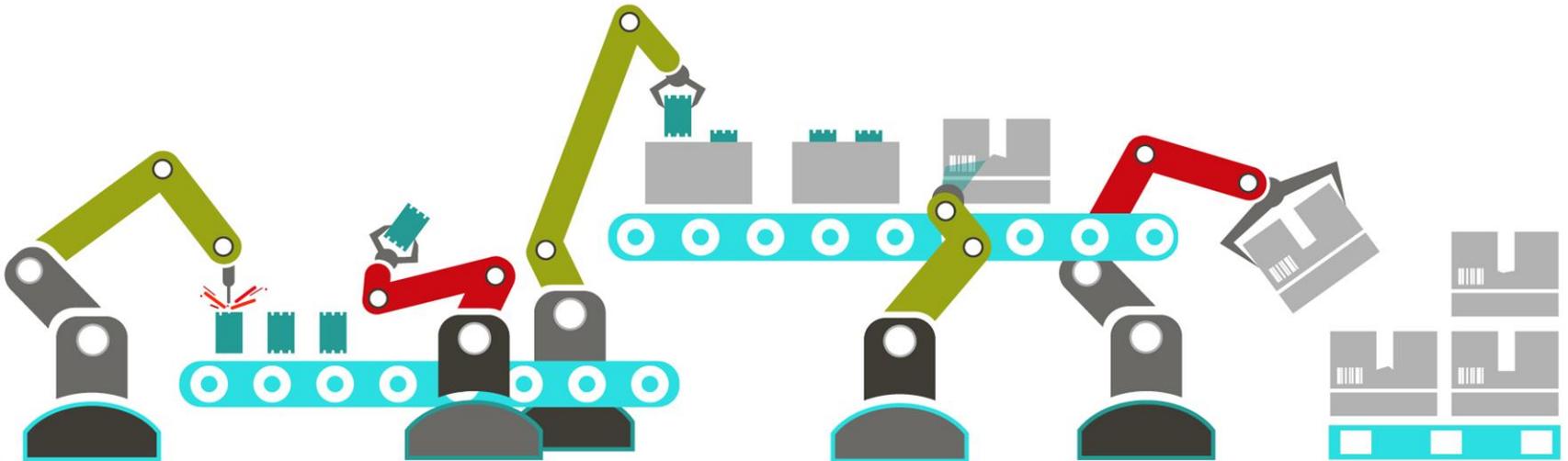Supporting High-Speed Response While Maintaining High Accuracy
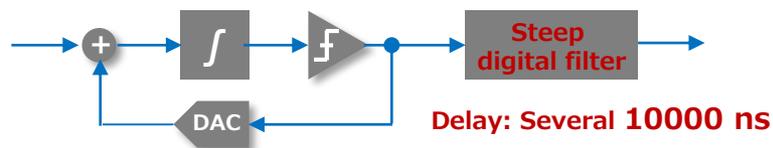
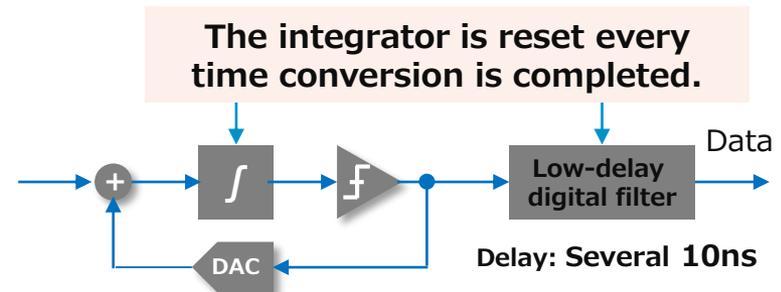# What Are the Secrets of the Noise Suppression A/D Converter?

This white paper introduces functions of noise suppression A/D converters by Asahi Kasei Microdevices Corporation, (AKM).

Overview

The "noise suppression A/D converter", a new A/D converter from Asahi Kasei Microdevices, suppresses noise by averaging oversampled data, like a delta-sigma A/D converter, while realizing high-speed response. This noise suppression A/D converter integrates a low-delay digital filter, realizing high-accuracy A/D conversion and high-speed response.

The integrator is reset every time conversion is completed.

