International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.2, Mar-Apr 2012 pp-233-238 ISSN: 2249-6645

Analysis and Design of a Quasi-TEM Slotted Tube Resonator for UHF-MRI

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ABSTRACT

Using the finite element method (FEM) and method of moments (MoM) in two dimensions, the electromagnetic (EM) analysis and design of a quasi-TEM slotted tube resonator (STR) are presented. The modeling of this resonator consists in analyzing the even- and odd-mode characteristic impedances (Z_{0e}, Z_{0o}), effective dielectric constants (ε_{effe}, ε_{effo}), the primary inductive and capacitive matrices ([L], [C]) and simulates the frequency response of S_{11} at the RF port of the designed inhomogeneous MRI probe using transmission line method (TLM). As an application, we present the design results of a UHF-MRI probe loaded with a human head model of average relative dielectric constant of 64 and using the optimum configuration of the TEM STR. The probe with high Q operates at 340 MHz (proton imaging at 8 T) and has -130.6 dB minimum reflections. The UHF-MRI probe using quasi-TEM STR is easy to construct, inexpensive, and simple to operate. Furthermore, the coil presented here may be constructed to work at different resonances frequencies.

Keywords **- Biological load, EM-parameters, high Q, frequency response, FEM, MoM and TLM calculations, human head model, Quasi-TEM slotted tube resonator, S-parameters, UHF-MRI probe.**

I. INTRODUCTION

Magnetic resonance imaging (MRI) is widely used to obtain clear images inside human body, especially high water content tissues such as muscle, brain etc. The fundamental principle of MRI is to receive nuclear magnetic resonance signals induced by radiating electromagnetic (EM) wave pulse to human body which is placed inside the high intensity static magnetic field. MRI is a method that has BCR) [4-5], TEM slotted elliptical tube resonator (TEM SER) [6-9] and TEM slotted tube resonator (TEM STR) [10-11] have been developed to use for different usages. Among these RF coils, the TEM STR has gradually come to be employed since it can produce the uniform magnetic field and can suppress the electric field.

This article is a continuation of our previous paper that appeared in Physics in Medicine and Biology magazine [12]. In support of the analysis and design of a high-Q quasi-TEM resonator for UHF-MRI applications based on loaded slotted tube resonator, we developed effectives approaches based on the use of the finite element method (FEM) and the method of moments (MoM).

For this type of quasi-TEM resonator, there are no numerical or experimental results in the scientific literature. For this reason we were obliged, for the same geometrical and physical parameters of our quasi-TEM resonator, to make simulations by using our two numerical approaches (FEM and MoM).

The aim of this work is to determine, for the optimum configuration of the quasi-TEM STR, the even- and odd-mode characteristic impedances (Z_{0e}, Z_{0o}), effective dielectric constants (ε_{effe}, ε_{effo}), the primary inductive and capacitive matrices ([L], [C]) and simulates the frequency response of S_{11} at the RF port of the designed loaded UHF-MRI probe using transmission line method (TLM) [13].

To demonstrate our numerical methods, the design results of a quasi-TEM MRI probe with high Q and -130.6 dB minimum reflection loaded with a human head model of average relative dielectric constant of ε_r=64 [14] for proton imaging at 8 T (340 MHz) will be presented.

II. QUASI-TEM SLOTTED TUBE RESONATOR

The quasi-TEM slotted-tube resonator is schematically shown in Fig. 1-a. This coil is assumed to be lossless and