P80

High-Frequency Low-Distortion Two-Tone Signal Generation Using Arbitrary Waveform Generator

Tomonori Yanagida, Shohei Shibuya, Koji Asami, Haruo Kobayashi
Division of Electronics and Informatics, Gunma University
Kiryu Gunma 376-8515 Japan, email: t161d096@gunma-u.ac.jp

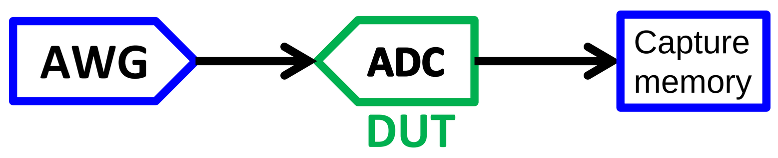
Research Objective & Background

Objective
Low-Distortion sine wave generation for communication application ADC test

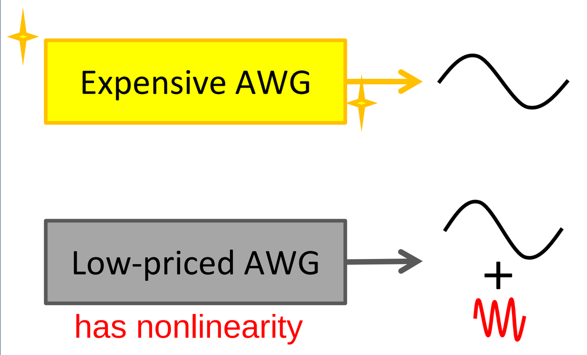
Approach
DSP algorithm using Arbitrary Waveform Generator

ADC Test Cost

ADC test system :