Data

| Steep digital filter |
Delay: Several 10000 ns

DAC

ΔΣ A/D Converter

| Low-delay digital filter |
Delay: Several 10ns

DAC

Noise Suppression A/D Converter

Overview

The noise suppression strength can be switched between four levels, so that the user can adjust the balance between noise suppression strength and responsiveness flexibly.


The noise suppression strength can be selected from four levels.
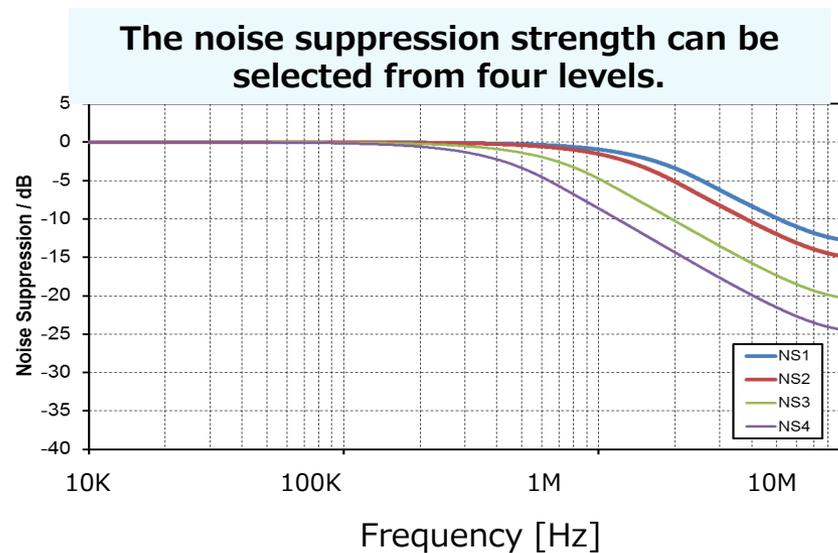
This document describes the noise suppression A/D converter of Asahi Kasei Microdevices.

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■ Features of the Nyquist AD converters

■ Features of the Oversampling A/D converters

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■ Noise Suppressing A/D converters

■ What kind of processes are executed?

■ Setting the Noise Suppression Strength

Features of Nyquist A/D Converters

Sampling 1MSPS

**Folding occurs due to the sampling theorem**

Analog ← | → Digital
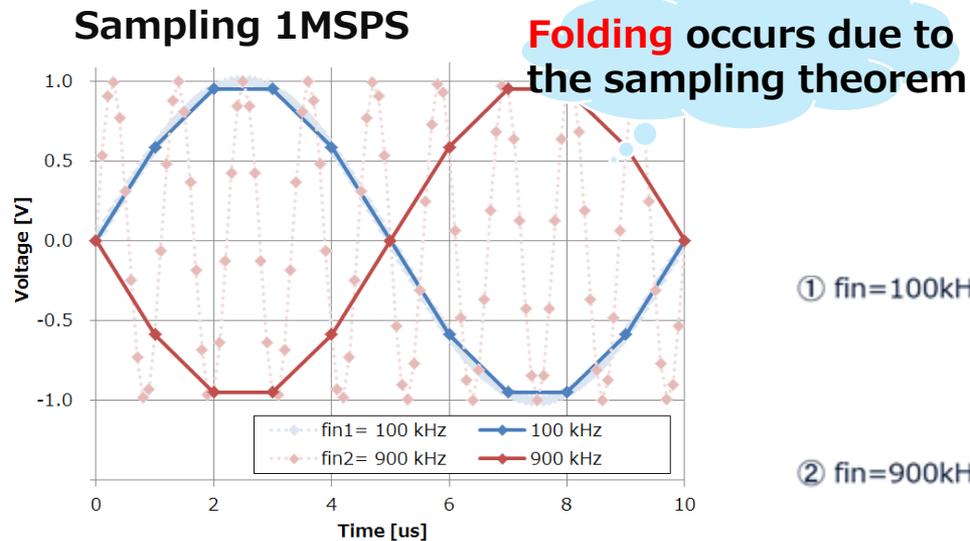
**Sampling Waveform
of the Nyquist A/D Converters**
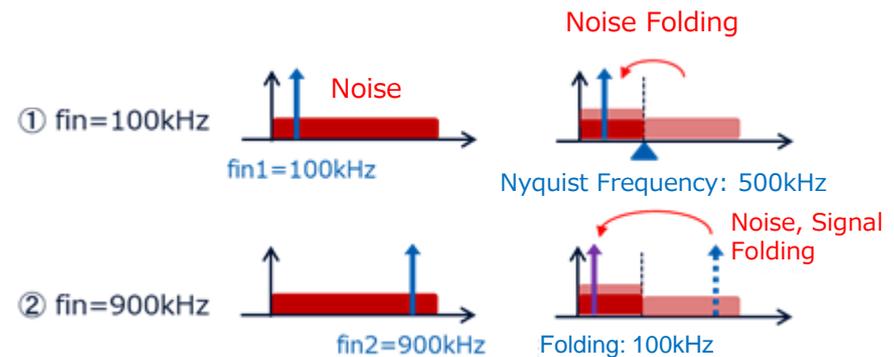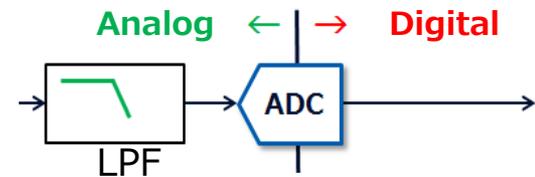
The Nyquist frequency is defined as half of the sampling frequency. If a frequency signal higher than the Nyquist frequency is input to the A/D converter, folding will occur on low-frequency components. This is referred to as the sampling theorem. For example, a 100kHz signal, (fin1), is sampled at 1 MHz, the waveform can be reproduced because the Nyquist frequency is 500 kHz. However, a 900kHz signal, (fin2), is sampled at 1 MHz, it is converted as 100 kHz components by the sampling theorem.

