P084

Pure Sine Signal Generation With Arbitrary Waveform Generator

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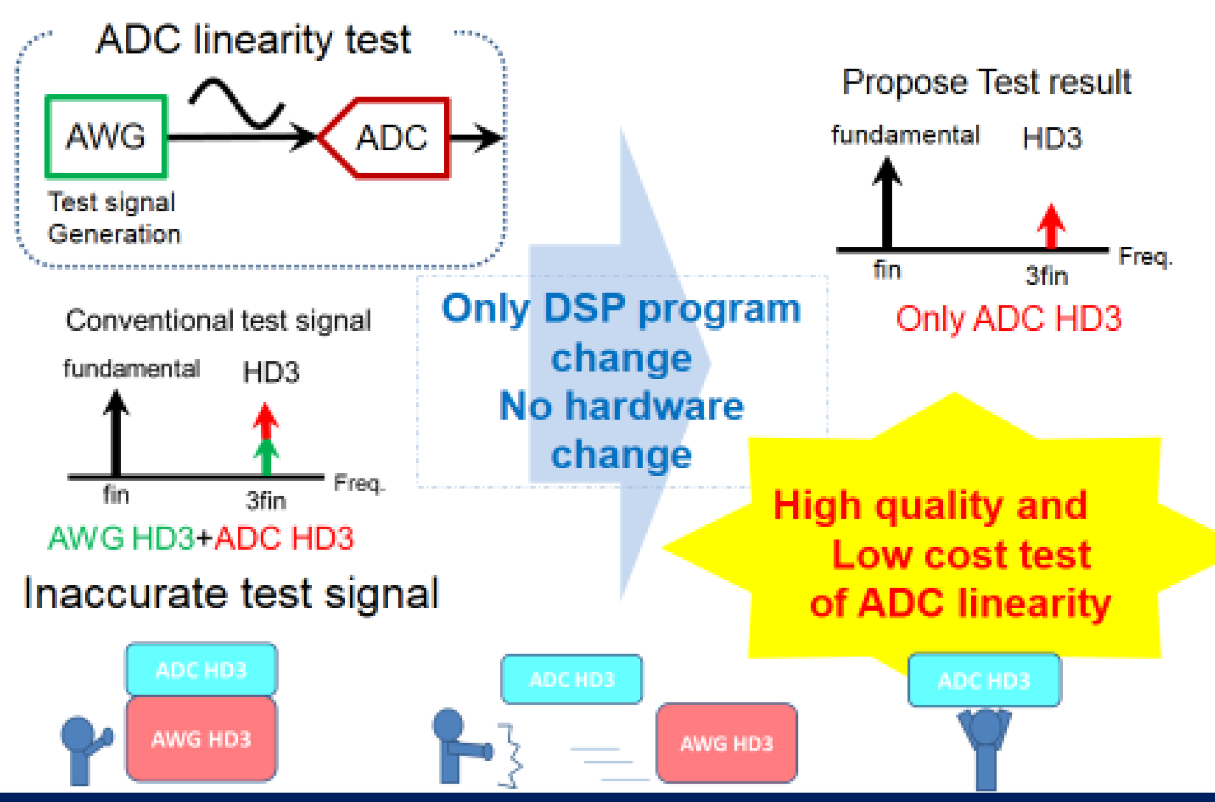
Purpose of Research & Background

