Low-Distortion Single-Tone and Two-Tone Sinewave Generation Using ΣΔ DAC

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Outline

- Research Purpose
- ADC Testing Signal Generation with ΣΔDAC
- Conventional Test Method
- Proposed Test Method
- Experimental Results
- Conclusion

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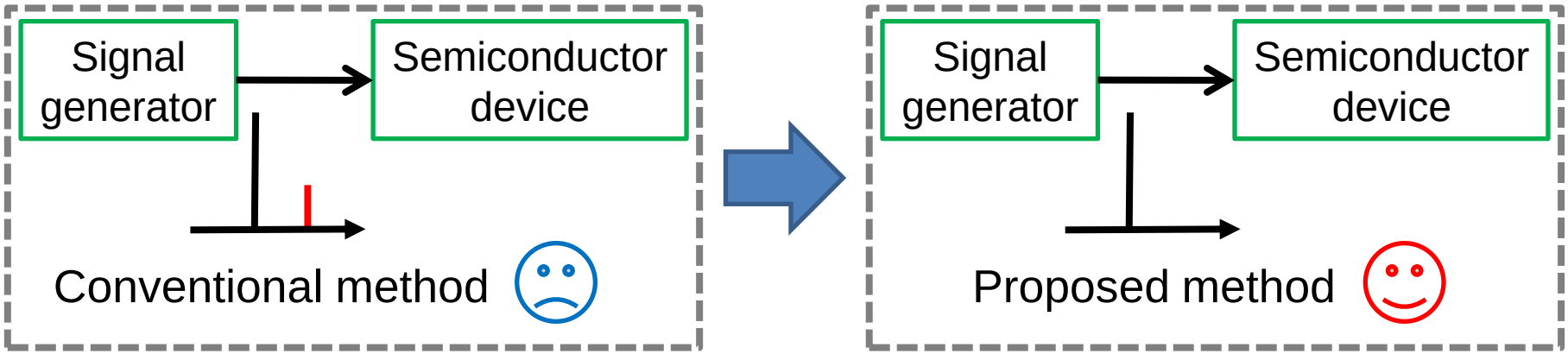
Research Purpose

Proper-quality low-cost testing of ADCs in SoC

Low-distortion sinusoidal signal generation with DSP and DAC cores in SoC



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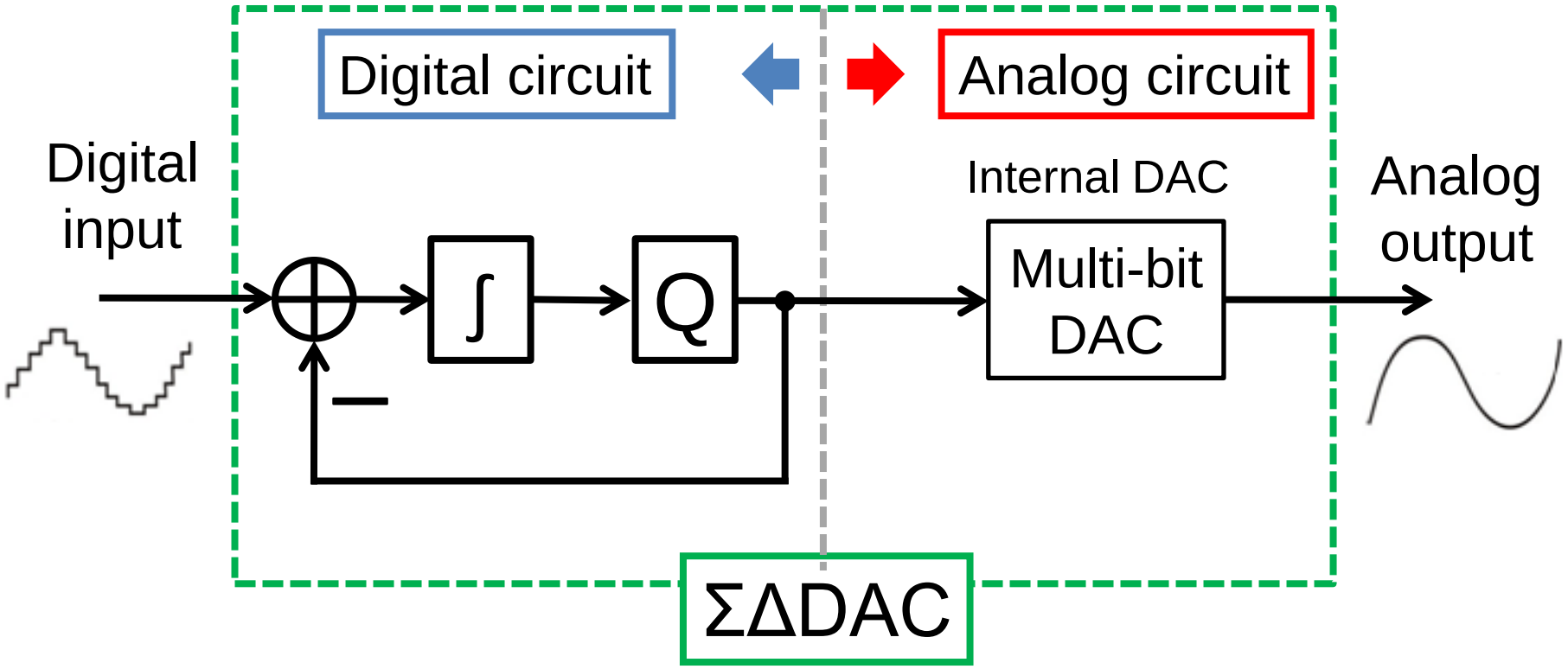
ΣΔDAC Configuration



