國立陽明交通大學

電子研究所

碩士論文

互補式金氧半之無線電源管理次系統及其在具可重複充電電池之植入式神經調控系統之應用

The Design of CMOS High Efficiency Wireless Power Management Subsystems and Their Applications on the Implantable Neuromodulation Systems with a Rechargeable Battery

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中華民國一一一年五月

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摘要

由於植入式生醫晶片的功能越來越複雜，在植入式晶片的應用中需要可靠且持久的電源，因為安全性和可靠度的考量，可重複充電的鋰電池被廣泛的使用在植入式生醫裝置中並透過無線充電的方式來避免病人需要頻繁替換電池。在本論文當中將新的設計概念應用在無線充電次系統當中，用以對具有可重複充電鋰電池的植入式生醫裝置進行充電，此次系統中主要包含兩個部分，第一部分為無線充電系統，當中包含資料傳輸電路、可調式功率發射器、線性電池充電電路以及主動式全波整流器，在偵測電池電壓後將資料傳輸至可調式功率發射器，透過改變功率發射器輸出功率，調整主動式全波整流器輸出電壓，以減少線性電池充電電路的功率消耗；第二部分為電池管理單元，使用切換電容式電源轉換器及低壓降穩壓器產生穩定的 1.8V 和 3V 供後端電路使用。此無線充電次系統中，主動式全波整流器在傳輸功率為 225mW 下最高效率可以達到 90.1%，線性電池充電器在充電電流為 50mA 下整個充電周期的平均效率可達 91.9%，接收端整體效率可達 82.8%，相較於整流器輸出電壓固定的架構效率得以提升 9%。電池管理系統中，為改善 3V 低壓降穩壓器輸出準位漂移問題，在電路架構中新增電阻式微調電路，微調範圍為-12.2%至 16.9%，微調刻度為 1.94%。

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ABSTRACT

Due to the increasingly complex function of implantable medical devices (IMDs). It is necessary that a reliable and enduring power source to IMDs. In recent years, rechargeable Lithium-ion (Li-ion) batteries have been widely used in IMDs for safety and reliability reasons. Wireless charging is used to charge IMDs with rechargeable batteries to avoid the need for frequent battery replacement by patients. In this work, new concepts have been applied in the wireless power charging subsystem. There are two parts in this system. The first part is wireless charging system with data telemetry circuit, adaptively controlled power transmitter (ACPT), linear battery charger and active full-wave rectifier. The battery voltage would be delivered to ACPT after being detected by the system. The output voltage of the active full-wave rectifier would be control through the ACPT to reduce the power consumption of the linear battery charger. The second part is the battery management unit with switched-capacitor power converter and low dropout regulators (LDO) to supply regulated voltages (1.8 V and 3

V) to the internal circuits. The maximum power conversion efficiency (PCE) of the active full-wave rectifier is 90.1% under the transfer power is 225 mW. The average PCE of the linear battery charger is 91.9% under the charging current is 50 mA. The average total PCE of the receiver is 82.8% which is 9% higher than the architecture in which the rectifier output voltage is fixed. The modified 3 V LDO with resistive trimming circuit which trimming range is from -12.2% to 16.9% and trimming scale is 1.94%.