Purpose of Research



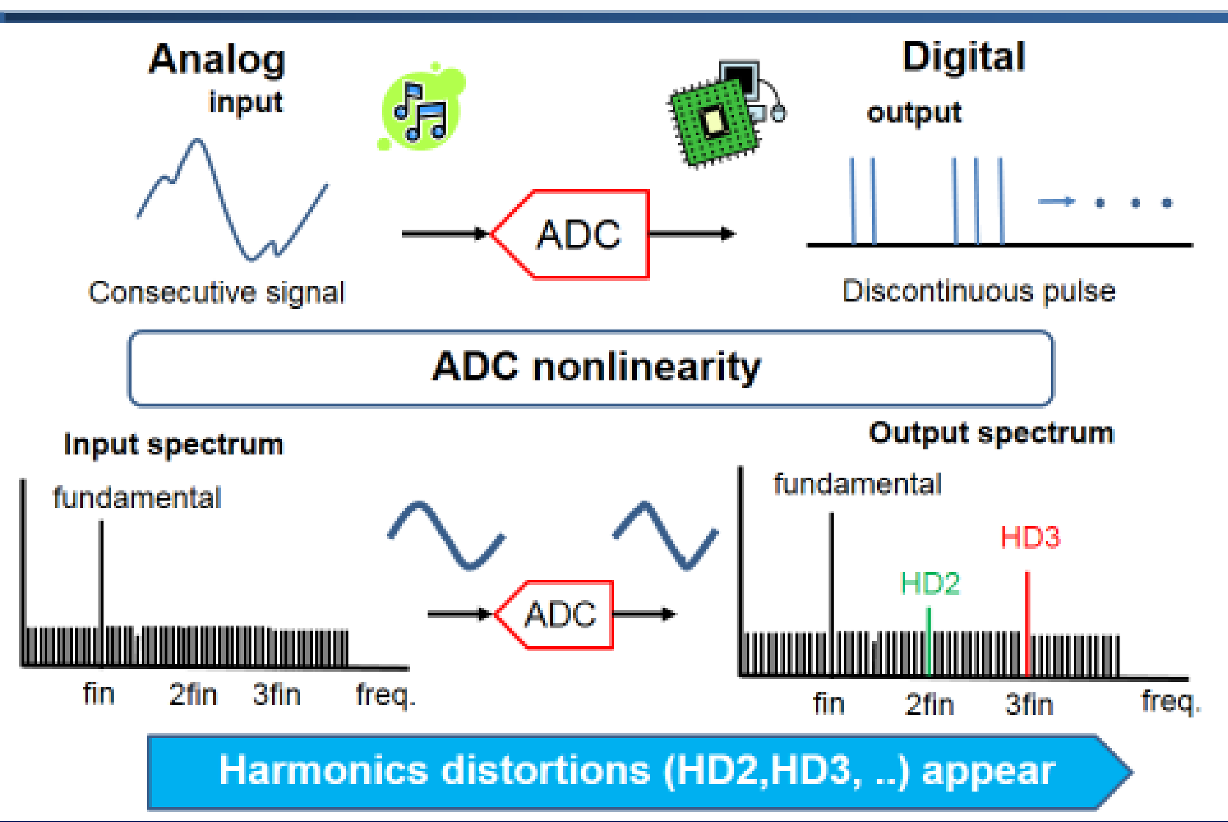
Background

- Testing cost → increasing
  silicon cost → decreasing.
- ADCs are important in mixed-signal SoCs.
- Need a low-cost, low-distortion signal source for ADC linearity testing.

