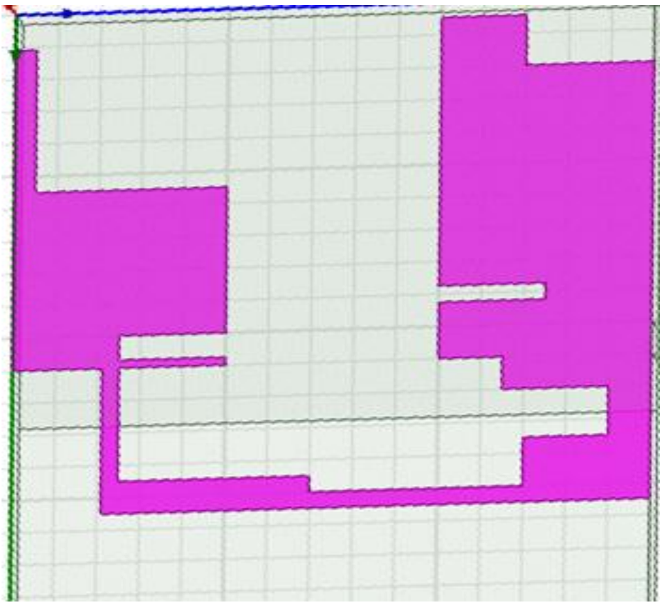

Fig. 2 Conformal Patch Antenna

The antenna consists of partial ground with the dimensions of 2.5mm*3mm shown in figure 3. The use of partial ground is to increase gain and enhance bandwidth. The antenna operates at ISM band frequency of 2.4 GHz and produce the return loss of -16.2 dB. A line feed is given to the conformal patch antenna. The dimensions of the patch is given in the table I.

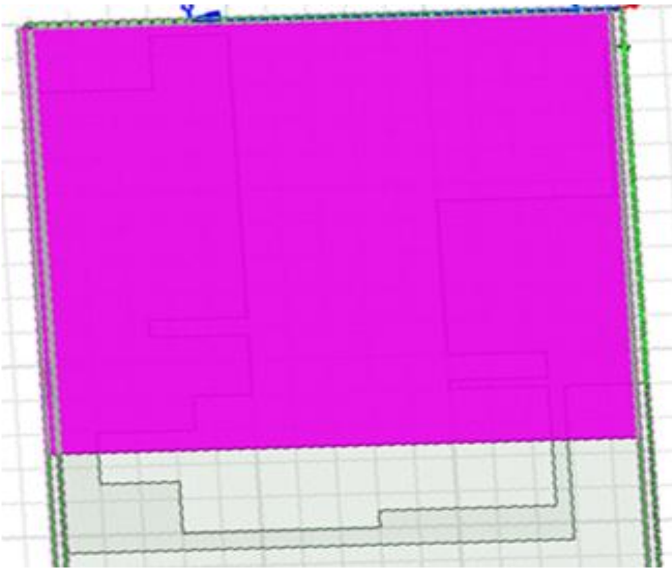

Fig. 3 Partial Ground Plane

L	L1	L2	L3	L4	L5
1.98	0.9	0.7	0.1	0.3	0.3
L6	L7	L8	L9	L10	L11
0.2	0.35	0.1	1.66	0.31	2.7
W	W1	W2	W3	W4	W5
0.5	0.5	0.9	1	0.3	0.5
W6	W7	W8	W9	LA	WA
0.5	0.4	0.6	2.58	3.8	3

Table I Dimensions of the Conformal Antenna

3. SIMULATED RESULTS

The antenna is simulated using HFSS – High Frequency Structure Simulator and the outputs are verified. The Return loss is the power loss in the signals that are returned or reflected back along the transmission line. In this antenna design, the obtained return loss is shown in the figure 3. With the designed antenna, the required bandwidth of frequency about 2.4 GHz with high gain and high efficiency is achieved.

