色谱 » 2010, Vol. 28 » Issue (08) :737-742 DOI: 10.3724/SP.J.1123.2010.00737

微型气相色谱仪的CTC前端模拟电路设计

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Design of amplifier circuit for thermal conductivity detector in micro gas chromatography

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摘要 Agilent公司生产的Agilent 3000+系列色谱仪是微型气相色谱仪(micro GC)的典型代表,其热导检测器的信号放大电路和模数转换器(analog-to-digital convertor, ADC)存在功耗大、工作温度过高等不足。文中分析了micro GC电路的功能需求,从选用低噪声的24 bit Δ-Σ ADC ADS1255入手,设计了高共模电压容限、低噪声的全差分放大电路及其他外围电路,并且对全差分放大电路建立了噪声模型,计算了其噪声理论值,优化了系统设计参数。另外,还设计了一个测试平台,对所设计的全差分放大电路和ADC的性能进行了全面的测试评估,结果表明新设计的热导检测器放大电路与ADC的总噪声(以美国材料与试验协会(ASTM)标准值计)仅为1.25 μV,总功耗降低了3.7 W,满足micro GC的功能需求,而且可靠性高、体积小、结构简单,可用于新一代micro GC的研发和生产。

关键词： 微型气相色谱仪 热导检测器 低噪声 全差分放大电路 模数转换器

Abstract： Agilent 3000+is a typical micro gas chromatograph (micro GC) which is widely used for its fast analysis, high resolution, wide dynamic range and energy-efficient. However its amplifier circuit and analog-to-digital convertor (ADC) are of high power consumption and high working temperature. Based on the results of theoretical calculation, ADS1255, a 24-bit Δ-Σ ADC from TI, was selected as the core component for its low noise and energy-efficient. Furthermore, a low noise, high common-mode voltage durable full differential amplifier circuit was designed to accomplish the functions of impedance matching, filtering, and level shifting in front of ADC. The full differential amplifier was optimized with the analysis of noise model and theoretical calculation. In addition, a testing platform was developed to test the full differential amplifier and ADC. The testing results showed that the American Society for Testing and Materials (ASTM) noise value of new full different amplifier and ADC was as low as 1.25 μV and the power dissipation was 3.7 W lower than that of the old circuit. The new circuit is low noise, energy-efficient, compact and cheap and can cater for the requirement of the micro GC of next generation.

Keywords： micro gas chromatography (micro GC) thermal conductivity detector (TCD) low noise full differential amplifier circuit analog-to-digital (ADC)

Received 2010-05-10; published 2010-08-20

Fund:

中国博士后科学基金项目(No. 20090460750)

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引用本文:

刘鸿飞*, 陈忠.微型气相色谱仪的CTC前端模拟电路设计[J] 色谱, 2010,V28(08): 737-742

LIU Hongfei*, CHEN Zhong.Design of amplifier circuit for thermal conductivity detector in micro gas chromatography[J] Chinese Journal of Chromatography, 2010,V28(08): 737-742

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