- Use existing AWGs
- AWG nonlinearity
  →Reduction by changing DSP program

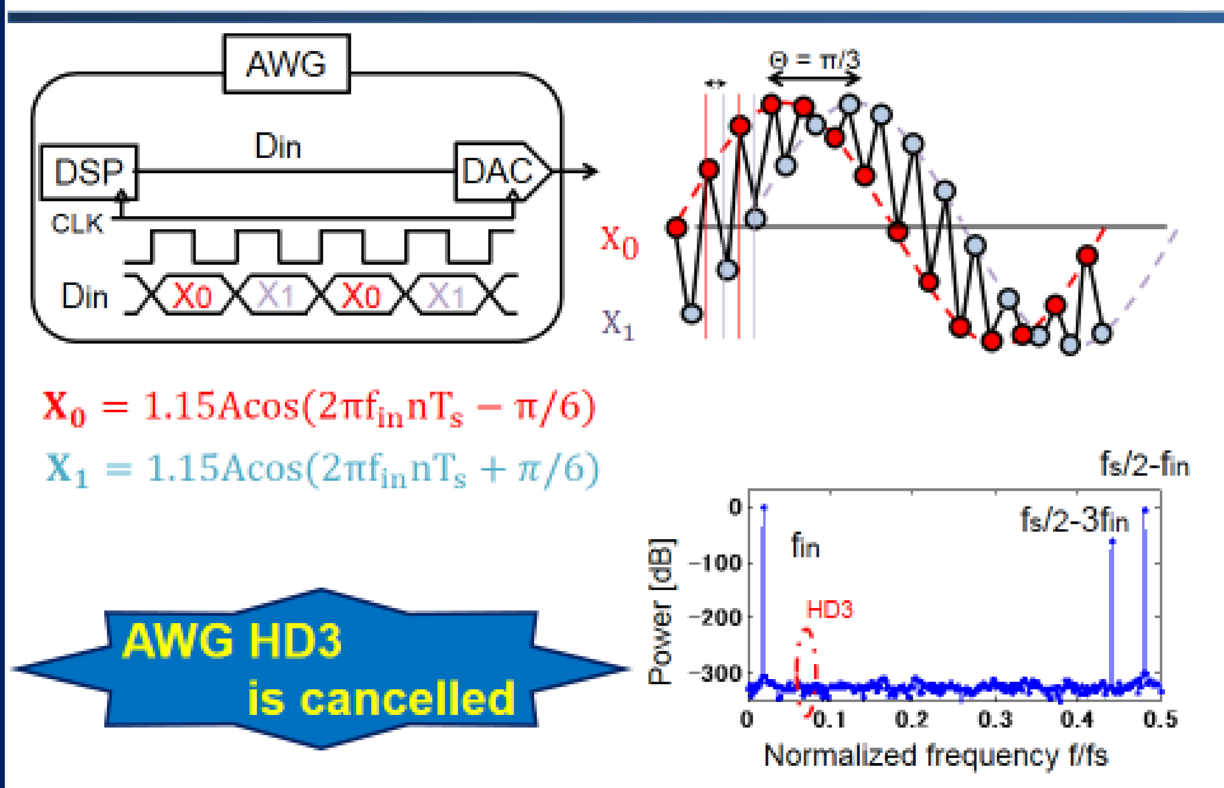
AWG : Arbitrary Waveform Generator
ADC : Analog to Digital Converter