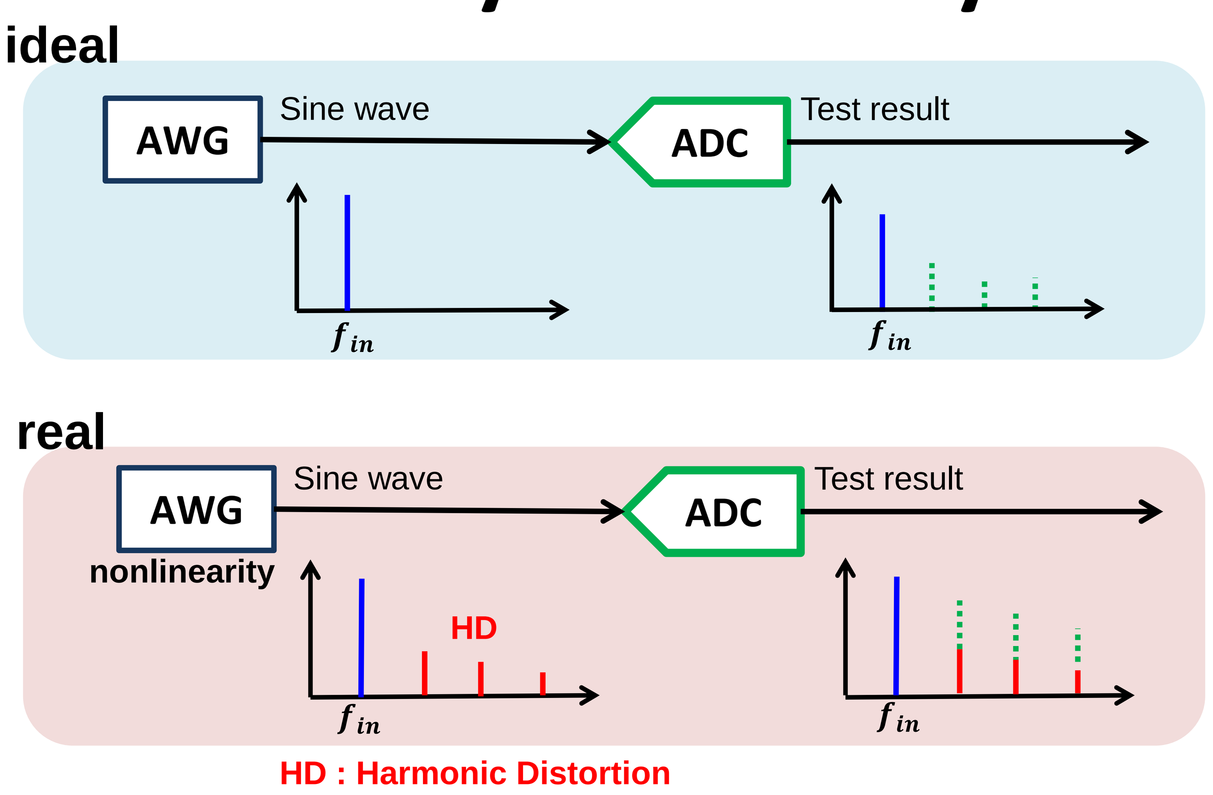


AWG : Arbitrary Waveform Generator
Expensive



	Cost	Quality
Expensive AWG	NG	OK
Low-priced AWG	OK	NG
Low-priced AWG + Proposed method	OK	OK