Features of Nyquist A/D Converters

Analog ← | → **Digital**

LPF · ADC

③ Role of LPF

Signal

Nyquist Frequency
LPF Cutoff Frequency
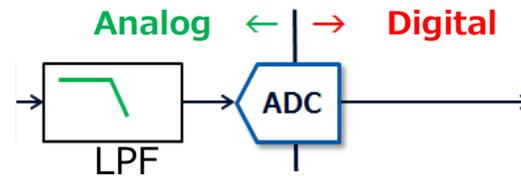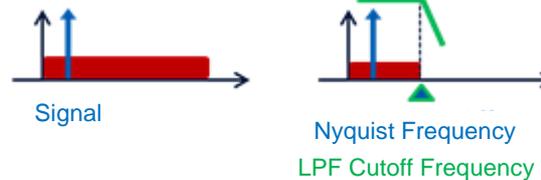
Although it depends on noise design, folded noise can be prevented by setting the cutoff frequency of the LPF located in the input stage of the A/D converter to a value close to the Nyquist frequency. The lower the cutoff frequency of the LPF, the larger the time delay. Thus, it is necessary to consider that there is a trade-off relationship between the folding noise and frequency of the signal that is A/D converted for LPF cutoff frequency.

Features of Oversampling A/D converters
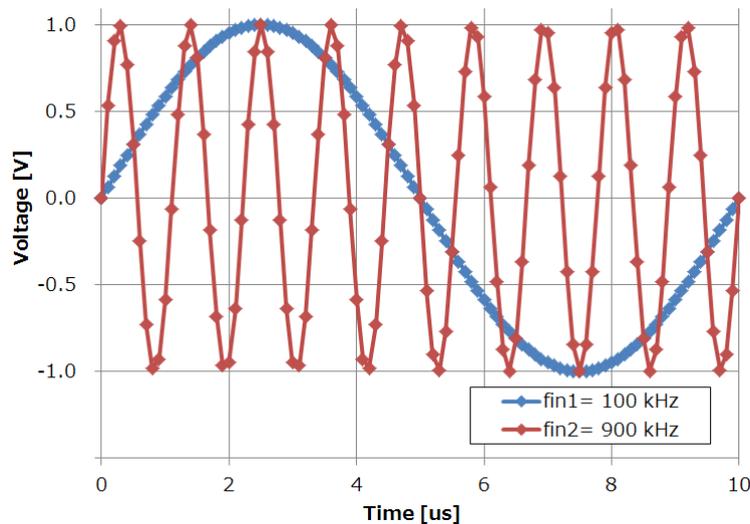
Sampling waveform of the oversampling A/D converter