Analog to Digital Converter

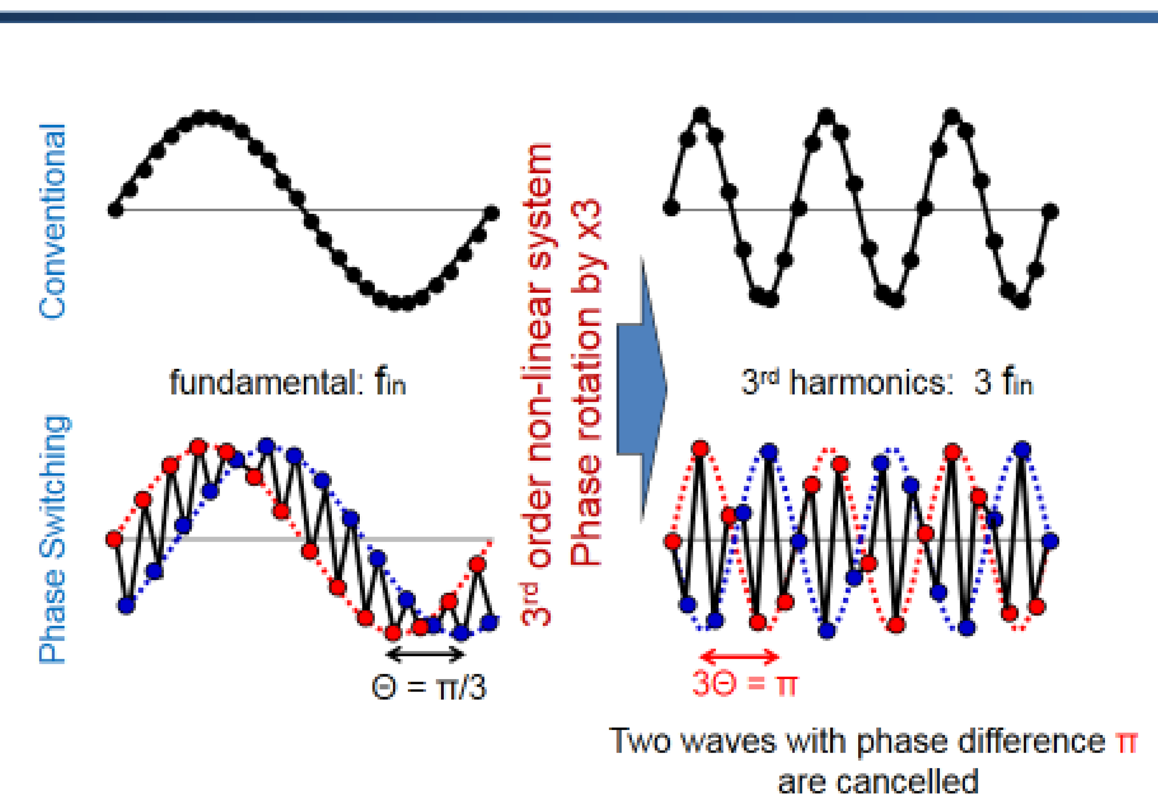


Proposed method

Proposed Signal



Principle of 3rd Harmonics Cancellation



Model for Theoretical Analysis

- AWG Input with Phase Switching

$$D_{in}(nT_s) = \begin{cases} A\cdot\sin\left(2\pi f_{in} nT_s - \frac{\pi}{6}\right) & n: odd \\ A\cdot\sin\left(2\pi f_{in} nT_s + \frac{\pi}{6}\right) & n: even \end{cases}$$

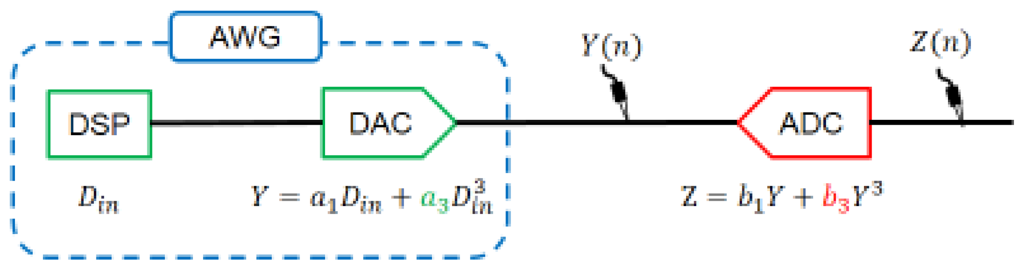
- AWG Nonlinearity Model

$$Y(nTs) = a_1 D_{in}(n) + a_3\{D_{in}(n)\}^3$$

- ADC Nonlinearity Model

$$Z(n) = b_1 Y(nT_s) + b_3\{Y(nT_s)\}^3$$

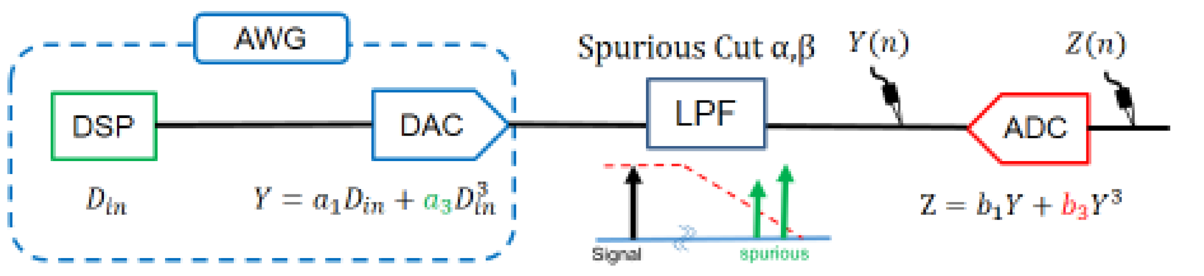
For simplicity $f_{s(AWG)} = f_{s(ADC)}$



Theoretical Analysis & Experiment Result

Theoretical Analysis

- AWG Output with LPF



$$Y(nT_s) = \frac{\sqrt{3}}{2}\left(a_1 A + \frac{3}{4}a_3 A^3\right)\sin(2\pi f_{in} nT_s) \quad \text{Signal}$$

$$+\frac{1}{2}\cdot\alpha\cdot\left(a_1 A + \frac{3}{4}a_3 A^3\right)\cos\left(2\pi\left(\frac{f_s}{2} - f_{in}\right)nT_s\right) \quad \text{Spurious}$$

$$-\frac{1}{4}\cdot\beta\cdot a_3 A^3 \cos\left(2\pi\left(\frac{f_s}{2} - 3f_{in}\right)nT_s\right)$$

