Achieving a Higher ADC Resolution Using Oversampling on dsPIC33A Devices

The key feature of an ADC is resolution. A higher conversion resolution can be achieved by using an oversampling of the input signal. Refer to application note AN1152 - Achieving Higher ADC Resolution Using Oversampling (DS01152A) for the theory of oversampling.

The ADC resolution is proportional to the signal-to-noise ratio (**SNR**). Equation 1 shows the relation between the **SNR** and resolution:

Equation 1. Relation Between the SNR and Resolution

$$SNR = 6.02 \times R + 1.77 + 10 \times \log\left(\frac{1}{N}\right)[dB]$$

Where **SNR** is a signal-to-noise ratio in dB, **R** is the resolution (number of ADC result bits) and **N** is the number of samples for oversampling.

Increasing the SNR will increase the resolution. Table 1 describes the relationship between the number of oversampling samples, SNR and the achievable extra bits of resolution.

Table 1. Relationship Between the Oversampling Factor, SNR and Extra Bits of Resolution

Oversampling Samples Number	SNR Improvement, dB	Extra Bits of Resolution
4	6	1
16	12	2
64	18	3
256	24	4

The High-speed 40 MSPS A/D Converters on most dsPIC33A devices have hardware oversampling accumulators. The oversampling hardware simplifies the implementation of the oversampling without a software overhead. Oversampling is enabled when the MODE bits are set to 3 in the channel control register. The number of accumulated samples in the ADnCHxDATA register is defined by ACCNUM bits. 4, 16, 64 and 256 accumulated conversions options are available with 13, 14, 15 and 16 bits in the result register (ADnCHxDATA).

The effective number of bits (ENOB) was measured for the different oversampling factors on the dsPIC33AK128MC106 device. The back-to-back conversions were done with the 40 MSPS conversion rate. Table 2 shows the test result.

Table 2. ENOB for Different Oversampling Samples Number

Oversampling Samples Number	Measured Effective Number of Bits (ENOB)	Theoretical ENOB Improvement, Bits	Measured ENOB Improvement, Bits
1 (no oversampling)	10.5	0	0
4	11.5	1	1
16	12.3	2	1.8
64	12.8	3	2.3
256	13.1	4	2.6

In the dsPIC33AK128MC106 test results, the oversampling effectiveness drops as the number of accumulations is increased. The ground noise on the dsPIC33AK128MC106 device limits the ability to increase the SNR which caps the maximum ENOB to around 13-bits.

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