ΣΔDAC ⇒ can be implanted with DSP and DAC cores inside SoC in test mode

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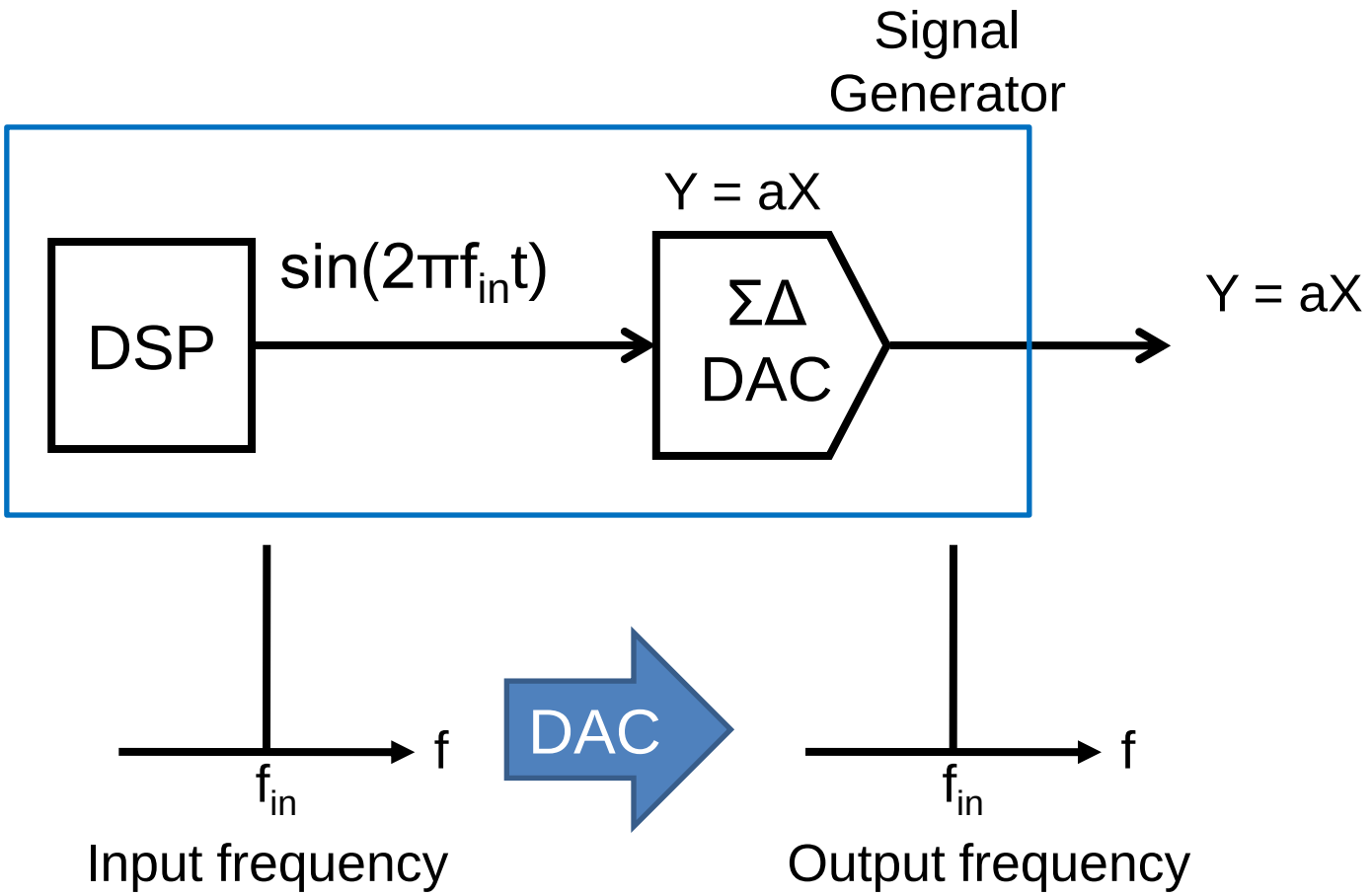
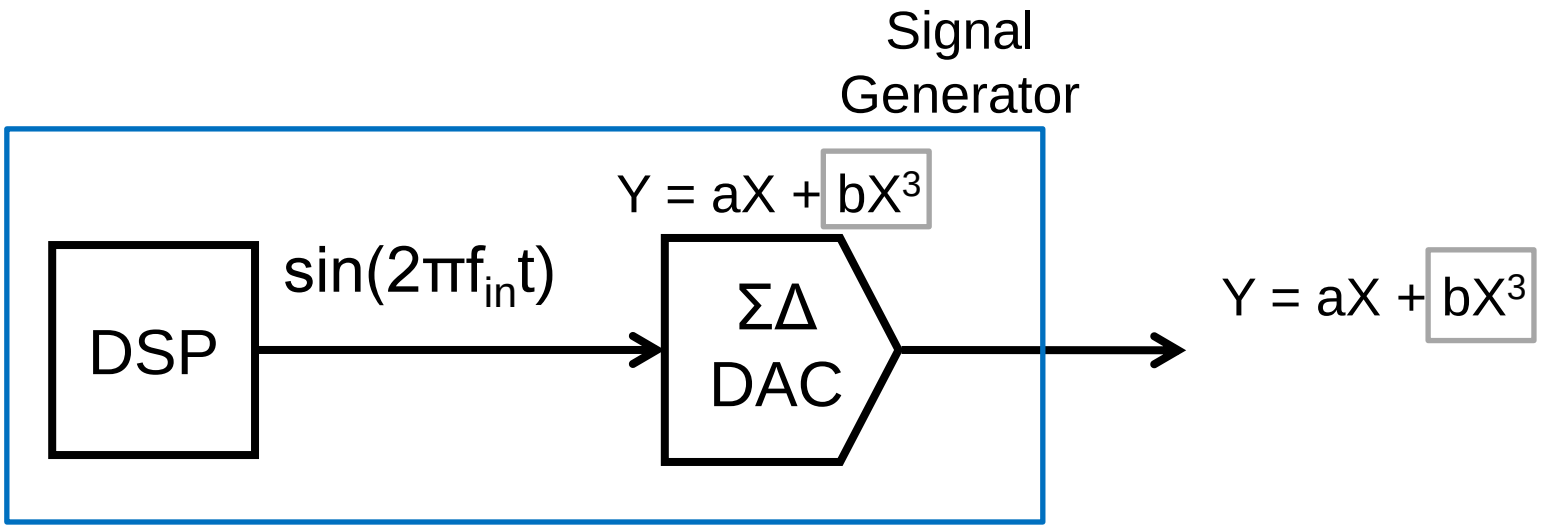
Ideally Linear ΣΔDAC