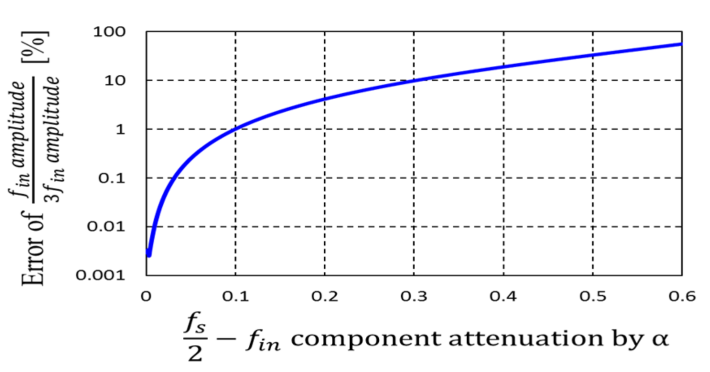
filter
$0 \le \alpha, \beta \le 1$

Through A/D Converter

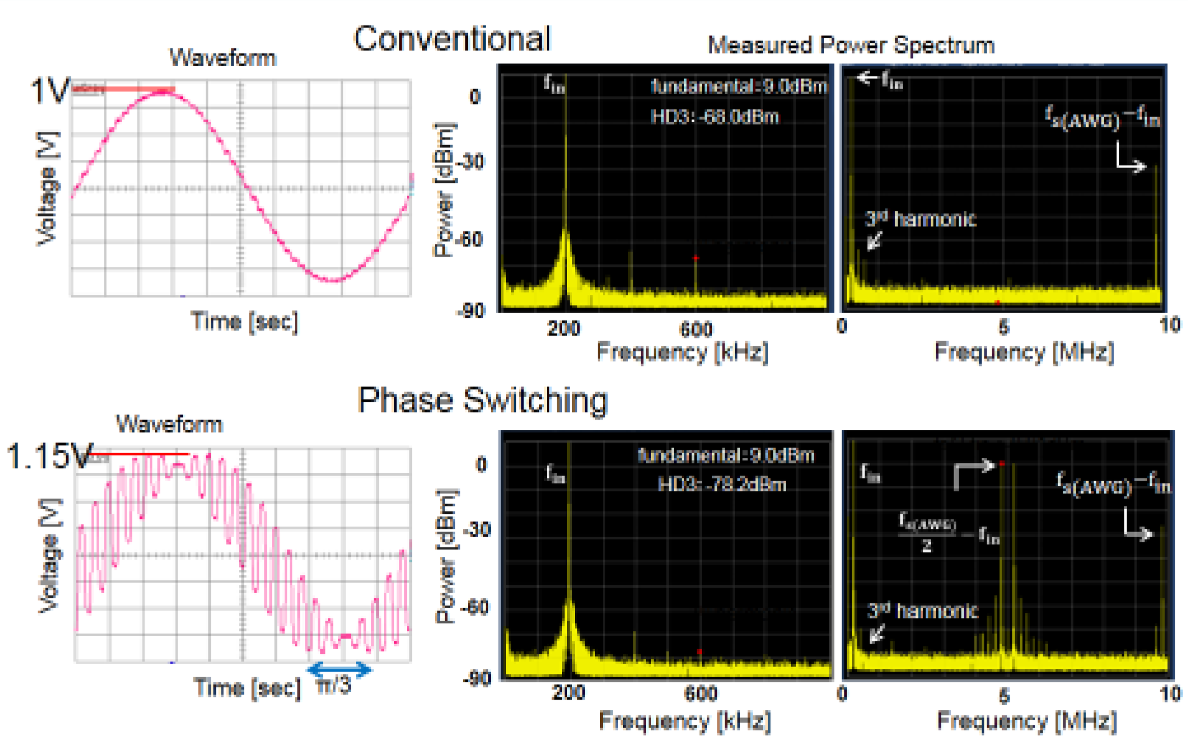
- ADC Output

$$Z(nT_s) = Z_{f_{in}}\sin(2\pi f_{in} nT_s)$$
$$+ Z_{3f_{in}}\sin(2\pi\cdot 3f_{in}\cdot nT_s) \quad \leftarrow \text{HD3}$$
$$+\cdots$$
$$\vdots$$
$$+Z_{-f_{in}}\sin\left(2\pi\left(\frac{f_s}{2} - f_{in}\right)nT_s\right)$$