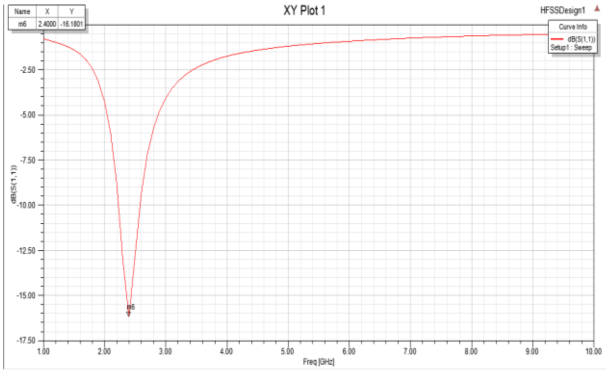

Fig.4 Return Loss of the antenna

Gain of the antenna is to direct the input radiation in a particular direction producing the output of the radiated antenna. The gain of the antenna is shown in figure 5.

SAR – Specific Absorption Rate is when human body is exposed to RF frequency, measures the rate of absorption which does not affect the tissues of the internal organs. Actual SAR rate is 1.6 W/kg as per the FCC and EU standards of the communication commission. The obtained SAR rate of the antenna is 1.0 W/kg and shown in figure 6.

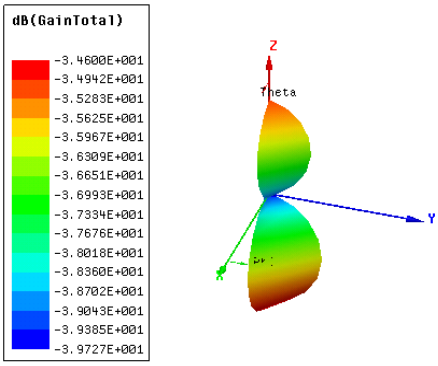

Fig. 5 Gain of the Antenna

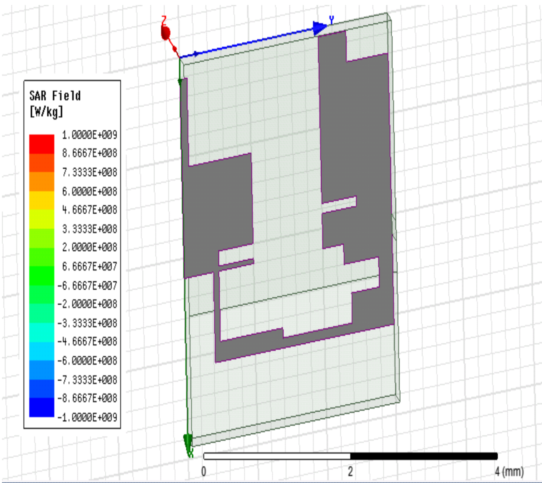

Fig. 6 Achieved SAR rate of the designed antenna

Radiation pattern is defined as a graphical representation of the radiaton properties of the antenna as a function of space coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity, radiation pattern that refers to the directional dependence of the strength of the radio waves from the antenna which is shown in figure 7.