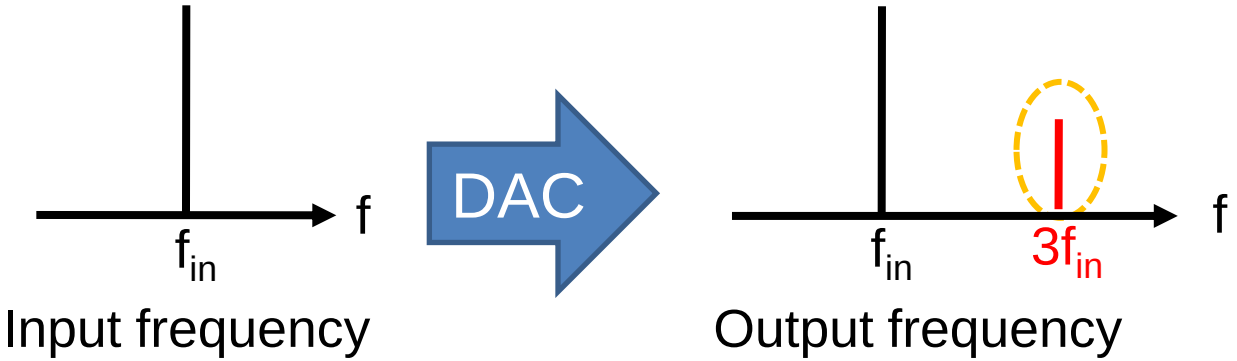


The same frequency of input and output signals

Actual ΣΔ DAC Single-tone Generation



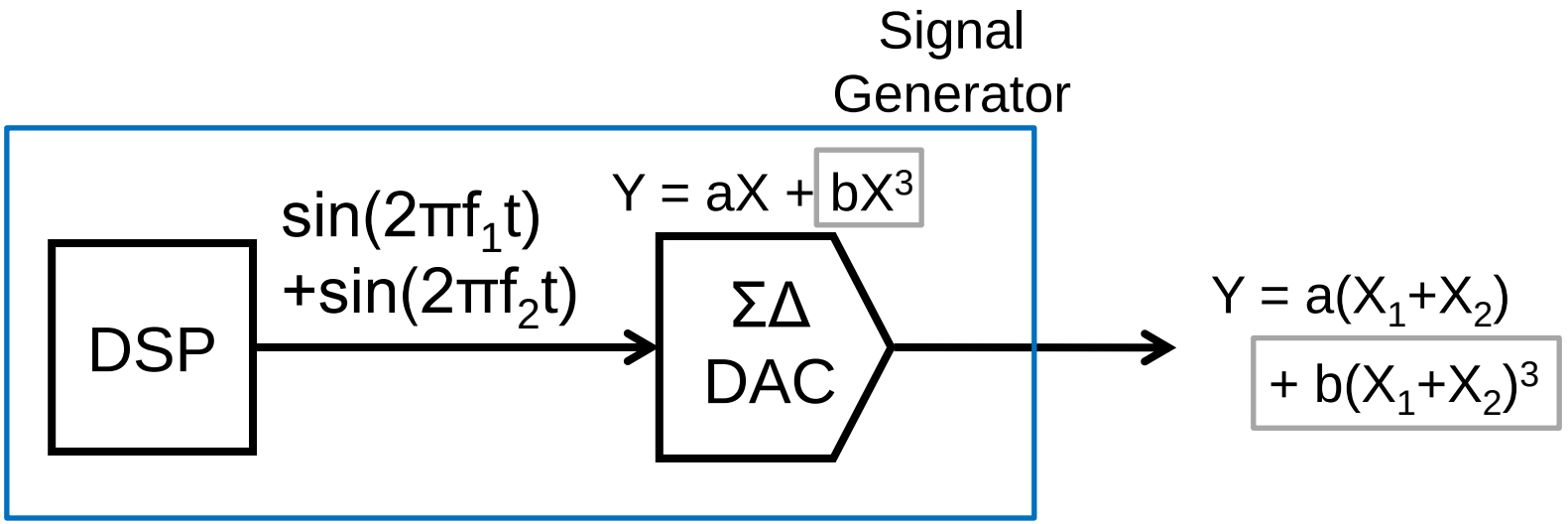
Output has 3rd order harmonic distortion(HD3)



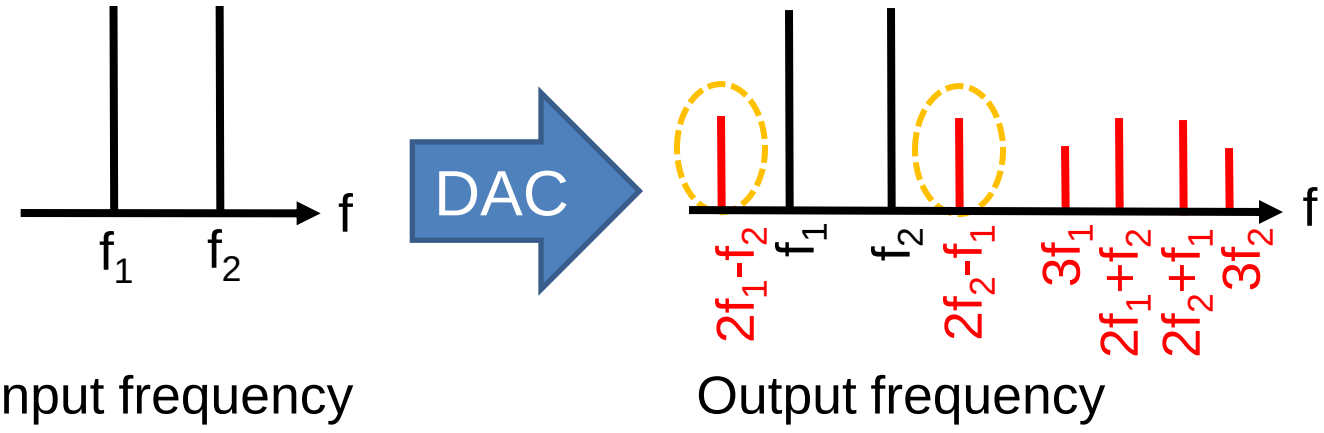
Input frequency

Output frequency

Actual ΣΔ DAC Two-tone Generation



Output has 3rd order Inter-modulation distortion(IMD3)



