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Segmented DAC Linearity Improvement With Layout Technique Using Magic Square

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This paper proposes a layout technique to improve the linearity of a unary array current digital-to-analog converter (DAC) by canceling systematic mismatch effects among unit current cells with their layout in a magic square[1)] way. The target applications are wireless communication transmitters and high frequency signal generators. Fig.1 shows a segmented DAC composed of unary array current cells, which have random and systematic errors. Systematic error has linear and quadratic error as shown in Fig.2 Then the DAC becomes non-linear. If the current cells are laid out in a sequential order, the DAC non-linearity is strongly influenced by the systematic errors (Fig.3).

There are some research efforts to reduce the systematic current source mismatch effects using layout technique [2)]. Here we present using magic square layout techniques. A mathematical matrix containing integers arranged in a constant sum of rows, columns and diagonal columns, is called magic square[1)] (Fig.4). We intend here to take the advantage of the magic square constant sum characteristics to the DAC current source array layout; we consider that the constant sum characteristics can achieve a good balance of current source array layout.

We have performed simulations in several conditions and compared the mismatch effect (DAC non-linearity) reduction among magic square, random walk and regular layout techniques. The results showed that the magic square layout technique is effective to reduce the linear gradient error effects.

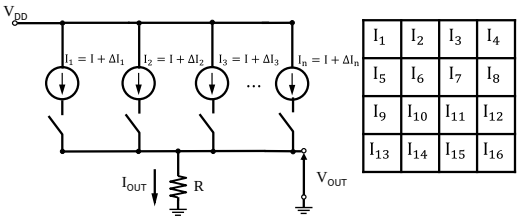

Fig. 1 Unary arraycurrent DAC and its layout

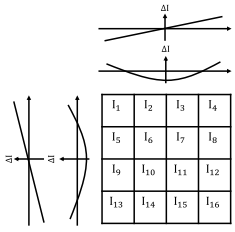

Fig. 2 Gradient error distribution

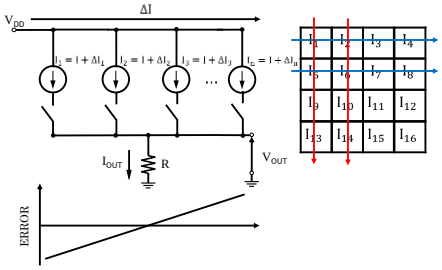

Fig. 3 Linear gradient error caused by missmuch

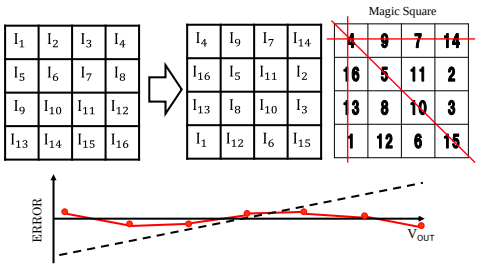

Fig. 4 Magic square layout and DAC nonlinearity reduction.

[1] Omori Kiyomi, Magic Square's World, Nippon Hyoron Publishing (2013).
[2] Xueqing LI, Qi WEI, Fei QIAO, Huazhong YANG, "Balanced Switching Schemes for Gradient-Error Compensation in Current-Steering DACs", IEICE Trans. Electron, vol.E95-C, no.11, pp.1790-1798 (Nov. 2012)