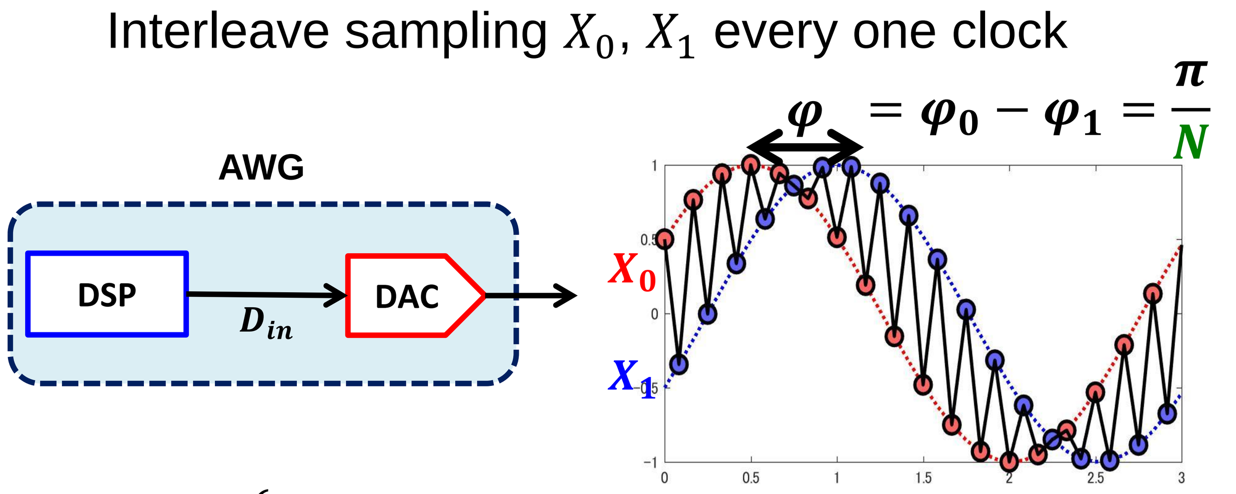
Ideality and Reality



Phase-Switching Method

Phase-Switching Method

Interleave sampling X_0, X_1 every one clock

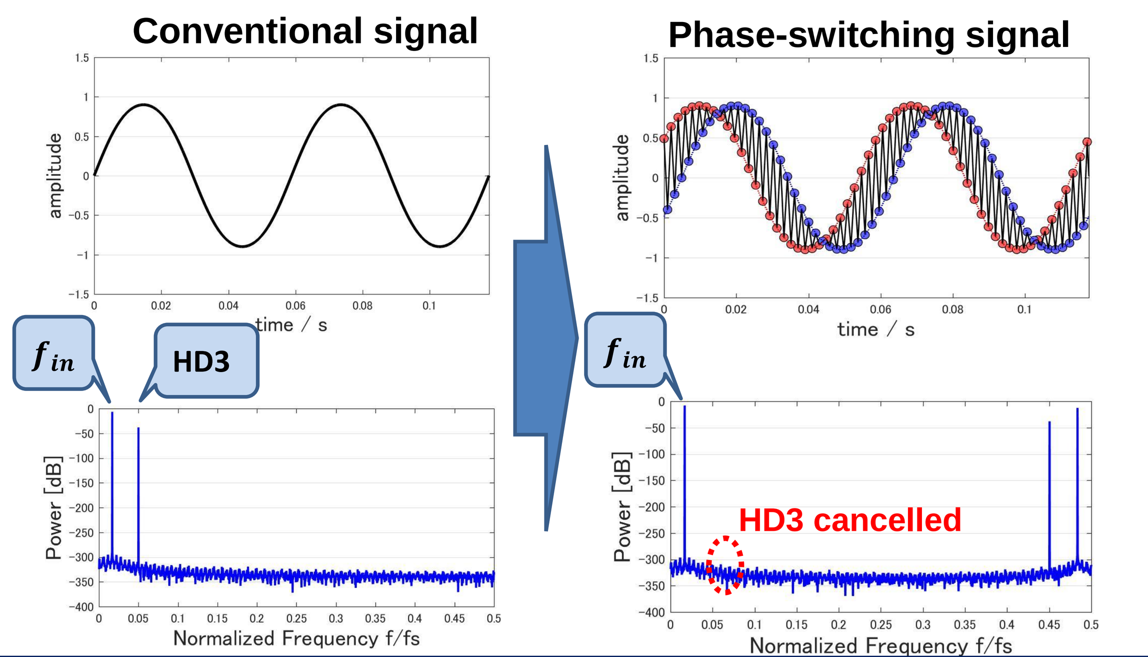


$$D_{in} = \begin{cases} X_0 = A\sin(2\pi f_{in} nT_s + \varphi_0) & n\text{: even} \\ X_1 = A\sin(2\pi f_{in} nT_s + \varphi_1) & n\text{: odd} \end{cases}$$