Input frequency

Output frequency

IMD3 components are difficult to remove by analog filter

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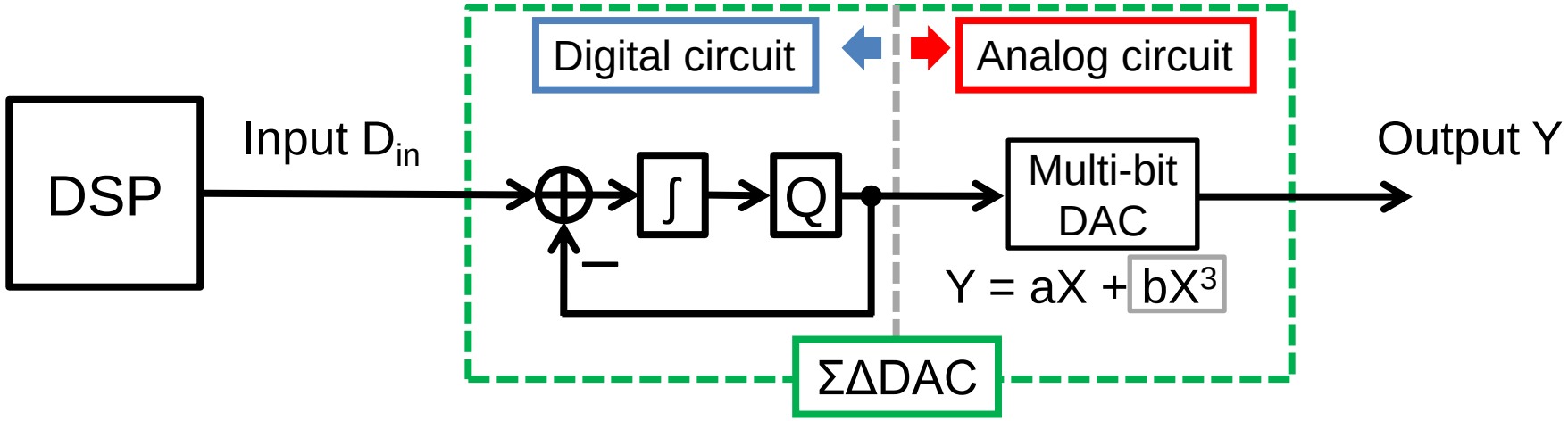
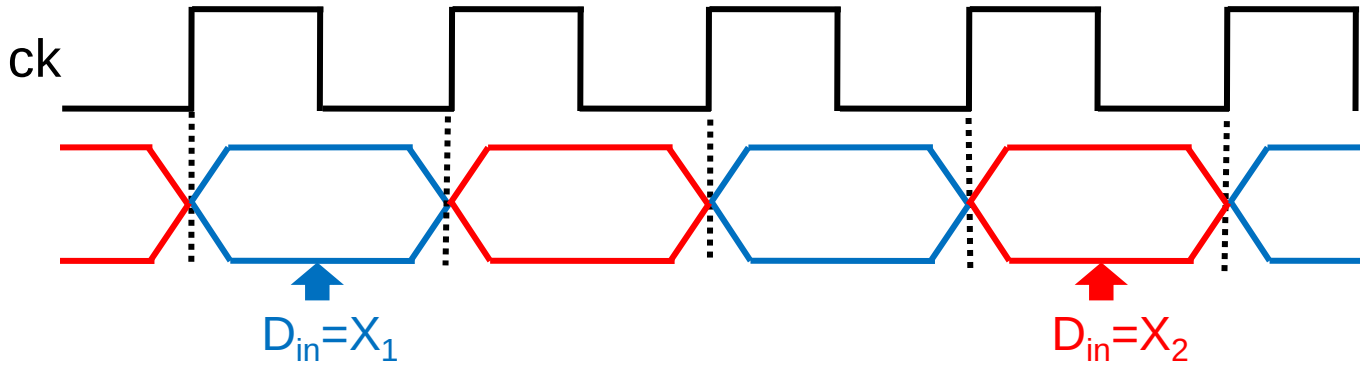
Proposed Method

