Abstract

In the transceivers of both wireless communication and wireline communication, automatic gain control (AGC) system is widely used to provides a constant output power independent of the input signal strength. The variable gain amplifier (VGA), as the core block of AGC, is not only required to provide a wide gain variation range but also desirable for a dB-linear gain characteristic. Due to the absence of intrinsic exponential relationship in standard CMOS technology, it is difficult to realize an accurate dB-linear characteristic with low power consumption and small die area. In addition, if a broad bandwidth is demanded for high-speed communications, the design becomes more challenging.

In this thesis, novel ideas are proposed to extend the gain range effectively with minimum hardware. Firstly, the approach by tuning the transconductance and output resistance of the amplifier simultaneously is brought forward. If both of the parameters can be tuned in the same direction while preserving an exponential feature in each, the total gain range would be the summation of the changes, leading to an extended gain tuning range as well as savings in power budget. Secondly, a new constructing method to improve the gain range is presented by exploiting the convex and concave functions together. As a result, an inverse S-shaped curve is obtained, which also offers the flexibility to choose various dB-linear accuracy for different applications.

Furthermore, a wideband VGA for wireless communication and a 10Gb/s AGC system for wireline communication are designed with the proposed exponential approximation methods respectively. Several broadband techniques are adopted in order to achieve an inductorless design while minimizing the chip area. Both of them are fabricated with 65 nm CMOS process and demonstrate a competitive performance compared with the state-of-art works. With the help of proposed exponential realization methods, VGA and AGC with large gain range, wide bandwidth while low power consumption are achieved.

Publication List

[1] **L. Kong**, Y. Chen, C. C. Boon, P.-I. Mak. And R. P. Martins, "A wideband inductorless dB-linear automatic-gain control amplifier using a single-branch negative exponential generator for wireline applications," *IEEE Transactions on Circuits and Systems I: Regular Papers,* vol. 65, no. 10, pp. 3196-3206, Oct. 2018.

[2] H. Liu, X. He, X. Zhu, C. C. Boon, X. Yi and **L. Kong**, "A wideband analog-controlled variable-gain amplifier with dB-linear characteristic for high-frequency applications," *IEEE Trans. Microw. Theory Tech.,* vol. 64, no. 2, pp.533–540, Feb. 2016.

[3] H. Liu, X. Zhu, C. C. Boon, X. Yi and **L. Kong**, "A 71 dB 150 μW variable-gain amplifier in 0.18 μm CMOS technology," *IEEE Microw. Wireless Compon. Lett.,* vol. 25, no. 5, pp. 334–336, May 2015.

[4] **L. Kong,** C. C. Boon, H. Liu, X. Zhu, "Design of a wideband VGA with 40 dB gain range and ±0.6 dB gain error in 65 nm CMOS Technology for high-speed wireless communication system," prepared for submission.