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Master Thesis

應用於植入式生醫元件具正一倍壓及正負三倍壓主動式整流器之新型高壓互補式金氧半高效率無線功率與雙向數據遙傳次系統

A New HV-CMOS High-Efficiency Wireless Power and Bilateral Data Telemetry Subsystem with 1X/3X (+6 V)/-3X (-6 V) Active Rectifier for Implantable Biomedical Devices

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摘要

近年來，植入式醫療元件(IMDs)被廣泛用於治療神經系統疾病，其大致上可以分為含有電池的植入式生醫裝置與不包含電池的植入式生醫裝置。本論文中提出的無線電源及雙向資料傳輸電源管理電路扮演了提供 IMDs 能量以及與外界溝通的媒介，可整合於不包含電池的骨導引式人工耳蝸植入次系統內，電路操作於 13.56-MHz 的醫療頻段並且使用台積電的 1P6M 0.18-μm 高壓製程，因為晶片須植入於人體內，體內的電力和資料傳輸需透過一對近場線圈，體內電路包含一個一倍壓及正負三倍壓整流器，可分別輸出+2 V，+6 V 以及-6 V 的電壓，+6 V 及-6 V 的高壓可直接做為刺激器電壓源取代電荷磊的使用，相比於有使用電荷磊的設計，提供高壓的能量轉換效率提升了 10~30%，整流器在最大輸出功率 36.2 mWatt 時效率 74.7%，資料傳輸方面，改良式二進制相位鍵移(BPSK)調變技術用於體外向體內的傳輸，而負載鍵移(PLSK)調變技術用於體內向體外，資料速率皆為 211 kbps，改良式二進制相位鍵移使用包絡檢波器解調資料，相較於使用鎖相迴路解調，功耗低，更適合應用於 IMDs。

關鍵詞: 主動式整流器、電子耳、刺激器、無線功率與雙向資料傳輸。

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ABSTRACT

Recently, implantable medical devices (IMDs) have been widely used in neuro-modulation diseases. IMDs can be divided into two categories according to the required power source, one is powered with battery and the other is powered without battery. The proposed wireless power and bilateral data telemetry circuit plays a crucial role in transferring power and communicating between external and internal controllers in IMDs. The circuit can be integrated into the batteryless bone-guided cochlear implant (BGCI) microsystem. The design, which operates at the industrial scientific medical (ISM) band at 13.56-MHz, uses TSMC 0.18-μm CMOS HV Mixed Signal Based Generation II BCD (Bipolar-CMOS-DMOS) 1P6M technology. Both power and data are transferred through a single inductive link formed by a pair of ferrite coils. The 1X/3X/-3X active half-wave rectifier in the internal unit generates 2 V, 6 V, and -6 V voltages. 6 V and -6 V send to the stimulator as the high compliance voltage (HV) source in replace of the charge pumps in BGCI microsystem, which improves the

maximum HV PCE by 10~30% compared to the design using charge pumps. The proposed rectifier has 74.7% PCE with 36.2 mWatt load. The system transfers data from the external to the implant unit through an improved binary phase-shift keying (BPSK) circuit. On the other hand, data from the implant unit to the external unit is through a pulsed load-shift keying (PLSK) circuit. The data rate is 211 kbps for BPSK and PLSK. The improved BPSK circuit use envelope-sensed demodulator, which requires a lower power consumption than the conventional PLL-based demodulator. The proposed demodulator is suitable for the low power application in neuro-modulation IMDs.

Keywords: Active rectifier, Cochlear implant, Stimulator, Wireless power and bilateral data telemetry.