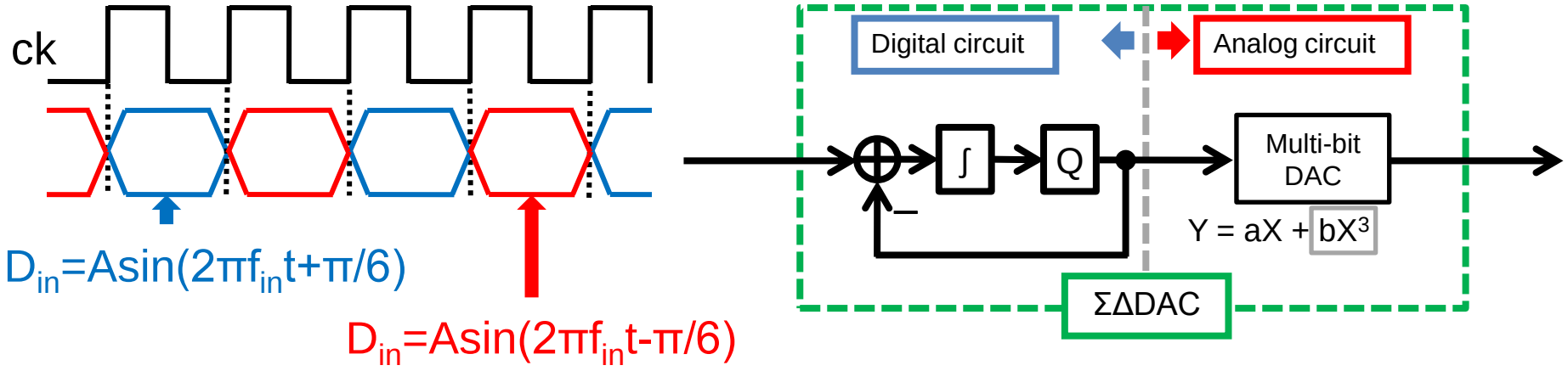


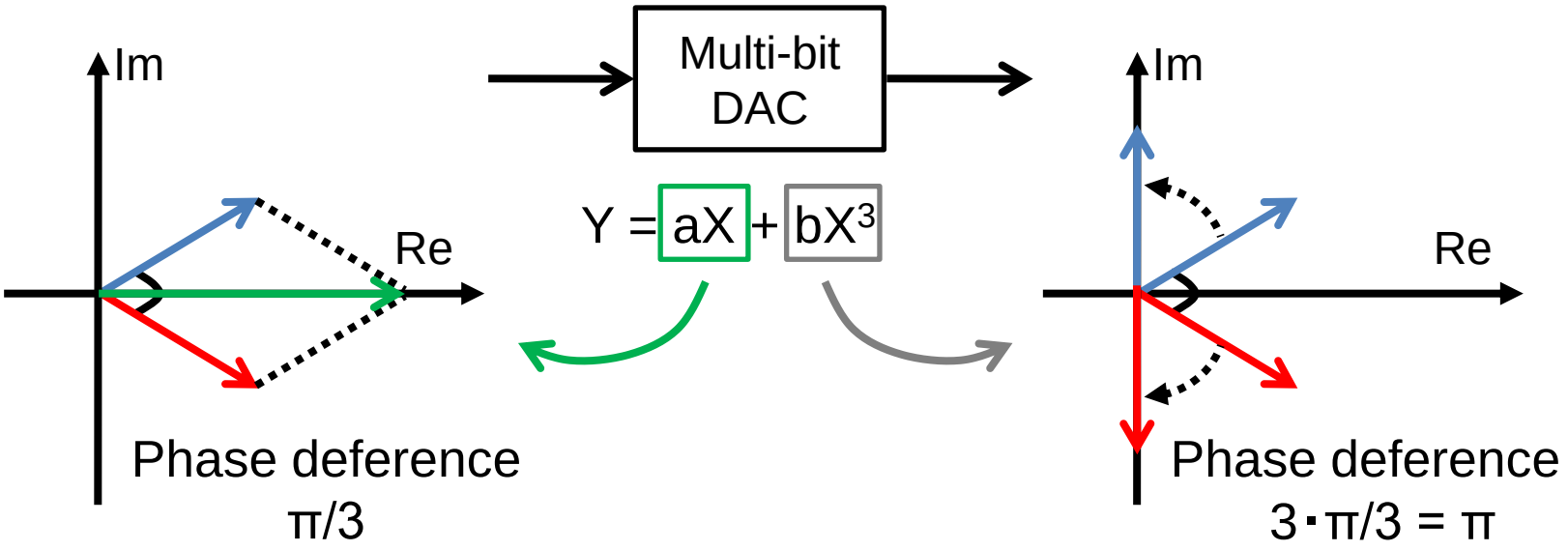


Interleave X_1 , X_2 generate D_{in}

Distortion components cancellation of output Y

Principle of Proposed Method

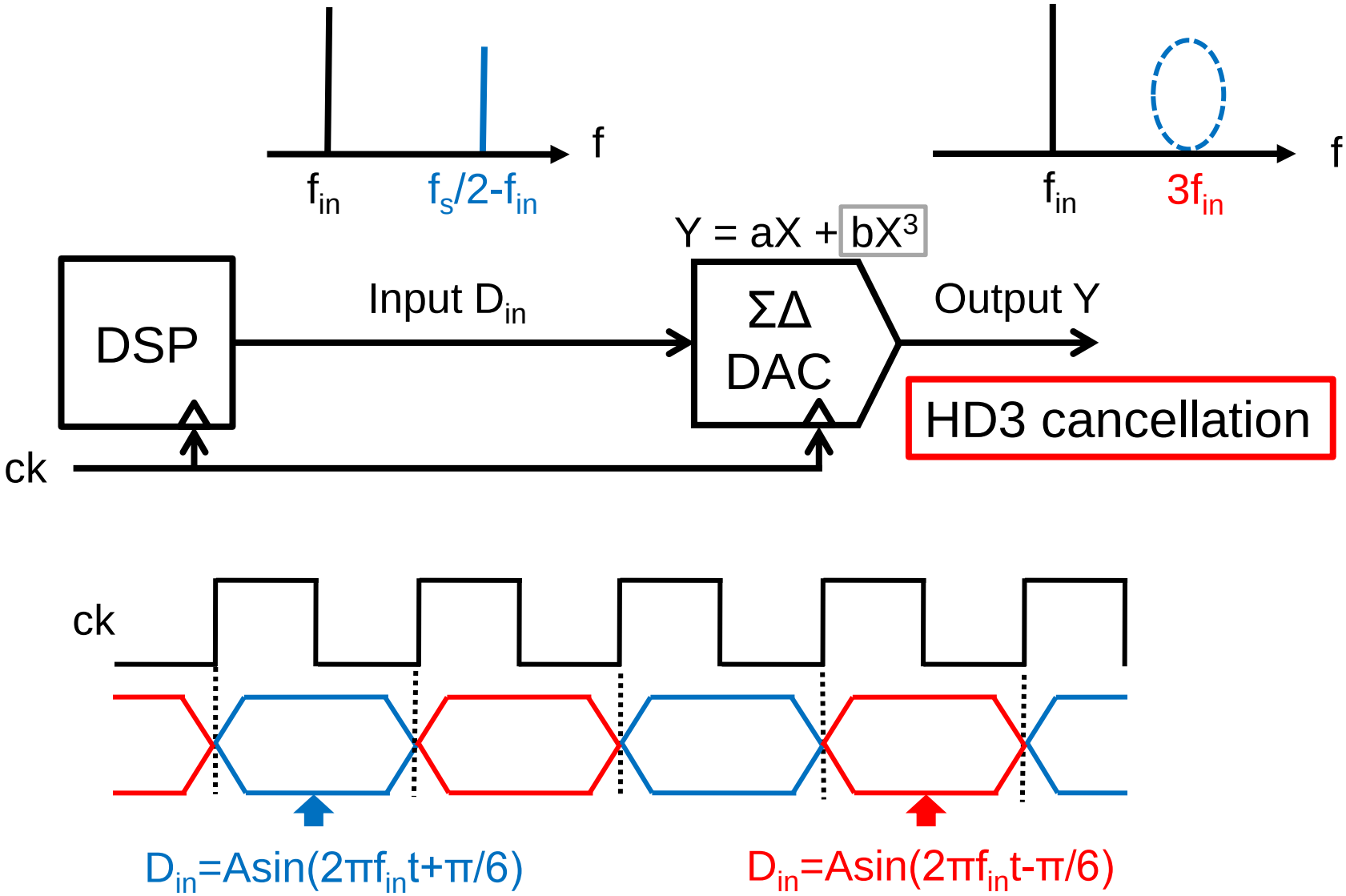




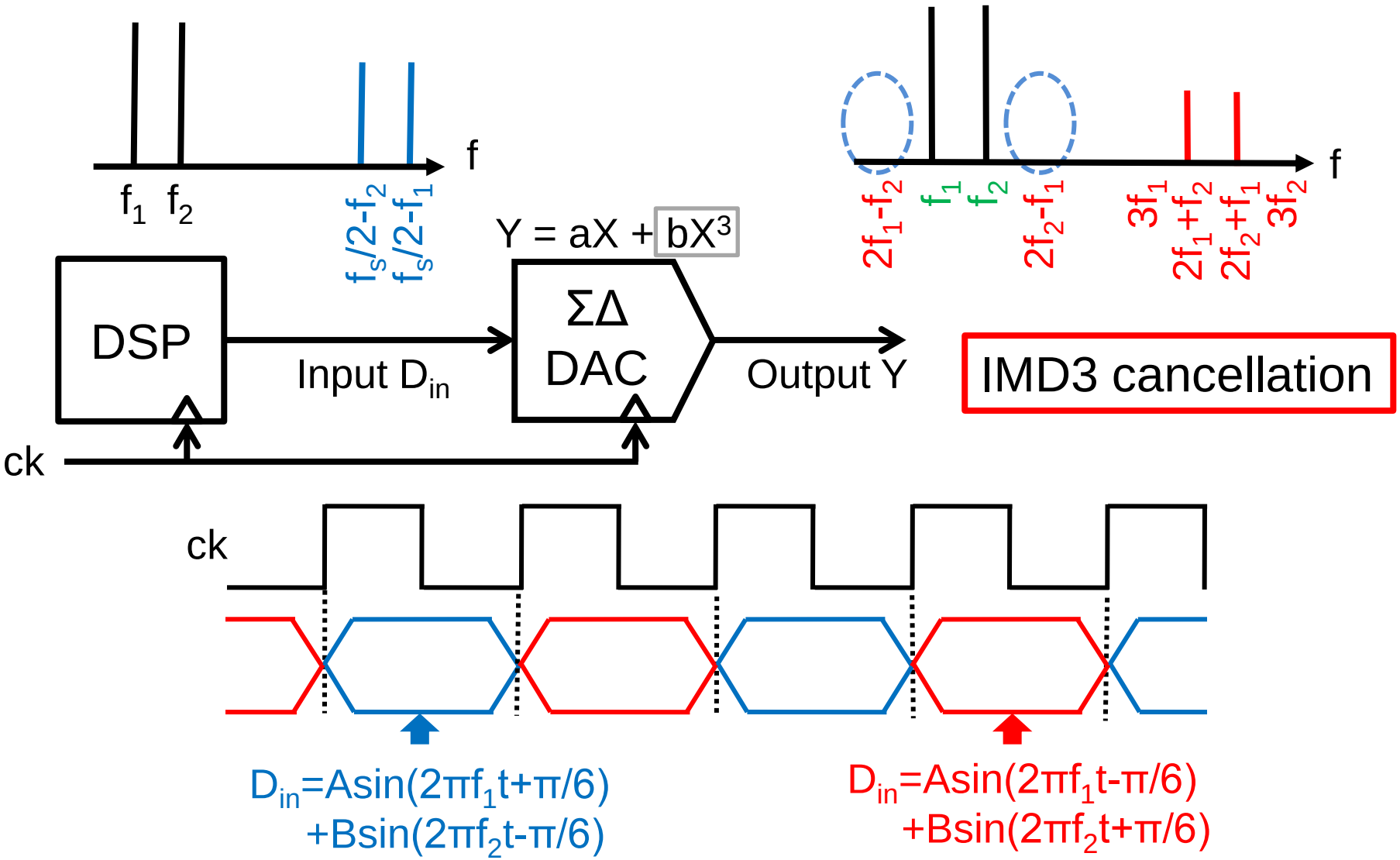
Signal component

Distortion component

Single-tone Signal Generation



Two-tone Signal Generation



For communication application ADC

