Chapter 36
Implanted Cardiac Pacemaker Mathematical Modeling and Research Based on the Volume Conduction

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ABSTRACT

The research of the communication between implanted Cardiac Pacemaker and external devices is a focus. In this paper, a data communications model based Volume Conduction is creatively presented, in this way the human body conductive ability will been utilized to transmit current, which is more effective and decrease for harm of the human body than the other ways, such as: RF, Optical Transcutaneous, etc. As the frequency increases the KHz level, the effect of background biological noise is considered negligible, the channel is thus modeled as AWGN channel in these frequencies. From Shannon information theory, in two-dimensional modulation, the volume conduction channel capacity formula was derived, further derivation: with extremely low SNR using in the two-level modulation can be very effective use of channel capacity, with high SNR a multi-level modulation is used in order to make full use of the channel capacity. Matlab software is used to the channel simulation, the input and output signal waveforms and eye diagram comparison, the curves of the BER and SNR.

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1. INTRODUCTION

Cardiac Pacemaker is a kind of typical implanted medical electronic devices (Berger et al., 2008; Reisner and Brauer, 2014) (hereinafter referred to as the implanted electronic devices), which is electronic equipment surgically embedded in living body. An implanted device is a replacement for the damaged organs, which can monitor the status of the damaged organs in the body, in real time pay attention to the changes of status, and on time send the corresponding electrical signals and information to the equipment in vitro. Implanted electronics belongs to biology, microelectronics, electronics, material science, information science cross discipline, is an important part of the biomedical electronics, is also the future an important development direction of biomedical engineering. With the rapid development of integrated circuit miniaturization, communication technology and clinical medicine, the position of the implanted electronic devices is more and more important in biomedical.

Cardiac pacemaker is an alternative to the pacemaker of the heart, which is an implanted electronic device making the heart beating up. As shown in Figure 1: cardiac pacemaker pulse generator is composed of the battery and circuit, can regularly to issue a certain frequency of pulse current, by pacemaker electrode wire the current is transferred to the atrial or ventricular muscle, make the local irritation of the myocardial cells excited, excitation is diffused by intercellular conduction diffusion, cause the contraction of atrial and ventricular. The electrical signals have the following functions: when running, the heart beats faster; when sleeping, the heart beats slowly. If ECG system will be abnormal, the heart jump very slowly, and may even stop completely. Patients implanted with a pacemaker, the entire becomes coated with titanium alloy, with power only disposable batteries. Cardiac pacemaker's lifetime is generally 5 years.

Currently implanted electronic devices mainly include the physical and electrical stimulation technology, which has forty years of development history. The most successful clinical application is in implanted Cardiac Pacemaker, nearly 10 years, implanted electronic technology has been studied for more treatments of diseases, such as chronic malignant pain, Parkinson's disease, deafness, blindness, etc. Now the implanted electronic devices for the clinical application include cardiac pacemakers, brain pacemaker, cochlear implants, retinal prosthesis, vagus nerve stimulator, etc.

Figure 1. Implantable cardiac pacemaker