- fin1= 100 kHz
- fin2= 900 kHz

Oversampling A/D Converters

ADC

Digital Filter

Suppressing & Folding Noise by Digital Filter

Folding

Signal Noise   Cutoff Frequency   Nyquist Frequency
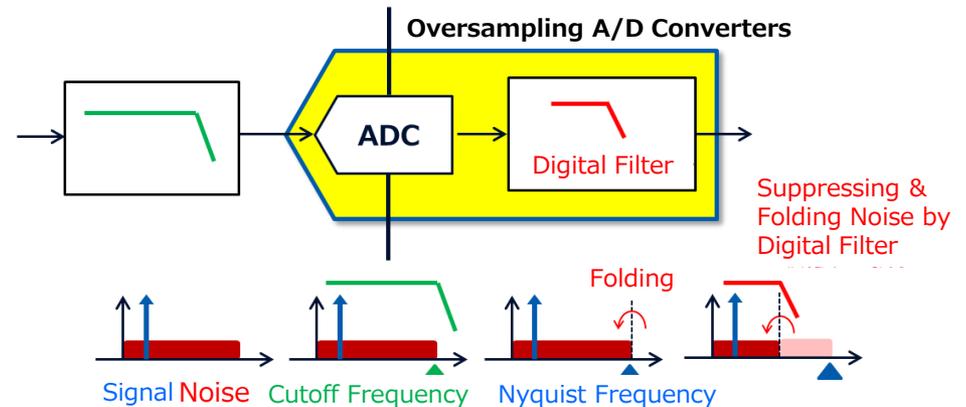
With an oversampling A/D converter, the cutoff frequency of LPF located at the input stage of the A/D converter can be increased (the delay of the LPF can be reduced by that). By doing this, signal band adjustment can be simplified since the signal band is set on the digital filter side. Therefore it is not necessary to change PCB every time changing the constant of LPF, and only digital settings are required.

Speeding up the A/D Conversion

Noise spectral density

Oversampling & Noise Shaping

Digital Filter

Frequency

Nyquist Frequency
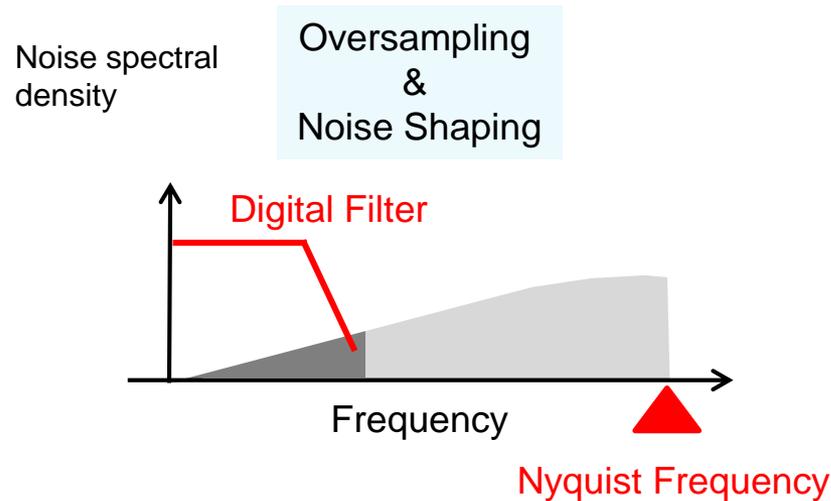
A delta-sigma type oversampling A/D converter is used when high accuracy is required in A/D conversion. Usually, quantization noise is uniformly distributed over the entire frequency band. For a delta-sigma converter, it is changed to that there is less quantization noise in low-frequency band than in the high-frequency band by using negative feedback and an integrator. This technique is called noise shaping.
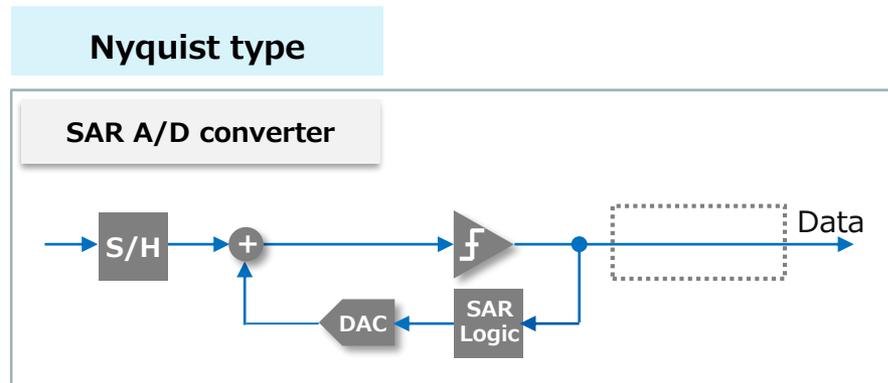
Speeding up the A/D Conversion

Noise spectral density

Improving the response increases the noise.