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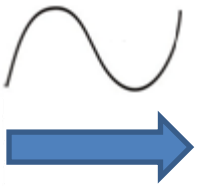
Experiment Condition

AWG Agilent 33120A Spectrum Analyzer : hp ESA-L1500A



Max. Sampling frequency (Hz)	40M
Resolution (bit)	12
Linearity	△

Frequency range (Hz)	9k～1.5G
Max amplitude (Vpp)	19.8

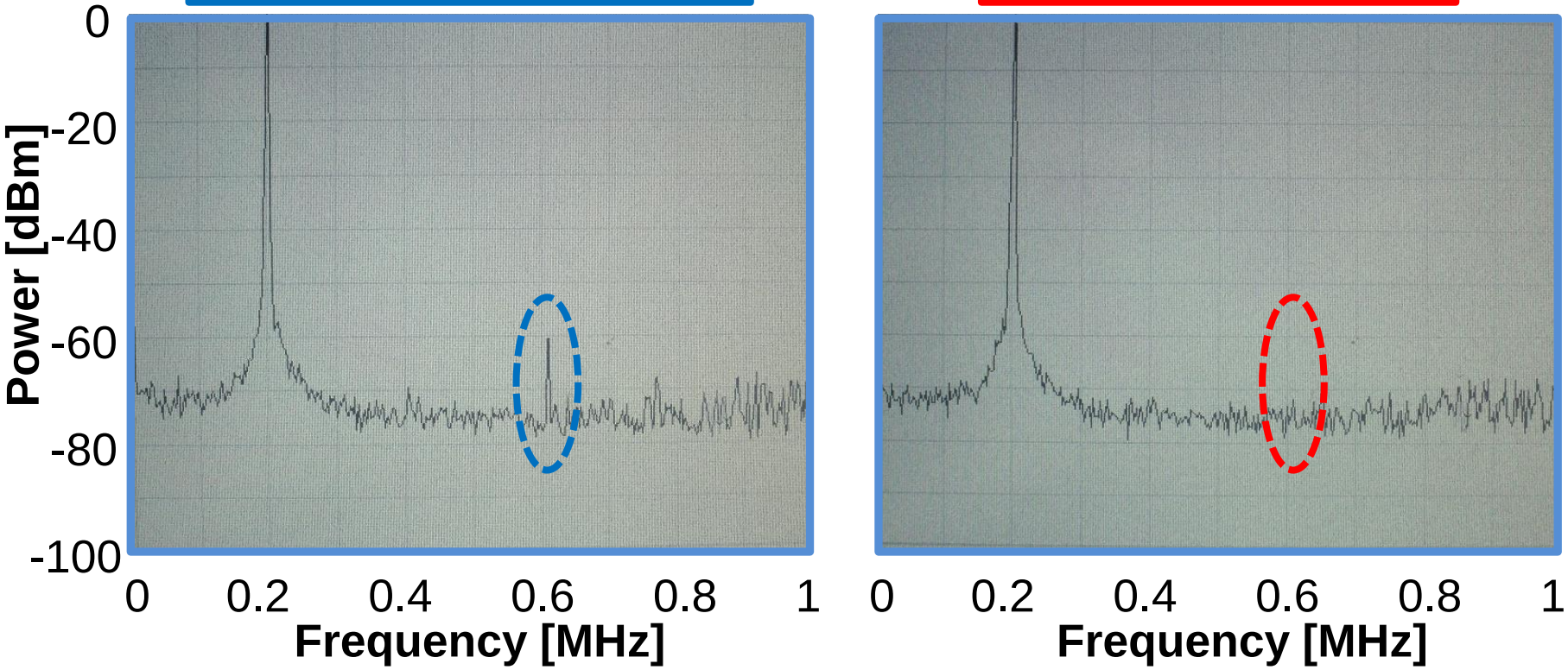
Input frequency (Hz)	200k
Input amplitude (V_{pp})	1
Sampling frequency (Hz)	8M

