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Study of Complex Multi-Bandpass DWA algorithm for I-Q Signal Generation

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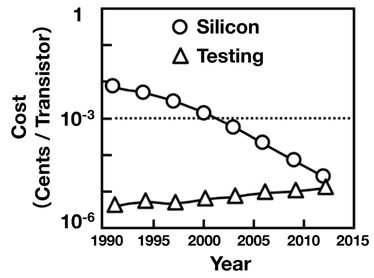
Introduction

Research Background

Demand for communication IC testing

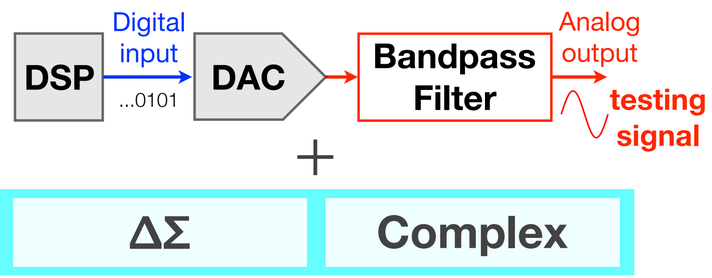


Silicon cost : Lower

Testing cost : Higher

Research Objective

High quality testing



Low cost, high quality signal

Research Objective

Multi-bit DA modulator（2~3bit）

⬇

Linearity degradation

⬇

Low quality signal

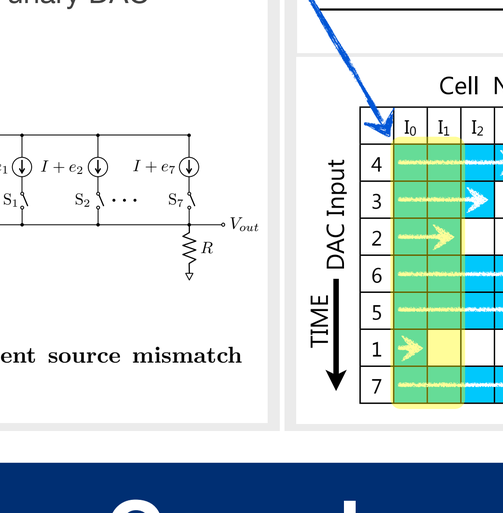
DWA algorithm

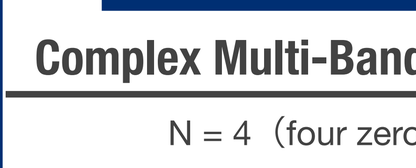
⬇

High quality signal

Complex ΔΣ DA modulator

Principle of complex BP noise shape



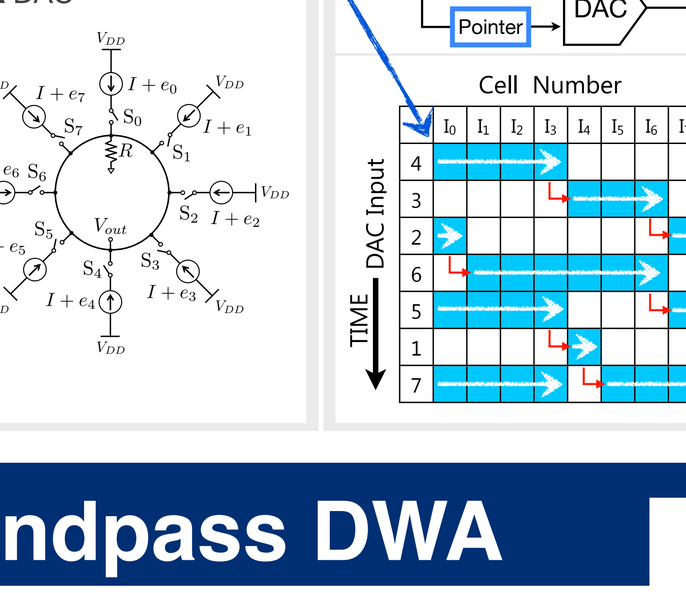


Signal Transfer Function = 1

$$I_{out} + jQ_{out} = \frac{H(z)}{1+H(z)}(I_{in} + jQ_{in}) + \frac{1}{1+H(z)}(E_I + jE_Q)$$

