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碩士論文

Institute of Electronics

National Yang Ming Chiao Tung University

Master Thesis

實現於高壓BCD製程之13.56-MHz無線功率和雙向數據傳輸電路以供生醫應用

13.56-MHz Wireless Power and Bilateral Data Telemetry Circuits Realized in High Voltage BCD Process for Biomedical Applications

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摘要

近年來，植入式醫療裝置（如腦機介面、神經調控系統等）應用越來越廣泛。由於這些裝置的晶片需要植入人體內，體內的能量與數據傳輸需通過近場線圈來實現。在本論文中，所設計的功率與雙向資料傳輸電路採用台積電的高壓 0.18-μm CMOS 製程 (T18HVG2-BCD)，有效避免了前代版本的過壓問題。電路整合了電源控制模組、脈衝負載鍵移反向遙測電路及二進制相位鍵移正向遙測電路，並在 13.56 MHz 的科學醫療頻段中運行。

相比傳統的負載鍵移調變技術，脈衝負載鍵移能提供更高的功率轉換效率，且能穩定接收並正確解調資料。在 105.9 kbps 的傳輸速率下，脈衝負載鍵移技術成功地將體內晶片資料傳輸至體外晶片並進行解調。另一方面，二進制相位鍵移調變器則在 211 kbps 的速率下，成功將資料由體外晶片傳輸至體內晶片。

電源控制電路由 4-bit 控制信號 IN[2:0]和 S 控制，能實現 14 種不同的功率輸出，使體內整流器產生 3.3 到 4.5 伏特的電壓。在整流器輸出功率為 225 mW 時，電源轉換效率達到 39.9%。

關鍵詞：植入式裝置、腦機介面、神經調控系統、功率與雙向數據傳輸電路、二進制相位鍵移、脈衝式負載鍵移

Improved Design on 13.56-MHz Power and Bilateral Data Telemetry Circuits for Implantable Biomedical Applications

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Abstract

In recent years, implantable medical devices, such as brain-machine interfaces and neural modulation systems, have become increasingly common. Since these devices require chips to be implanted in the human body, power and data transmission within the body are achieved through near-field coils. In this paper, the designed power and bilateral data transmission circuits are implemented using TSMC's high-voltage 0.18-μm CMOS process (T18HVG2-BCD), effectively addressing the over-voltage issues seen in previous versions. The circuits integrate a power control module, a pulse load-shift keying (PLSK) backward telemetry circuit, and a binary phase-shift keying (BPSK) forward telemetry circuit, operating at the 13.56 MHz ISM band.

Compared to traditional load-shift keying techniques, pulse load-shift keying provides better power conversion efficiency and reliably receives and demodulates data. At a transmission rate of 105.9 kbps, the pulse load-shift keying successfully transmits data from the in-body chip to the external chip and demodulates it correctly. Additionally, the binary phase-shift keying modulator transmits data from the external chip to the in-body chip at a rate of 211 kbps.

The power control circuit, driven by a 4-bit control signal IN[2:0] and S, supports 14 different power levels, enabling the in-body rectifier to produce an output voltage ranging from 3.3 to 4.5 volts. At a rectifier output power of 225 mW, the power conversion efficiency reaches 39.9%.

Keywords: Implantable device, brain-computer Interface, brain-machine interface, Neuro-modulation system, Power and bilateral data telemetry circuits, BPSK, PLSK.