Frequency

Quantization Noise

Nyquist Frequency
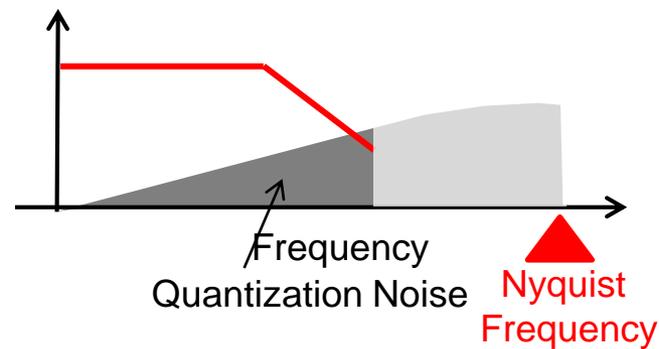
It is expected that A/D conversion accuracy is improved since a digital filter in the output stage of the delta-sigma A/D converter can reduce match high-frequency noise. However, the digital filter has steep filter characteristics, and it causes a very large delay. In contrast, if the band of the digital filter is broadened to quicken the response, the high-frequency noise that is noise-shaped becomes conspicuous, causing the deterioration of the noise characteristics. Thus, the delta-sigma A/D converter has a trade-off between "high-speed response" and "high accuracy".

What Is a Noise Suppression A/D Converter?

Nyquist type

SAR A/D converter

An SAR A/D converter, classified as the Nyquist ADC, does not have a digital filter, enabling high-speed response with successive approximation conversion.

When noise performance is required, the cutoff frequency at input stage of the A/D converter is lowered or the signal is averaged by taking multiple samples since an SAR A/D converter executes sampling only once. , The signal will be delayed by reducing the cutoff frequency or averaging.

What Is a Noise Suppression A/D Converter?

Oversampling type
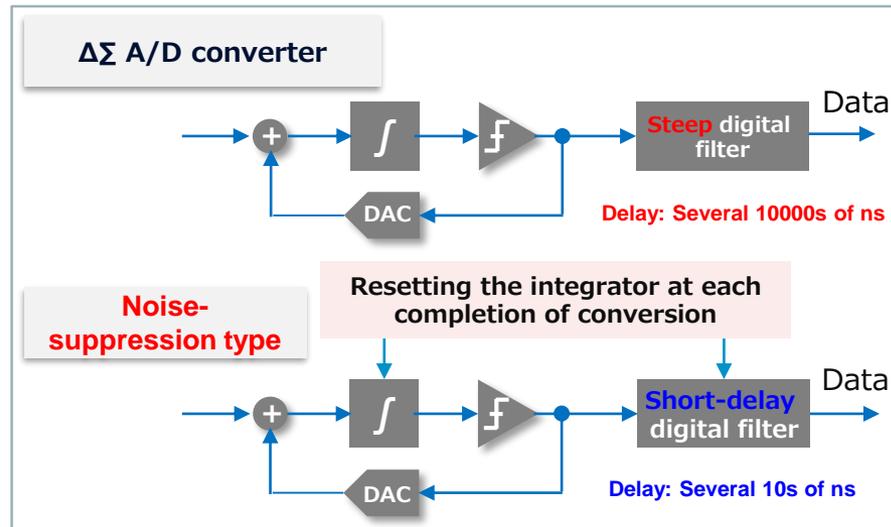
ΔΣ A/D converter

To increase noise performance, oversampling ADCs can be used. A delta-sigma type oversampling A/D converter has a trade-off between "high-speed response" and "high accuracy".

A noise suppression oversampling A/D converter has a short-delay digital filter, realizing high-accuracy A/D conversion and high-speed response in a short delay configuration.

Moreover, as a configuration of which the integrator is reset for every conversion cycle is adopted, a noise suppression A/D converter can be used in the same way as a SAR type without being affected by the previous data.