Noise Transfer Function = 0

2nd-order complex multi-BP ΔΣ DAC



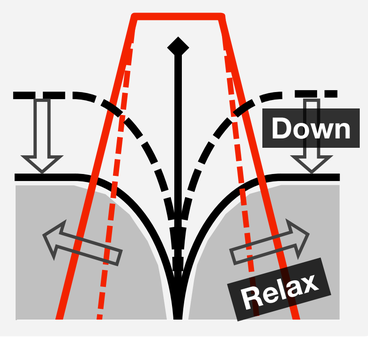
DWA algorithm

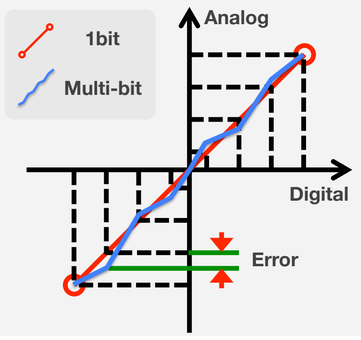
Multi-bit DA modulator

Multi-bit DA modulator（2~3bit）

⬇ **Quantization noise reduction**

⇩ **Linearity degradation**



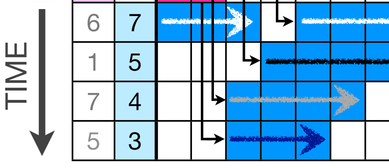


*Data Weighted Averaging | Select the element with DSP algorithm

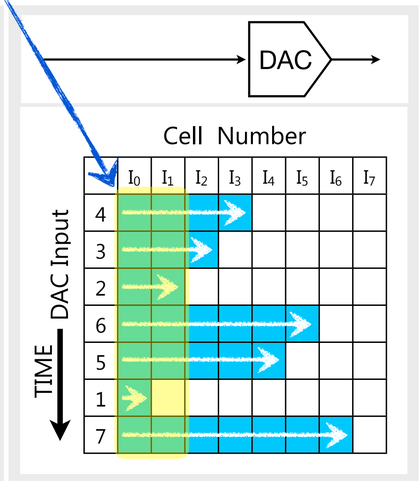
Multi-bit DAC

Accumulate mismatch of particular cell

Normal unary DAC



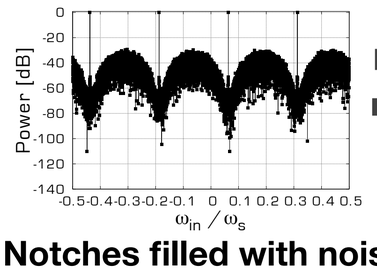
e_i : current source mismatch



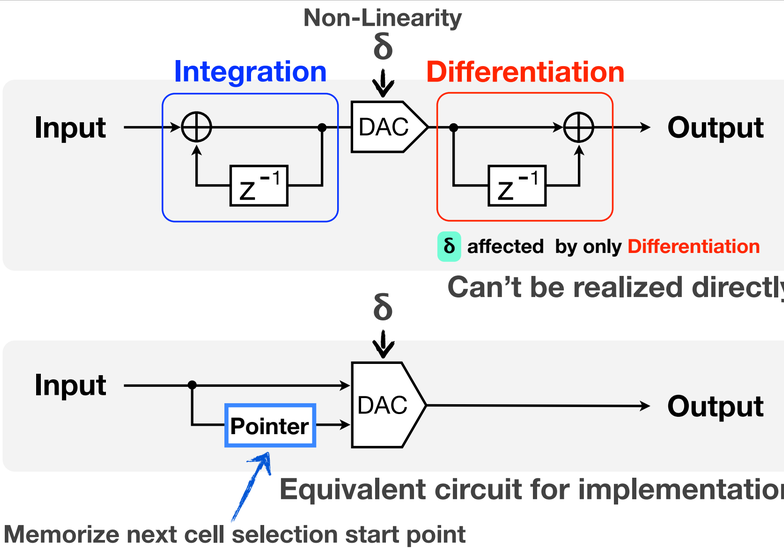
Multi-bit DAC + DWA*

Memorize next cell selection start point

DWA DAC



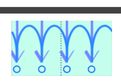
DWA = ΔΣ



Complex multi-bandpass DWA

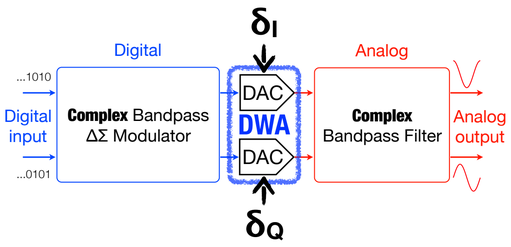
Complex Multi-Bandpass DWA algorithm

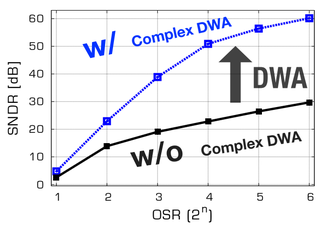
N = 4 （four zero points）



DAC$_1$ （**LP** operation） DAC$_2$ （**HP** operation）

Simulation result ~Actual Non-Linear DAC + DWA~





Notches filled with noise ➡ **Steep Notches**

Summary

- I,Q signal generation with digital centric for testing communication IC.
- Complex multi-BP ΔΣ DAC
- Multi-bit DAC
  - ◎ Relaxes the analog filter requirements
  - ✕ Degrades system linearity
    - ➡ ◎ DWA algorithm

Low cost, high quality I,Q signal generation.