RBW : Resolution band width (Hz)	1k
VBW : Video band width (Hz)	100k

Experiment Results : Single-tone Signal

Conventional method

Proposed method



Fundamental
(200kHz) : 3.8 dBm

-1.2 dB

2.6 dBm

HD3
(600kHz) : -60 dBm

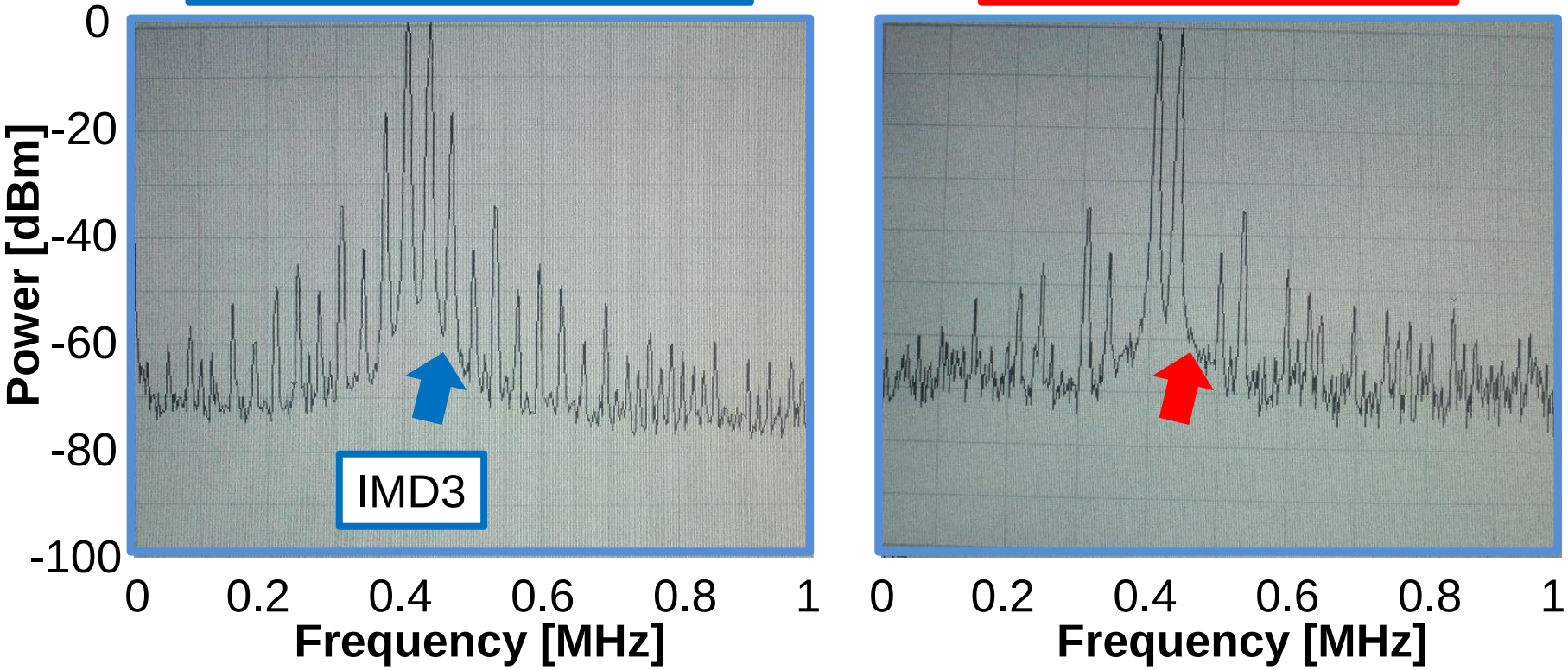
-14 dB

-74 dBm

Two-tone Signal

Conventional method

Proposed method



Fundamental
(200kHz) : 0.8 dBm

-1.3 dB

-0.5 dBm

HD3
(600kHz) : -17 dBm

-43 dB

-60 dBm

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Conclusion

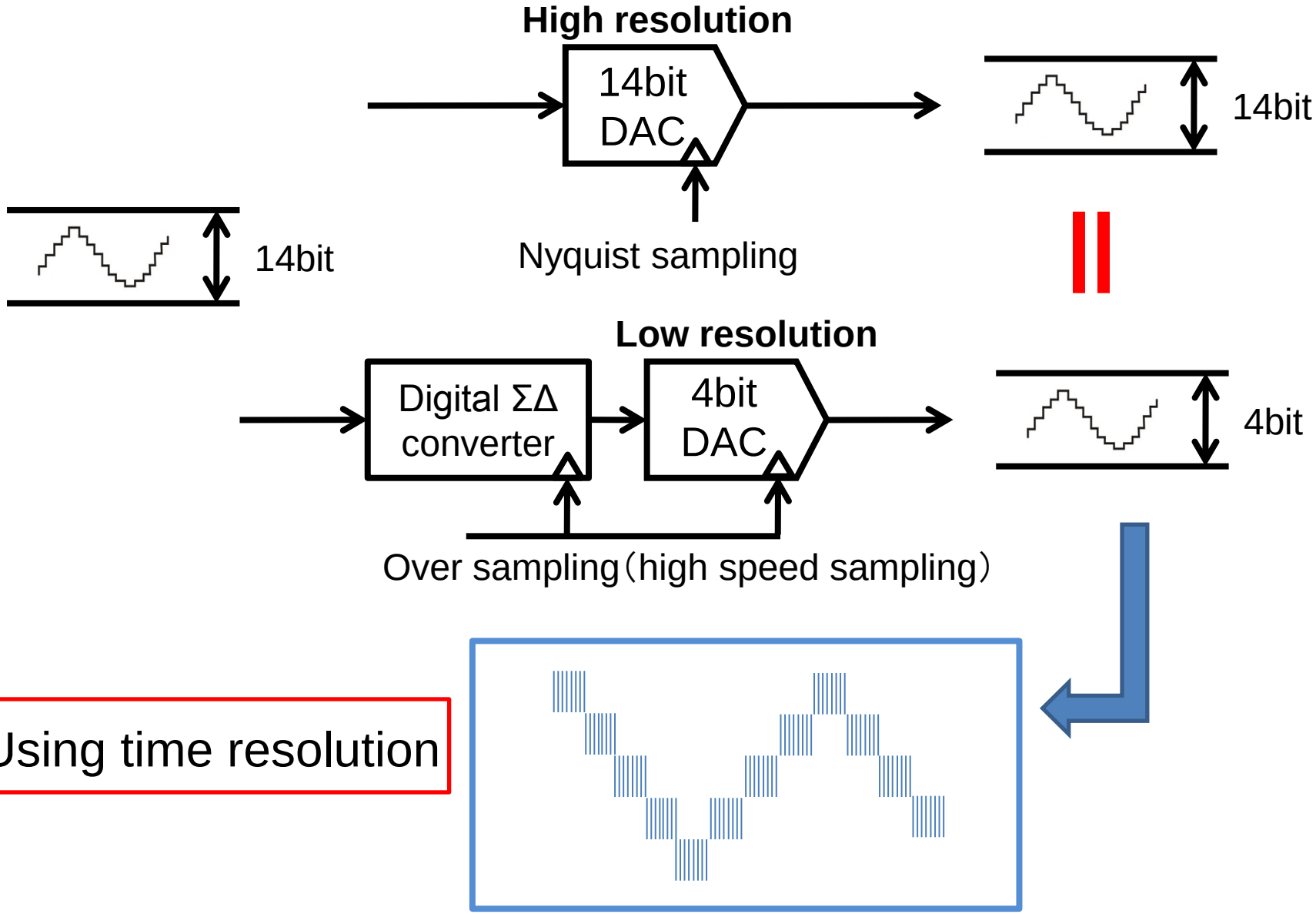
- Low-distortion sinewave generation using ΣΔ DAC