***N*th-order harmonics of AWG are cancelled**

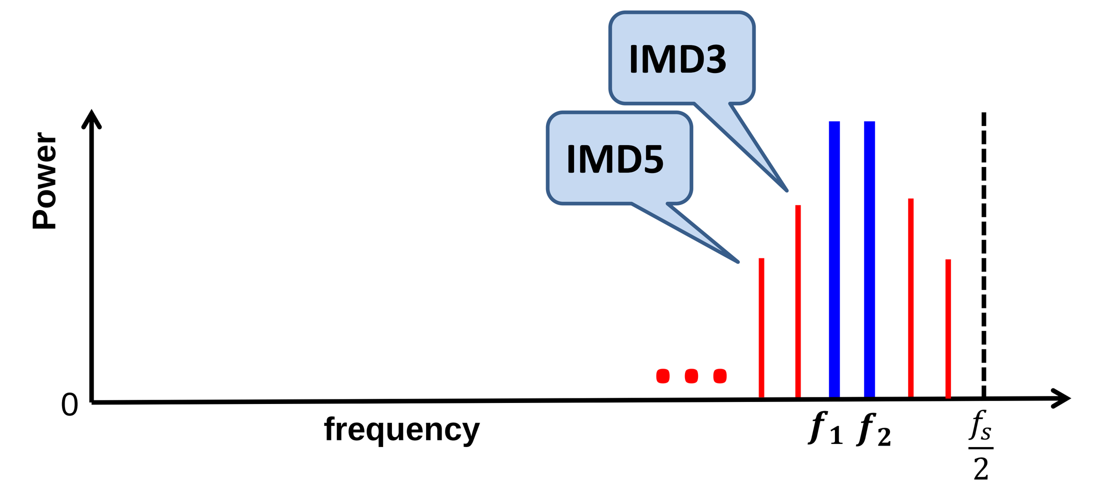
Preceding Study

Applying for low-frequency one-tone signal



Two-Tone Signal Case

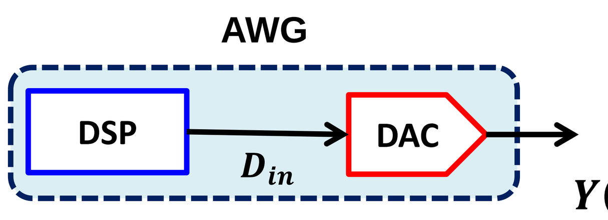
IMD = Intermodulation Distortion



The algorithm is NOT applicable

Proposed Algorithms and Simulation Results

Algorithm for IMD3 Cancellation



$$Y(nT_s) = a_1 D_{in} + a_3 D_{in}^3$$

Algorithm

$$D_{in} = \begin{cases} X_0 = A\sin(2\pi f_1 nT_s + \varphi_0) + B\sin(2\pi f_2 nT_s - \varphi_0) & n\text{: even} \\ X_1 = A\sin(2\pi f_1 nT_s - \varphi_0) + B\sin(2\pi f_2 nT_s + \varphi_0) & n\text{: odd} \end{cases}$$

$$\varphi_0 = \frac{\pi}{N}$$

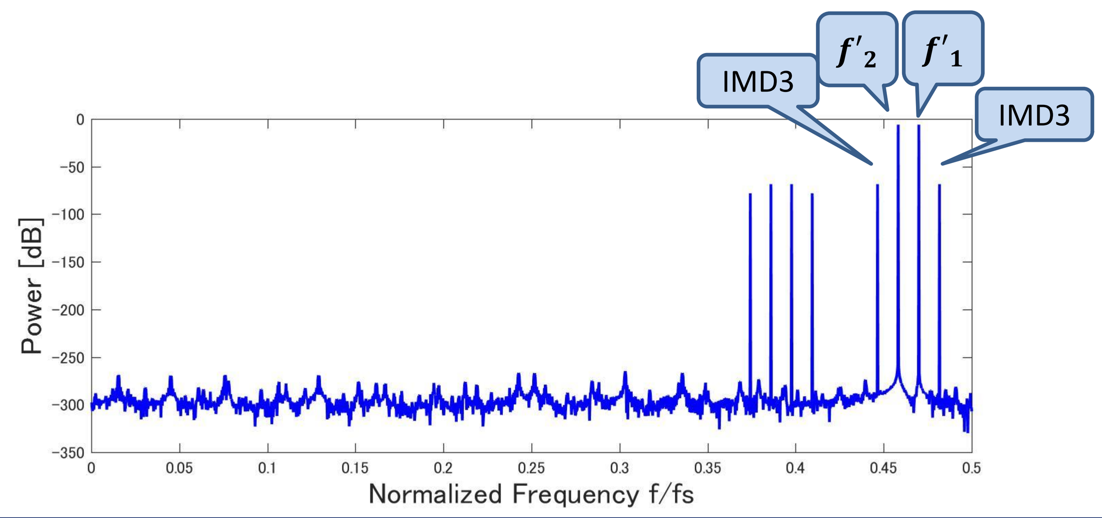
*N*th order IMD is cancelled

Simulation Results of IMD3 Cancellation

▪Conventional Method

$f'_1, f'_2/f_s$	481, 469 / 1024
a_1, a_3	1, -0.01

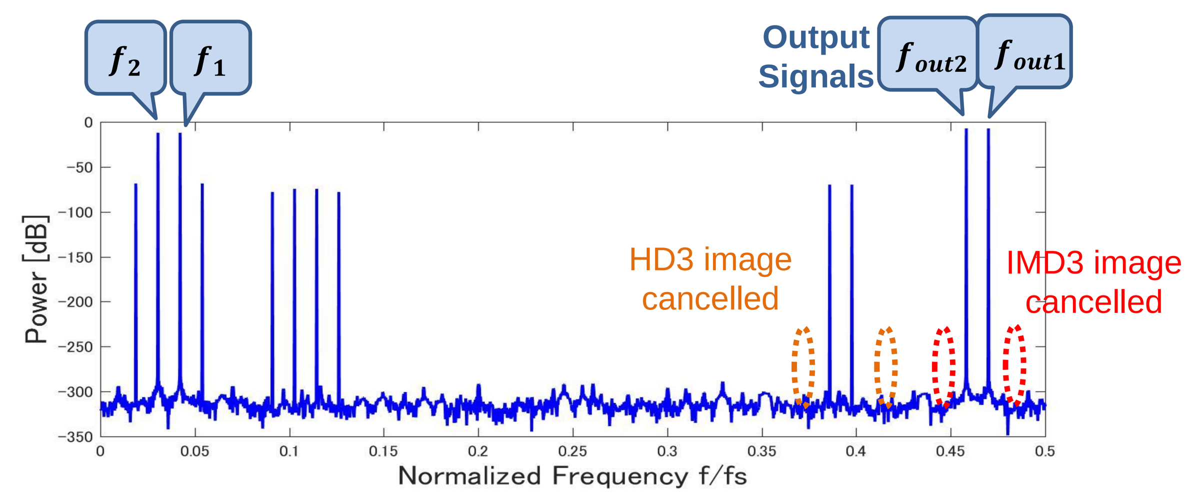
$$D_{in} = A\sin(2\pi f'_1 nT_s) + B\sin(2\pi f'_2 nT_s)$$



