Design and curative effect of Embedded Intelligent External Neural Pacemaker for Prostate

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Abstract. Aiming at the problem of extracorporeal treatment of prostate diseases, an embedded intelligent prostate extracorporeal nerve pacemaker has been designed using smart chips through the principle of digital signal generator. The treatment effect has been tested through the experiment on 22 related patients in the urology department. Experimental results show that the device can accurately simulate a variety of neural signals and the frequency and amplitude of which are adjustable. The performance of the device can be considered as stable and reliable. In particular, it can generate bioelectrical signals which are similar to the basic electrical rhythm of a normal human prostate, so that the bioelectrical activity of prostate pacemaker can return to normal rhythm. The treatment has achieved good auxiliary treatment effects. The device provides a new solution for the auxiliary treatment of prostate diseases.

1. Introduction
In recent years, cases of epilepsy and spinal injury diseases that have been treated by electrical stimulation have been continuously reported. The development of miniature neural electrodes will greatly improve people’s quality of life.

With the development of intelligent embedded technology, microelectronics technology, and neurobiology and related fields, by attaching or implanting compatible integrated circuit chips (ie implantable microelectronic system for recovery of neurological function) instead of necrotic or severely damaged nerve bundles, it has become possible to use the phenomena of Electrical signals of biological nerves to establish an artificial channel for nerve action potentials, and then achieve the purpose of nerve function recovery and reconstruction. And it has got more and more attention and research.

2. Prostate pacemaker
Since the successful application of pacemakers, especially cardiac pacemakers and brain pacemakers, a variety of neural pacemakers have also emerged, and Prostate pacemakers are one of them. The working principle of the body surface Prostate pacemaker is as follows: Since the electrical activity of where the Prostate pacemaker works can be driven by external stimulation, it can be done to generate Prostate bioelectrical signals similar to the basic electrical rhythm of normal human Prostate rhythm through modern electronic technology, so that the electrical activity of the Prostate pacemaker produces a "following effect". And then the normal rhythm is restored to achieve the purpose of treating Prostate
functional diseases. However, the existing Prostate pacemakers have some shortcomings, which are mainly manifested in: on the one hand, they cannot simulate the original nerve signal with high fidelity, the Prostate nerve signal waveform is distorted and the treatment effect is poor; on the other hand, the signal frequency is too high. And its high-order harmonic components are very large, which causes great side effects.

Therefore, this subject is to tackle the above-mentioned shortcomings, with the purpose of designing an embedded intelligent neural pacemaker and verifying its efficacy.

### 3. Design and production of pacemakers

Neural pacemaker is essentially a device that can simulate and generate nerve signals. For the similarity of analog neural signals, it is required to copy the neural signals without distortion as much as possible. In this article machine learning methods is used to simulate various neural signals with high fidelity. In addition, the frequency of neural signals is very low, it is times/min, so a special signal generation method is needed here.

According to project requirements, the overall design plan is shown in Figure 1.

![Figure 1. Block diagram of the overall design of a neural pacemaker](image)

#### 3.1. Acquisition of the Neural signal

**3.1.1 Electrodes for collecting nerve signals.** The implanted electrode used in this device is also called a micro-neural electrode, it refers to a microprobe or microprobe array that can measure the bioelectric potential of a single neuron cell and electrically stimulate the neuron cell from the outside. There are many styles of electrode sheet, and its conductivity is good, and the electrical impedance is uniform. There is no need to worry that the uneven current generated by the uneven electrical impedance will sting the skin.

![Figure 2. the pre-amplification circuit diagram.](image)

![Figure 3. A/D conversion circuit for identifying and extracting neural signals](image)

**3.1.2 Processing circuit of neural signal.** The nerve signals sensed by the electrodes are fed into the conditioning circuit through cables and be processed. The neural signal conditioning circuit performs processing such as noise reduction, amplification, recognition and extraction (A/D conversion) on the
signal. The preamplifier circuit mainly needs to consider the influence of noise, input impedance and common mode rejection ratio. The circuit is shown in Figure 2, including three parts: input buffer, high frequency filter and instrument amplifier circuit.