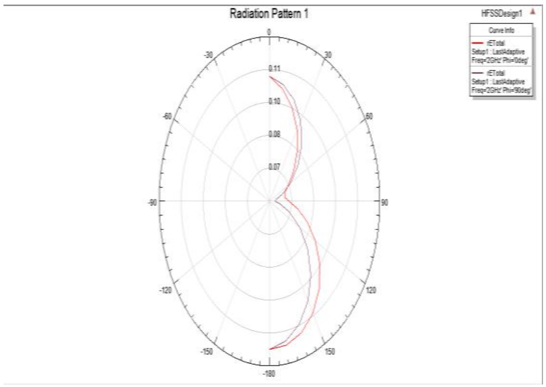

Fig. 7 Radiation Pattern of the antenna

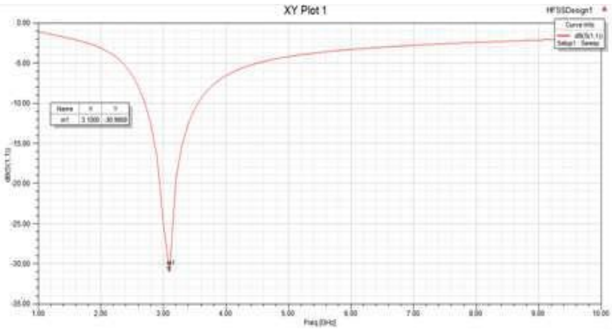

Fig. 8 Return Loss of FR4

Substrate material plays an important role in the antenna design. The substrate properties that are taken into considerations while selecting a dielectric include : dielectric constant and loss tangent and their variation with temperature and frequency , homogeneity, dimensional stability with processing and temperature, humidity and aging. Other physical properties such as resistance to chemicals, impact resistance, formability, bonding ability, foil adhesion, etc., are important in fabrication.

Return loss shown in figure 4 and 8 shows that the antenna is resonating in between 2 GHz and 3 GHz. shows the return loss of -30 dB at 3 GHz for Fr4 dielectric material comparatively shows return loss of -16.2 dB at 2.4 GHz. In fact both the results shows good return loss values however Rogers provide return loss at 2.4 GHz which is applicable for ISM band.

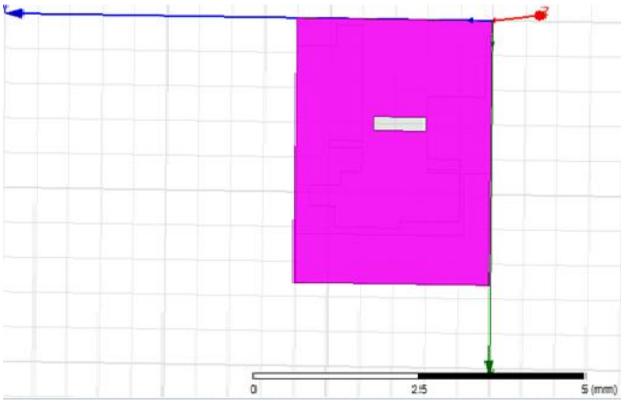

Fig. 9 Slotted Ground Plane

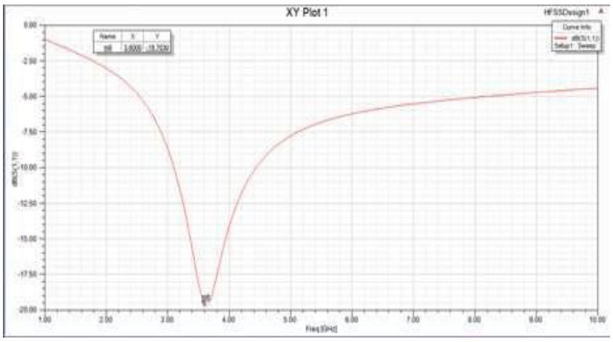

Fig. 10 Return Loss for Slotted Ground Plane

A ground plane is a conducting surface large in comparison to the wavelength, such as the Earth, which is connected to the transmitter's ground wire and serves as a reflecting surface for radio waves.

In the figure 4 and 10, it shows that the full ground plane and slotted ground plane shown in figure 9 has no effect in the efficiency rather in achieving the required frequency. Therefore partial ground plane is used to achieve the required ISM band of frequency 2.4 GHz with good efficiency of about - 16.2 dB which is applicable for ISM band applications.

4. CONCLUSION

In this paper, the conformal wideband antenna is designed for detecting stomach cancer in Wireless Capsule Endoscopy. The proposed system of the antenna is designed with different substrate material called Rogers to achieve the required ISM band of frequency operating at 2.4 GHz with the efficiency of about -16.2 dB which is suitable and applicable for medical application. Also, less Specific Absorption Rate (SAR) is achieved when compared with the normal acceptable SAR rate of about 1 W/kg. The analysis of results with different substrate materials and types of ground plane are simulated and studied. Also the parameters of the antenna are measured.

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