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Design Group

低成本低功率雙斜率式互補金氧半溫度感測器

A Low-cost Low-power Dual-slope CMOS Temperature Sensor

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作品摘要

本作品將介紹一個低成本低功率雙斜率式溫度感測晶片，如圖 1。本晶片使用了一個正比於絕對溫度 (PTAT) 的電流產生器，其運作在電晶體的次臨界區。另外還用了一個具創新性的對溫度不敏感的互補式金氧半電晶體反向器，此反相器用以產生一個 PTAT 脈寬之脈波，並取代了傳統式的電壓比較器，節省了更多功耗。輸出之 PTAT 脈波接著以一個二進位計數器來做數位量化。本溫度感測晶片，在 -40℃到 85℃的工業溫度範圍內，達到 -3.39/+2℃ 以內的誤差，而平均溫度解析可達 0.259℃ /LSB。感測器的轉換率達到 3.5 kSa/s，而且只需 2V 電壓即可使用，功耗僅 14.286 μW，能源效率可達 4.082 nJ/Sa，並擁有 0.274 nJ℃ ^2 的 resolution FoM。本晶片以 TSMC 0.35 μm CMOS 製程實現。核心電路所占面積僅 0.0345 mm^2。本晶片採用的雙斜率架構集合結構精巧、省電、高解析度與精確度、高設計彈性、免熱電偶等等的眾多優點，以相當成熟又低成本之製程即可實現，不需價格高昂的製程。它非常適合用於快速溫度監測以及電路系統之熱管理，亦適合整合進任何積體電路及晶片封裝。

Abstract

A dual-slope CMOS temperature sensor is presented in this work, as shown in Fig. 1. It employs a proportional-to-absolute-temperature (PTAT) current generator, which operates in the sub-threshold region, and a novel temperature-insensitive CMOS inverter, replacing a traditional voltage comparator for power saving, to create PTAT pulse width. A binary counter is then utilized to quantize the pulse to a digital output value. It achieves a temperature inaccuracy of -3.39℃ to +2℃ over the common industrial temperature range from -40℃ to 85℃ for five measured chip samples, and an average temperature resolution of 0.259 ℃ /LSB. The conversion rate of the digital output data is 3.5 kSa/s. 2 V supply voltage is utilized and total power dissipation is 14.286 μW, leading to 4.082 nJ/Sa energy efficiency and 0.274 nJ ℃ ^2 resolution FoM. It was fabricated by TSMC 0.35 μm CMOS process and the core area occupies 0.0345 mm^2. The utilized dual-slope architecture has the advantages of compactness, power-saving, high resolution, good accuracy, high design flexibility, and relieving the use of the extra off-chip thermocouple. It can be implemented by common CMOS process and be integrated in any circuit or package.

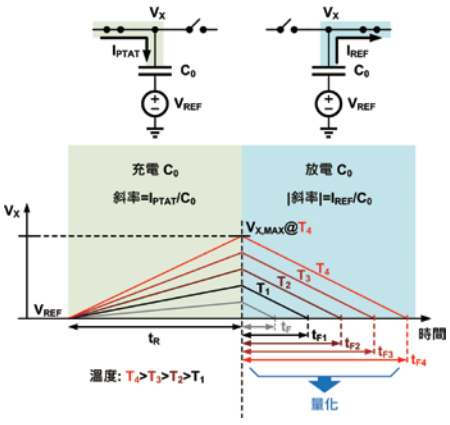

圖 1. 所提出的雙斜率式溫度感測器的基本原理

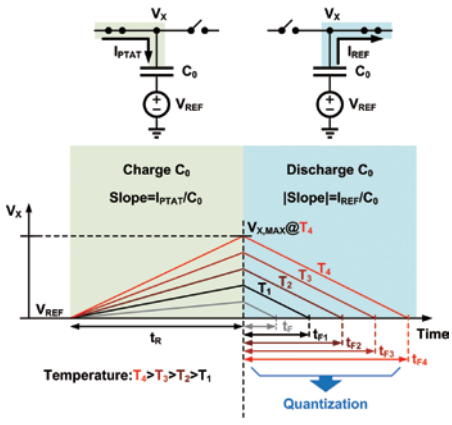

Fig 1. Basic principle of the proposed dual-slope temperature sensorsensor