$$+Z_{-3f_{in}}\sin\left(2\pi\cdot\left(\frac{f_s}{2} - 3f_{in}\right)\cdot nT_s\right) \quad \leftarrow \text{aliasing HD3}$$
$$= -Z_{-3f_{in}}\sin(2\pi\cdot 3f_{in}\cdot nT_s)$$
$$+\cdots$$

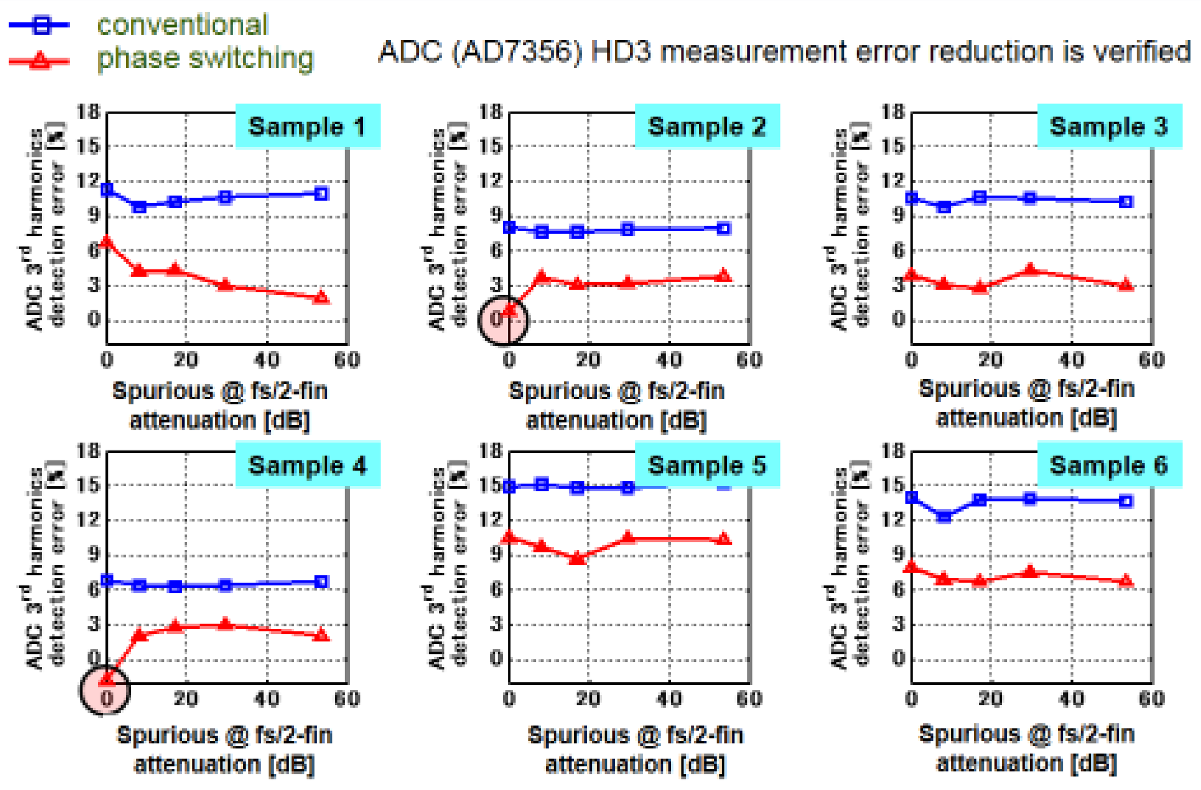
- When filter $\alpha = 1$, $Z_{f_{in}} = Z_{-3f_{in}}$ ➡ ADC HD3 cancelled
- When filter $\alpha \neq 1$, $Z_{f_{in}} \neq Z_{-3f_{in}}$ ➡ HD3 accurate measurement