Circuit design for neural signal recognition and extraction (A/D conversion): The MAX165 chip can be used to collect neural signals, but neural signals have their own special properties. It is an electrical signal that looks like a pulse. In order to accurately reflect the neural signal information, the sampling rate needs to be adjusted according to the collected graphics. Therefore, experiments were done with the existing high-frequency A/D chip MAX1198 in the laboratory. The circuit diagram is shown as in Figure 3.

3.2 Machine learning and simulation of neural signals

3.2.1 Design and production of the hardware part. A single-chip microcomputer is used to analyze and store the collected neural signals, and the digitization of the neural signals is realized through machine learning algorithms. Then generate standard digital Prostate neural signals, and then use the standard neural signals as needed.

Due to the fully digital design and the use of direct signal coupling and DC amplifiers, the problem of low-frequency signal realization and transmission is completely solved. The STC12C5A60S2/AD/PWM series single-chip microcomputer is selected, and the digital-to-analog conversion circuit is AD5320. The designed hardware circuit is shown in Figure 4.

3.2.2 Design of the software part. The system software is designed on the basis of the hardware system according to the functional requirements. Its software design flow chart is shown as in Fig. 6. Mainly include:

a. Initialization program of the system: including setting working status, configuring internal registers, and initializing serial communication;

b. Programs for collecting and processing signals;

c. Data transmission and display program: send the collected data to the PC and LCD control screen program through the serial port;

d. program for system boot loading: by burning the above program into FLASH, the system's boot loading operation is realized.

Figure 4. Hardware circuit diagram with single-chip microcomputer
3.3 Fabrication and installation of experimental equipment.
The physical picture of the embedded intelligent neural pacemaker is shown in Figure 5.

4. Experiment and analysis of neural pacemaker
Due to the low signal strength of the nerve pacemaker on the body surface, it will not cause harm to the human body. And the pacemaker has been used in many animal experiments. It has passed the expert's identification and can be used in clinical trials.

22 patients with functional prostate disease (ages 16 to 47 years old, all of which showed abnormal rhythm in prostate electrogram examination) in the department of urology were treated with the developed prostate external nerve pacemaker for surface prostate pacing. Among them, there are 13 cases of functional urinary dysfunction (7 cases are mainly manifested by frequent urination and urgency, and 6 cases are mainly manifested by mucus, sticky filaments or purulent secretions at the urethral orifice in the morning); posterior urethra, perineum There were 4 cases with anal discomfort; 2 cases with penile, testicular and groin pain; 1 case with painful ejaculation; 2 cases with premature ejaculation and impotence.

4.1 Treatment plan
Set relevant parameters according to the results of Prostate electrogram examination. Normally, the gastric pacing rate is three times per minute and the intestinal pacing rate is ten times per minute; the degree of treatment should be such that the skin at the place where the electrodes are attached to the abdomen has a slight puncture or burning sensation. At the same time, make adjustments based on the color of the indicator on the instrument. The frequency of treatment is usually 1 time a day, 30 minutes each time, and a course of treatment totals 10 times.

4.2 Evaluation index and curative effect standard.
Observe the symptoms before and after treatment and compare them as an evaluation index. The symptoms are classified: level 0 is asymptomatic; level 1 is occasional symptoms; level 2 is more obvious, but does not affect work and life; level 3 is that the symptoms are severe enough to affect work
and life. After treatment, it is defined that 2 grades of clinical symptom improvement or complete disappearance is defined as significant effect, 1 grade of improvement is effective, and no improvement or aggravation of symptoms is defined as ineffective. Define the effective rate as the sum of the number of significant effects and improvement effects divided by the total. After the treatment, 13 of the 22 cases were effective, accounting for 59%; 5 cases were effective, accounting for 23%; 4 cases were ineffective, accounting for 18%. The total effective rate was 82%, the treatment process was smooth and no complications occurred.

5. Conclusion
The pacemaker for Prostate nerves is a therapeutic instrument for Prostate functional diseases developed based on the latest international "Prostate pacing" theory and using modern embedded intelligent technology. The device is used for the treatment of functional Prostate diseases, can significantly improve symptoms and improve the quality of life of patients, and is especially effective for the treatment of functional dyspepsia.

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