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碩 士 論 文

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Master Thesis

具主動電荷平衡之八通道單端雙端雙架構電流電壓雙
模式高壓刺激器以供神經調節應用

**Dual-Configuration Dual-Mode 8-Channel Stimulator
with Active Charge Balance Realized in BCD Process
for Neuromodulation**

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摘要

　　神經刺激是一種醫療技術，會透過電極將電訊號輸送到特定的區域，以刺激神經系統，通常是用來治療神經疾病，其中常見的包括帕金森氏症、癲癇和聽力障礙。為了實現最佳的刺激效果，會根據病人去調整刺激的大小、持續時間以及頻率，此外可以選擇不同刺激方式，去調整單極或雙極刺激、定電壓或定電流刺激以及單相或雙相刺激。

　　為了能有符合更廣泛的應用，本篇論文提出了一個八通道單端雙端雙架構定電流-定電壓雙模式高壓刺激器。此刺激器定電流能產生 $\pm 0.2\,\mathrm{mA} \sim \pm 10\,\mathrm{mA}$，每 0.2 mA 一階，定電壓則能產生 $\pm 0.2\,\mathrm{V} \sim \pm 10\,\mathrm{V}$，每 $0.2\,\mathrm{V}$ 一階。為了避免過壓問題，使用了 $0.18\text{-}\mu\mathrm{m}$ BCD 製程。此刺激器能夠根據不同的應用，透過輸入控制訊號可以調整不同的刺激參數如刺激強度、頻率、持續時間、定電壓或定電流、單極或雙極設置以及單相或雙相刺激。在刺激結束後，可以透過放電電路減少殘餘電荷，降低對身體組織的傷害。

　　本刺激器已在電極與人體組織介面的等效電路模型上完成驗證，並且進行了仿生測試，可達到最大電流 $\pm 10\,\mathrm{mA}$ 和最大電壓 $\pm 10\,\mathrm{V}$ 的刺激。此外，藉由動物實驗驗證此刺激器能成功在豬的深腦打出刺激。

關鍵詞/字 ─ 神經調節、深腦刺激、單極刺激、雙極刺激、定電流刺激、定電壓刺激、高壓刺激器。

Dual-Configuration Dual-Mode 8-Channel Stimulator with Active Charge Balance Realized in BCD Process for Neuromodulation

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Abstract

Neural stimulation is a medical technique that delivers electrical pulses to specific areas through electrodes to stimulate the nervous system. It is commonly used for the treatment of neurological disorders such as Parkinson's disease, epilepsy, and hearing impairments. To achieve effective stimulation, parameters like amplitude, duration, frequency, monopolar/bipolar configurations, constant voltage/current output, or monophasic/biphasic waveforms should be adjusted based on the patient's condition.

This thesis proposed a dual-configuration dual-mode 8-channel high-voltage stimulator to fit a wider range of applications. The range of stimulus current is ±0.2 mA to ±10 mA with a 0.2 mA/step increment, while the range of stimulus voltage is ±0.2 V to ±10 V with a 0.2 V/step increment. The stimulator has been fabricated in a 0.18-μm BCD process to prevent overstress issues. The stimulation parameters, including stimulus amplitude, frequency, duration, constant current/voltage output, monopolar/bipolar configurations, and monophasic/biphasic waveforms, are adjustable through input control signals. Furthermore, the discharge circuit reduces the residual charge after stimulation to minimize the potential harm to tissues.

The stimulator has been validated with an electrode-tissue model. Moreover, the imitation measurement is also conducted to demonstrate the capability of delivering a maximum stimulation of ±10 mA and ±10 V. Furthermore, the stimulator is validated through animal experiments, demonstrating its capability to deliver stimulation in the deep brain of a pig successfully.

Keywords – Neuromodulation, deep brain stimulation (DBS), monopolar stimulation, bipolar stimulation, constant current stimulation, constant voltage stimulation, high voltage stimulator.