What type of process is executed?

One of the features of the AK925x series that are noise suppression A/D converters of Asahi Kasei Microdevices is achieving short delay output while performing oversampling like a delta-sigma A/D converter internally. Thus, the high-frequency noise components contained in an analog input signal can be suppressed and, at the same time, high-speed response is realized as with the SAR type.

Example: AK9255

[N]th Oversampling

Analog Input Signal (input)

Internal Integrator Reset

CSN (input) — **[N]th A/D Conversion Start**

SCLK (input) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

[N]th A/D Conversion Completion

SDOx (output) D15 D14 D13 D12 D11 D10 D9 D8 D7 D6 D5 D4 D3 D2 D1 D0

[N-1]th A/D Conversion Data Output

[N]th A/D Conversion Data Output
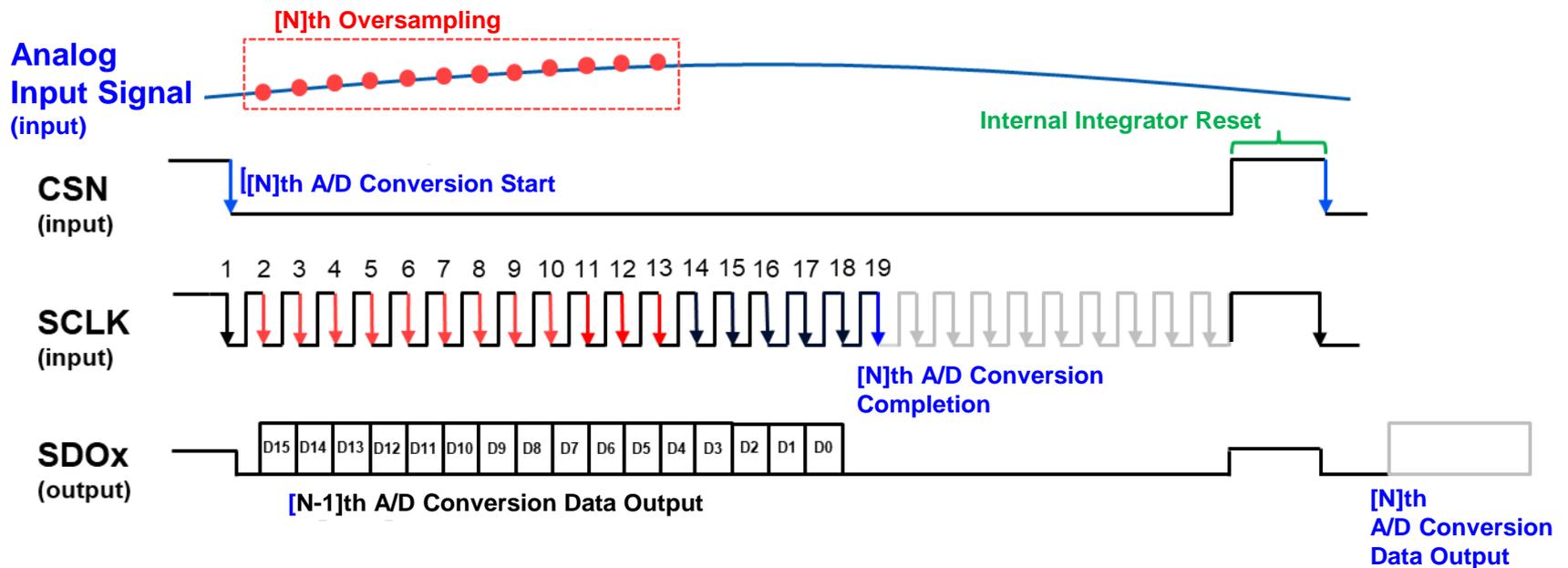
Noise Suppression Strength Setting

By changing the number of weighted averaging times on the data from analog signal oversampling, four levels of noise suppression strength are available with the AK925x series. This has an effect on suppressing the noise of the ADC itself, in addition to suppressing the noise contained in the signal. The user can adjust the balance between "high-speed response" and "noise suppression strength" flexibly.

Example: AK9255

Parameter	NS1	NS2	NS3	NS4
Speed [MSPS]	1.0	0.6	0.4	0.3
NS Effect* [dB]	-5.1	-7.5	-9.4	-10.8
S/N [dBFS]	86	88	89	90