  Single-tone : HD3 cancellation

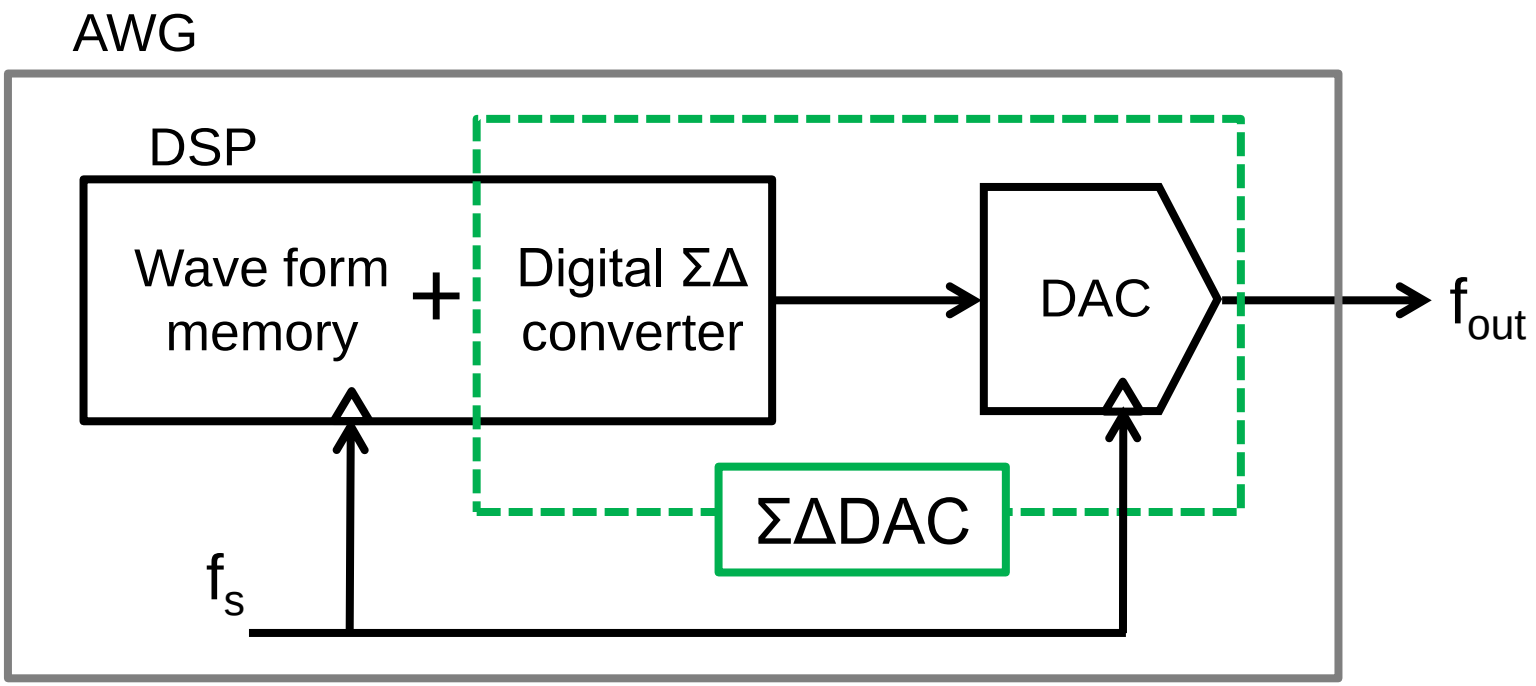
  Two-tone : IMD3 cancellation
- Only DSP programming change
- No need for DAC nonlinearity identification
- Effectiveness is verified with theoretical analysis and experiments

appendix

ΣΔDAC & NyquistDAC



AWG by ΣΔDAC



$f_{out} << f_s$

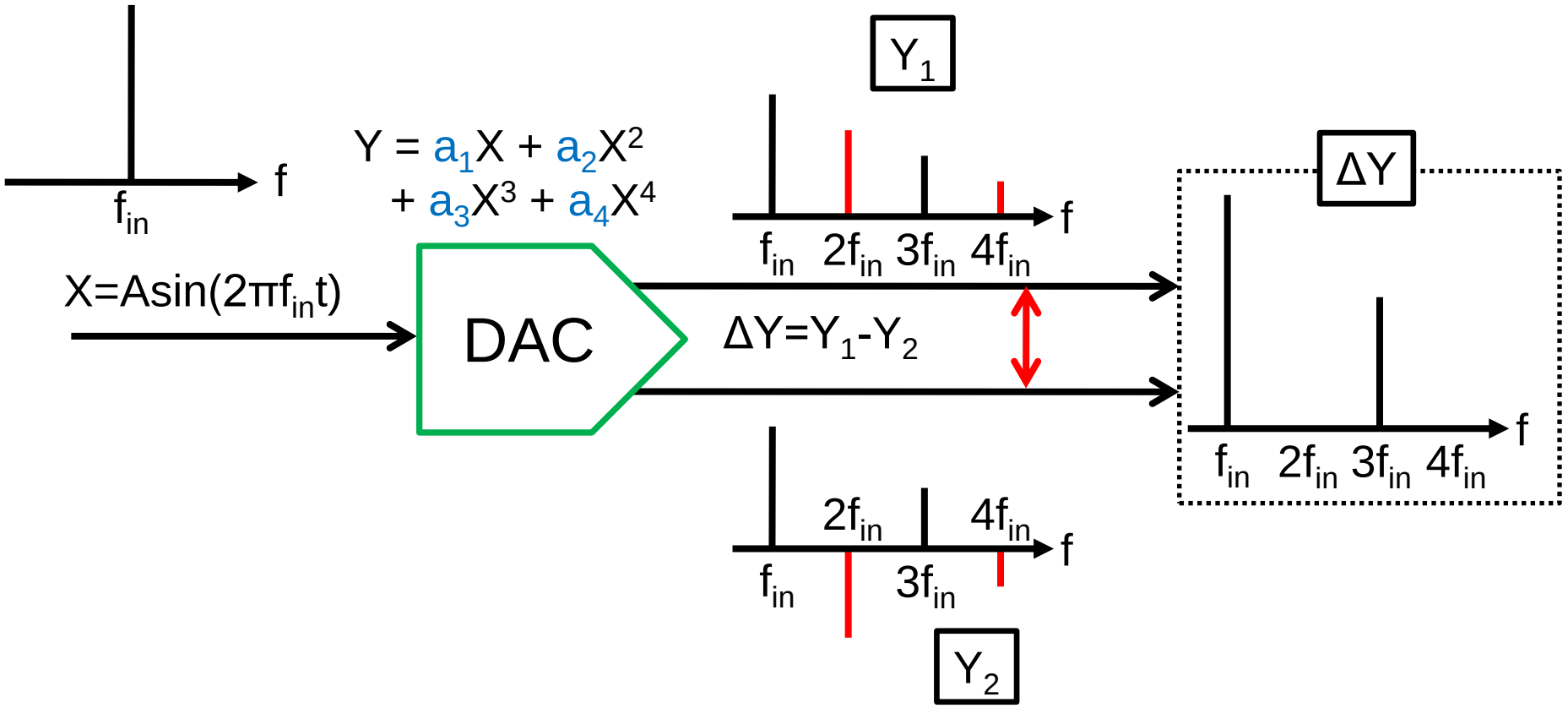
Resolution up

High speed AWG

(f_s ☺ Resolution ☹)

especially effective

Even Harmonics Cancellation by Differential



Even harmonics are cancelled by differential signals.

Focus on the third-order harmonics

Principle of Proposed Method