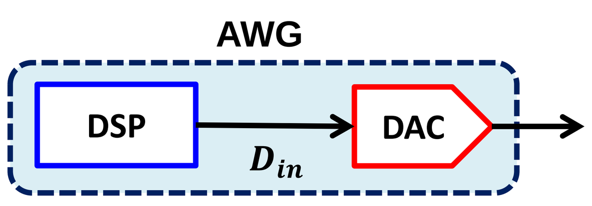
▪Proposed Method

$f'_1, f'_2/f_s$	31, 43/ 1024
a_1, a_3	1, -0.01

$$D_{in} = \begin{cases} X_0 = A\sin(2\pi f_1 nT_s + \pi/3) + B\sin(2\pi f_2 nT_s - \pi/3) & n\text{: even} \\ X_1 = A\sin(2\pi f_1 nT_s - \pi/3) + B\sin(2\pi f_2 nT_s + \pi/3) & n\text{: odd} \end{cases}$$



Algorithm for IMD3 and IMD5



$$Y(nT_s) = a_1 D_{in} + a_3 D_{in}^3 + a_5 D_{in}^5$$

Algorithm

$$D_{in} = \begin{cases} A\sin(2\pi f_1 nT_s + \varphi_1 + \varphi_2) + B\sin(2\pi f_2 nT_s - \varphi_1 - \varphi_2) & n = 4k \\ A\sin(2\pi f_1 nT_s - \varphi_1 + \varphi_2) + B\sin(2\pi f_2 nT_s + \varphi_1 - \varphi_2) & n = 4k+1 \\ A\sin(2\pi f_1 nT_s + \varphi_1 - \varphi_2) + B\sin(2\pi f_2 nT_s - \varphi_1 + \varphi_2) & n = 4k+2 \\ A\sin(2\pi f_1 nT_s - \varphi_1 - \varphi_2) + B\sin(2\pi f_2 nT_s + \varphi_1 + \varphi_2) & n = 4k+3 \end{cases}$$