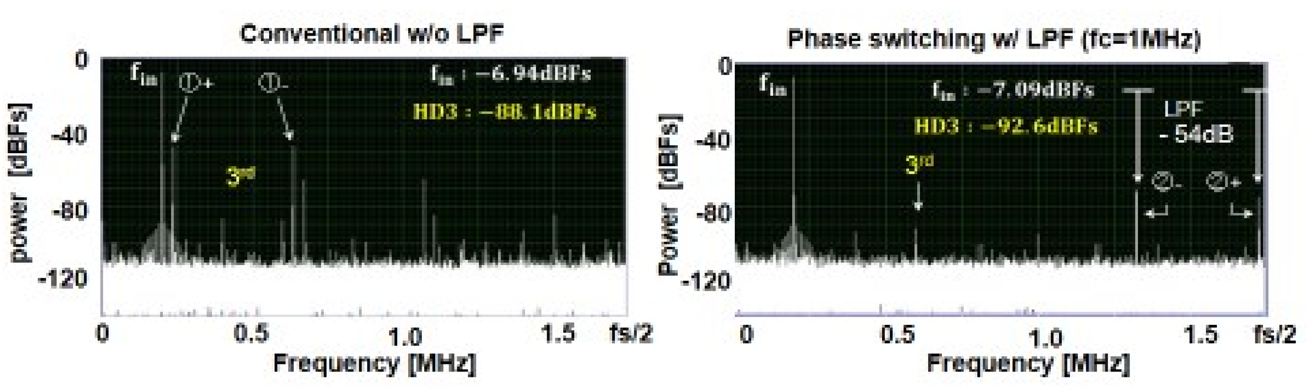
Conventional and Phase Switching Signals

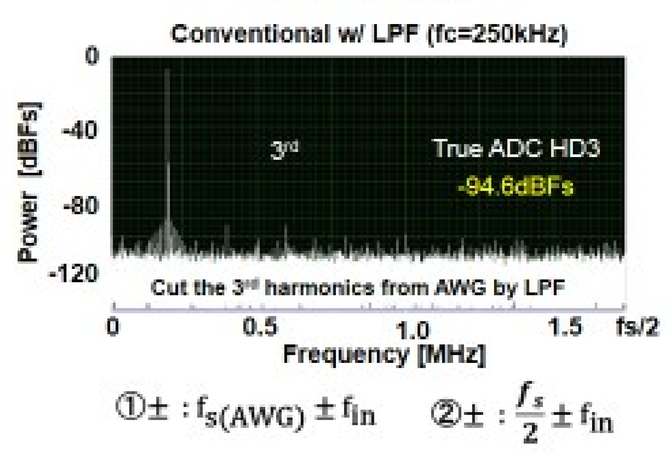


ADC HD3 Measurement Results



Use apparatus
- AWG (Agilent 33220A) : $f_{s(AWG)}$=10[MHz]
- 12bit SARADC (AD7356) : $f_{s(ADC)}$=3.478261[MHz])





①± : $f_{s(AWG)} \pm f_{in}$ ②± : $\frac{f_s}{2} \pm f_{in}$

True ADC HD3: -94.6dBFs

Conventional method
Measured HD3: -88.1dBFs
Error 6.8%

Proposed method
Measured HD3: -92.6dBFs
Error 2.1%

Summary

Conclusion

- We have shown
  high quality signal generation method
  for ADC linearity test
  with low cost AWG
  by theoretical analysis and experiments

References

[1] K. Wakabayashi, K. Kato, T. Yamada, O. Kobayashi, H. Kobayashi, F. Abe, K. Niitsu, "Low-Distortion Sinewave Generation Method Using Arbitrary Waveform Generation", Journal of Electronic Testing, vol.28, no. 5, pp.641-651 (Oct.2012)
[2] F. Abe, Y. Kobayashi, K. Sawada, K. Kato, O. Kobayashi, H. Kobayashi, "Low-Distortion Signal Generation for ADC Testing", IEEE International Test Conference, Seattle, WA (Oct. 2014)