國立陽明交通大學

電子研究所

碩 士 論 文

**Institute of Electronics**

**National Yang Ming Chiao Tung University**

**Master Thesis**

# 應用於帕金森疾病控制系統晶片正負1伏共模與正負30毫伏差模偽影訊號消除及電極組織阻抗量測電路之互補式金氧半局部場電位類比前端放大器設計

# Design of CMOS Analog Front-End Local-Field-Potential (LFP) Amplifier with ±1-V Common-mode and ±30-mV Differential-mode Artifact Signals Removal and Electrode-Tissue Impedance Measurement Circuits for Parkinson's Disease Control SoC Applications

研 究 生：賴勁愷 (Lai, Chin Kai)

指導教授：吳重雨 (Wu, Chung Yu)

柯明道 (Ker, Ming Dou)

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研 究 生 ： 賴勁愷　　Student : Chin-Kai Lai

指導教授 ： 吳重雨 博士　　Advisor : Dr. Chung-Yu Wu

柯明道 博士　　Dr. Ming-Dou Ker

國立陽明交通大學

電子研究所




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學生: 賴勁愷　　指導教授: 吳重雨教授、柯明道教授

國立陽明交通大學

電子研究所

## 摘要

本論文介紹了一個應用在局部場電位訊號量測且能耐受±1V共模和±30mV差模偽影訊號的四通道類比前端放大電路，以及電極組織阻抗量測電路。在類比前端放大器這方面，為了讓電路有更低的雜訊，此電路使用截波調變技術來移除電路本身在頻寬內的雜訊。在壓抑偽影訊號上，此電路使用由高壓元件組成的截波調變器搭配時脈電位調變控制電路來完整的將帶有偽影訊號的局部場電位訊號順利傳送到核心電路端，再透過場效電晶體組成的二極體搭配高輸入電壓範圍的訊號放大器來維持後端電路的運作，此外還利用了一個差模偽影訊號消除電路來消除電極不對稱產生的差模偽影雜訊。第一級放大器採用了有兩個電流補償電路的軌到軌輸入放大器來達到較大的輸入範圍並維持訊號線性度。再來使用了開關電容低通濾波器和開關電容放大器來選擇通道並提供可調變的增益及低通頻寬。

此類比前端大器電路使用台積電0.18μm CMOS混訊/高頻製程技術。總諧波失真在沒有刺激的情況下為0.33%，有±1V共模和±30mV差模偽影訊號的情況下為1.19%。共模拒斥比於60Hz可以達到133.2dB，輸入阻抗在不同增益下於100Hz頻寬內皆能大於126MΩ。

此電極組織阻抗量測電路可以測量單極對地的電極組織阻值，量測的阻值誤差落在7-9%之間，占用的額外功號為2.65μW，額外面積約為0.047mm$^2$。

關鍵字: 刺激偽影訊號、斬波放大器、類比前端放大器、電極組織阻抗量測、帕金森疾病控制、局部場電位訊號。

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**Student : Chin-Kai Lai** **Advisor : Prof. Chun-Yu Wu**

**Prof. Ming-Dou Ker**

***Institute of Electronics***

***National Yang Ming Chiao-Tung University***



## Abstract

This paper presents a 4-channel LFP analog front-end (AFE) amplifier circuit with ±1V common-mode and ±30mV differential-mode artifact signals removal and electrode-tissue impedance measurement circuits. The capacitively-coupled chopper instrumentation amplifier (CCCIA) with chopper modulation is used to amplify LFP signals and suppress flicker noise. To conduct the large CMA, an input chopper which consists of I/O devices and dynamic clock level shifter are adopted. Besides, clamping diodes and signal amplifier with high input common-mode range are also applied to resist the CM variation caused by CMA. For DMA cancellation, a differential-mode artifact cancellation loop (DMACL) is proposed. The first-stage amplifier employs a rail-to-rail input folded-cascode (RRFC) op-amp with two current compensation circuits to achieve a large input range while maintaining the linearity of the signal.

The switched-capacitor (SC) low-pass filters (LPFs) and SC amplifier (SC-Amp) are then adopted to select channels and provide tunable gains and low-pass corners.

The AFE amplifier circuit is fabricated in TSMC 0.18um CMOS mixed signal/RF process. The measured THD is 0.33% under no stimulation and 1.19% under ±1V common-mode artifact and ±30mV differential-mode artifact. The CMRR of AFE amplifier with RLD circuit is 133.2dB @60Hz. The input impedance under different gains are all larger than 126MΩ within 100Hz.

The proposed electrode-tissue impedance measurement circuit is able to measure the monopolar impedance value. The measured error is about 7-9%. And the extra power consumption is 2.65μW, the extra area is 0.047mm$^2$.

Keywords: stimulation artifact, chopper amplifier, analog front-end amplifier, electrode-tissue impedance measurement, Parkinsons's disease control, local field potential signal (LFP).