

ARCHITECTURAL APPROACHES FOR HIGH-PERFORMANCE ANALOG-TO-DIGITAL CONVERSION USING REDUNDANT DACS

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Abstract

The paper considers the design principles of high-performance analog-to-digital systems based on redundant digital-to-analog converters (DACs). The main approaches to improving the speed, accuracy, and noise immunity of analog-to-digital conversion systems are analyzed. The use of redundant DACs allows reducing the influence of component mismatches, improving linearity, and ensuring more stable system operation. The architectural features and advantages of such systems in modern electronic devices are discussed.

Keywords: analog-to-digital systems, redundant DAC, high-performance converters, signal processing, electronic systems.

Анотація

У роботі розглядаються принципи побудови високопродуктивних аналого-цифрових систем на основі надлишкових цифро-аналогових перетворювачів (ЦАП). Проаналізовано основні підходи до підвищення швидкодії, точності та завадостійкості аналого-цифрових перетворювачів. Використання надлишкових ЦАП дозволяє зменшити вплив похибок компонентів, підвищити лінійність та забезпечити більш стабільну роботу системи. Описано основні архітектурні особливості та переваги використання таких систем у сучасній електроніці.

Ключові слова: аналого-цифрові системи, аналого-цифрове перетворення, надлишковий ЦАП, високопродуктивні перетворювачі, обробка сигналів, електронні системи.

Introduction

Modern digital systems widely rely on analog-to-digital converters (ADCs) to process signals from real-world sources. Applications such as telecommunications, measurement systems, and embedded electronics require high-speed and high-accuracy conversion of analog signals into digital form.

However, achieving both high precision and high speed in ADC systems is a complex engineering problem. Errors caused by component mismatches, noise, and nonlinearities can significantly reduce system performance. Therefore, new architectural approaches are actively being developed to improve converter characteristics.

One of the promising approaches is the use of redundant digital-to-analog converters within the architecture of analog-to-digital systems. Redundancy helps compensate for internal errors and improves the robustness of the conversion process.

Research results

High-performance analog-to-digital systems are widely used in modern electronics, including communication systems, measurement equipment, and data acquisition devices. The key challenge in such systems is achieving high conversion speed while maintaining high accuracy and stability of operation. Traditional analog-to-digital converter architectures often face limitations caused by component mismatches, noise, and nonlinearities [1].

One promising solution to this problem is the use of redundant digital-to-analog converters (DACs) in the architecture of analog-to-digital systems. Redundant DAC structures introduce additional conversion levels that allow error correction during the conversion process. This redundancy helps reduce the influence of inaccuracies in analog components and improves the reliability of the system [2].

In conventional converter architectures, the accuracy of the final digital result strongly depends on the

precision of internal circuit elements. Even small deviations in component parameters can lead to significant conversion errors. Redundant architectures provide additional flexibility, allowing the system to compensate for these deviations and maintain stable operation [3].

Another important advantage of redundant DAC-based systems is the improvement of linearity characteristics. The presence of redundant conversion steps reduces differential and integral nonlinearity errors, which significantly improves the overall quality of signal conversion. This is especially important in high-precision measurement systems and high-speed signal processing applications [4].

In addition, the use of redundancy allows designers to relax the strict accuracy requirements for individual circuit components while still achieving high system performance. This approach simplifies circuit design and improves the scalability of high-performance analog-to-digital systems.

Conclusion

High-performance analog-to-digital systems based on redundant DAC architectures represent an effective solution for improving the accuracy, speed, and reliability of signal conversion. The use of redundancy enables compensation of component mismatches and reduction of nonlinear errors.

Such systems are particularly promising for modern electronic applications that require high-speed signal processing and precise data acquisition. Further research in this area may focus on optimizing circuit architectures and reducing power consumption while maintaining high conversion performance.

REFERENCES

1. Wang J. Overview of Structure Design and Development of Analog to Digital Converter. 2024. URL: <https://doi.org/10.54254/2755-2721/2024.18199>
2. Azarov O., Dudnyk O., Obertiukh M., Lukashuk O., Murashchenko O. Combined architecture of an analog-to-digital converter with balanced throughput–cost trade-off. 2025. URL: <https://doi.org/10.32620/reks.2025.4.18>
3. Murmann B. ADC Performance Survey 2025. URL: <https://github.com/bmurmann/ADC-survey>
4. Khan A., et al. Analog-to-digital converters: a review of existing architectures and a new proposal for high resolution sensors. 2023. URL: <https://doi.org/10.1108/SR-09-2022-0369x>

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