$$\varphi_1 = \frac{\pi}{N_x} \quad \varphi_2 = \frac{\pi}{2N_y}$$

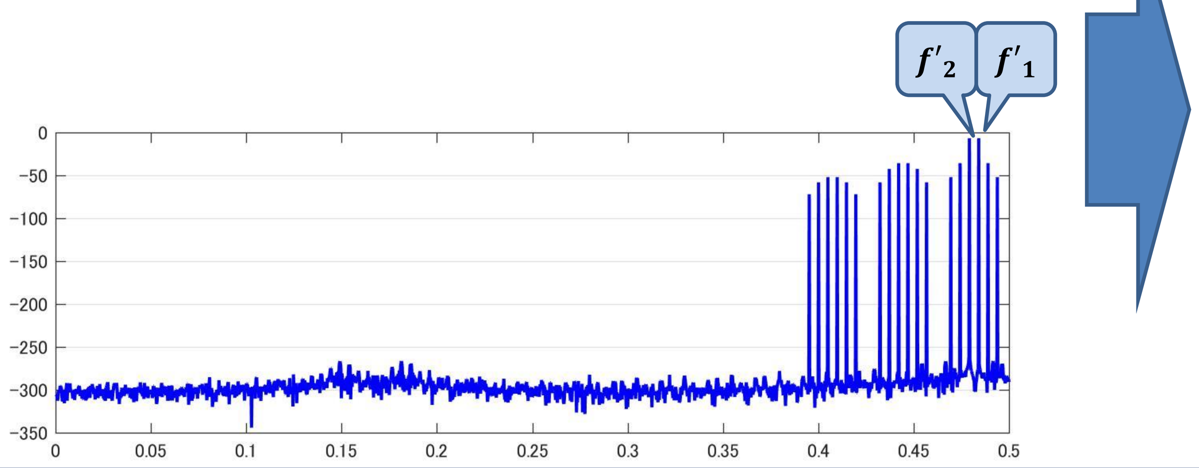
N_xth and N_yth order IMD are cancelled

Simulation Results of IMD3 and IMD5 Cancellation

▪Conventional Method

$f'_1, f'_2/f_s$	991, 981 / 2024
a_1, a_3, a_5	1, -0.01, -0.008

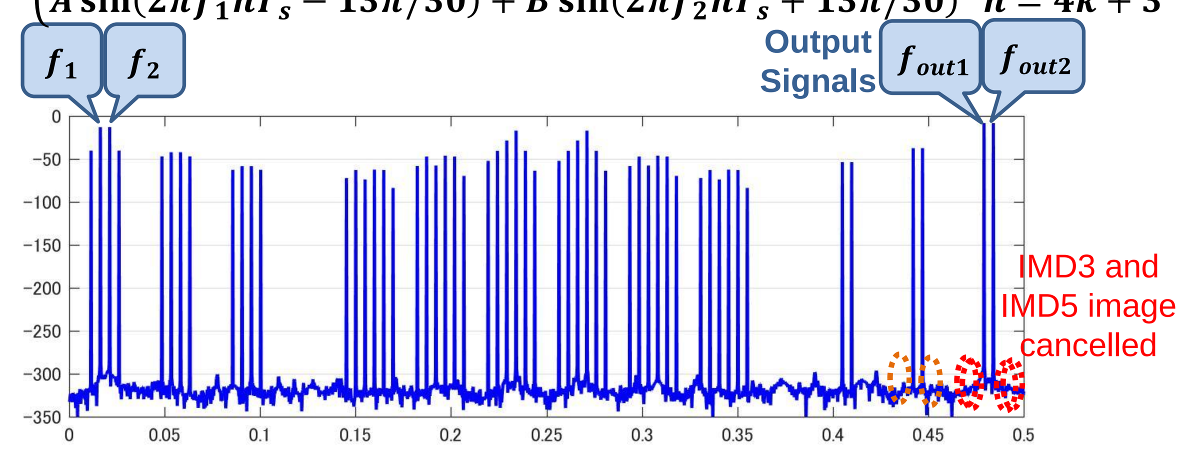
$$D_{in} = A\sin(2\pi f'_1 nT_s) + B\sin(2\pi f'_2 nT_s)$$



▪Proposed Method

$f_1, f_2/f_s$	33, 43 / 2024
a_1, a_3, a_5	1, -0.01, -0.008

$$D_{in} = \begin{cases} A\sin(2\pi f_1 nT_s + 13\pi/30) + B\sin(2\pi f_2 nT_s - 13\pi/30) & n = 4k \\ A\sin(2\pi f_1 nT_s + 7\pi/30) + B\sin(2\pi f_2 nT_s - 7\pi/30) & n = 4k+1 \\ A\sin(2\pi f_1 nT_s - 7\pi/30) + B\sin(2\pi f_2 nT_s + 7\pi/30) & n = 4k+2 \\ A\sin(2\pi f_1 nT_s - 13\pi/30) + B\sin(2\pi f_2 nT_s + 13\pi/30) & n = 4k+3 \end{cases}$$



Summary

- Proposal of high-frequency low-distortion signal generation algorithms with AWG.
- Need only for simple analog HPF. No need for AWG nonlinearity identification.