Design of the Micro-Strip Antenna for Wireless Capsule Endoscope

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ABSTRACT

This paper analyzed the type of mini-type antenna, studied the miniaturization technique based on simulation in depth, and finally designed the high-performance micro-strip antenna. The advantages of micro-strip antenna are light-weight, compact size, relatively thin thickness, and so on. However, it still needs aggressive miniaturization to satisfy the requirements of encapsulation. Techniques for miniaturization of antenna mainly include a ground plane, double-layer patch, shorting pin or wall, lossless dielectric substrate and the spiral structure. The techniques of multi-layer and shorting wall can narrow down the resonant frequency and attain bandwidth enhancement. Nonetheless, they have a complicated structure. Thus, simulation researched the influence of the surrounding tissue in detail, the position relation of shorting pin and the feed point, the substrate parameters and the structure parameters of the spiral antenna on performance. At last, through the techniques of the shorting pin, high permittivity substrate and the spiral shape, two Archimedean micro-strip patch antennas were developed for wireless capsule endoscope. The antenna has the bandwidth of about 300 MHz, the minimum voltage standing-wave ratio of 1.14:1, and the diameter of 8.3 mm. Therefore, the antenna can offer excellent performance for transmitting image data.

Keywords: Human Tissue, Micro-Strip Antenna, Miniaturization, Wireless Capsule Endoscope

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INTRODUCTION

Since it was firstly reported (Iddan, Meron, Glukhovsky & Swain, 2000), Wireless capsule endoscope (WCE) had become increasingly attractive for imaging examination of the small intestine in a noninvasive manner without discomfort and necessity for sedation (Glukhovsky, 2003; Delvaux & Gay, 2008; Pasha, 2009). Moreover, it can be used for tissue sample and biopsy or treatment (Sang, Yo & Seung, 2005; Kyoung-chul, Jinhoon, Doyoung & Dong-il, 2005). Meanwhile, Yamamoto & Kita (2005) and Roberts-Thomson, Singh, Teo, Nguyen & Lidums (2010) pointed out that WCE would be led to innovations in the future. However, the signal is easily interfered by other radio-frequency devices and attenuated by the human tissue during transferring. In order to enhance the anti-interference ability, Kim & Nooshabadi (2010) designed a tunable all-digital CMOS chip; Woo et al. (2010) designed a high-speed receiver; the author optimized transceiver mode with channel changing (Zhao & Peng, 2007; Zhao & Hou, 2009). Although these methods can enhance the ability of RF communication for transferring data to a certain extent, the characteristic of an antenna must be studied in depth to ensure the data reliably transfer.

Because of the high-water tissue, the absorption of electromagnetic wave increases with frequency. At higher frequency, the increased spacing between an antenna and the body counteracts losses in tissues. Therefore, it may be puzzling to select a reasonable frequency. Wang, Timothy & Cumming (2007) estimated that lower frequency had a better signal-to-noise ratio, but the signal was coupled with a much smaller. Scanlon et al. (2000, 2001) pointed out that body-worn antenna suffered from reduced efficiency, radiation pattern fragmentation, and variation impedance in feed point due to electromagnetic absorption in tissue. Despite with much higher tissue losses at 2.45 GHz, antenna performs surprisingly well in this band. Chirwa et al. (2002, 2003a, 2003b) studied two representative antennas for an ingested medical device, and indicated that the maximum radiation occurred between 450 MHz and 900 MHz. However, they only researched the radiation at the frequency range from 150 MHz to 1.2 GHz. Chan, Meng, Wu & Wang (2005) estimated attenuation at the four ISM bands from 100 MHz to 6 GHz with a simplified experimental model. The result showed that 915 MHz and 2.45 GHz were good choices for the wireless link. And, there were many prototypes of WCE used the frequency of 2.45 GHz (Chiu & Chen, 2005; Han, Chi & Wang, 2006; Xie, Li, Chen, Li & Wang, 2006; Zhao, Hou, Wang & Peng, 2010).

So, this paper firstly analyzed the type of small-size antenna, and compared the merits and flaws. Besides that, it studied the miniaturization technique of micro-strip antenna by simulation, including the surrounding tissue, the position relation of shorting pin and the feed point, the substrate parameters and the structure parameters. Finally, it designed two robust antennas using the relevant miniaturization techniques in the 2.45 GHz frequency band for WCE.

ANTENNA ANALYSIS

The antenna is an important part of the wireless medical device. It requires reducing the size as small as possible without degradation of performance. There are three types of antenna for consideration, including the monopole antenna, helical antenna, and micro-strip antenna.

Monopole Antenna

Because of the wide-band frequency characteristic and high radiation efficiency, monopole antenna usually appears in the electronic systems with facility to design and manufacture for