Product Document

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Application Note

AS5x47y DAEC

Dynamic Angle Error Compensation Details

Content Guide

1 General Description

One of the main features of the AS5x47y magnetic position sensors is the dynamic angle error compensation (DAEC). It allows the AS5x47y to output the angular position nearly latency-free with respect to a defined maximum acceleration.

A big advantage is, that compared with other solutions, the AS5x47p postion sensors don't need a special synchronization between controller and position sensor. It is used with the encoder output to replace an existing optical encoder or can be read over the digital interface.

The total position error results from static (eg. output noise and non-linearity) and dynamic components (eg. dynamic angle error).

The dynamic angle error comes from the propagation delay and is zero for standstill and increases with the angular speed up to maximum speed of the application (eg. 14,5 krpm). The DAE is calculated for a typical propagation delay. (eg. 200µs). Using the automatic compensation feature DAEC, this error is dramatically reduced to a neglible component. (Please not that values are exemplary – for product details refer to the product datasheet)

2 What is the dynamic angle error (DAE)?

Digital sensor outputs have a propagation delay resulting from the signal processing. When measuring the angle of a sensor magnet in static condition, the propagation delay will not cause additional angle error.

As soon as the magnet is rotating, the propagation delay of the output signal will cause an angle error at the sensor output. The error is as big as the angle of rotation during the propagation delay and for constant angular speed it can be calculated as:

Equation 1: Dynamic Angle Error

$$DAE = Propagation\ delay\ \times \frac{Speed(rpm) \times 360\ deg}{60\ s} = 0{,}0002s\ \times \frac{3000 \times 360\ deg}{60\ s} = 3.6\ deg$$

For the maximum possible rotation speed of 14,5 krpm (AS5147) the DAE grows up to 17.4 degree (For the AS5147P the max. rotating speed is 28 krpm and would therefor result in a maximum DAE of 33.6 degree). As the DAE depends on the angular velocity, it could be compensated in the application by calculating the DAE and adding it to the measured angle. The propagation delay has a tolerance of ±10 % and therefor the compensation cannot be better than ±10 % of the DAE. (eg. ±0.36 deg @ 3krpm) (Please not that values are exemplary – for product details refer to the product datasheet)

In addition, a compensation algorithm will load the MCU and it takes time to implement the software and qualified software has to be changed in case of replacing a existing system.

3 Why integrated compensation is better…

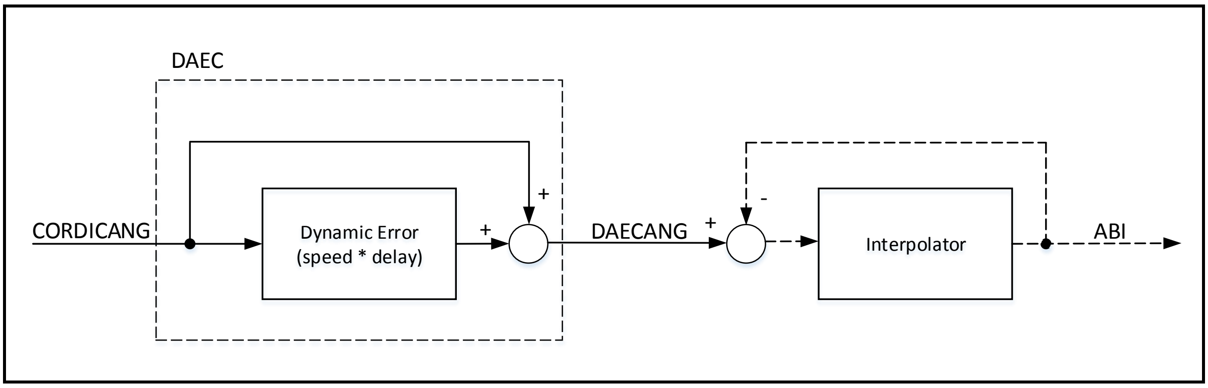
Basically the internal compensation follows the compensation principle introduced above but performing the compensation internally offers following advantages:

- **Independed from oscillator** variation because angle conversion and DAEC use same timebase

- Almost **NO DAE at the encoder output** because close implementation with integrated interpolator
- **Latency-free angle** information in the **DAECANG** register resulting from very high update rate of the compensation value of the internal intrpolator

The block diagram of the DEAC is shown below in Figure 1.

Figure 1: DAEC block diagram



4 DAEC error budget

With activated DAEC(default), the dynamic angle error depends on the acceleration of the angle signal. For constant speed, the dynamic angle error is compensated and the latency is reduced to ±1.9µs. For constant speed at 14.5krpm the DAE is reduced to ±0.165deg as shown in Equation 2. (Please not that values are exemplary – for product details refer to the product datasheet.)

Equation 2: DAE after compensation at constant speed

$$DAE = Propagation\ delay \times \frac{Speed(rpm) \times 360\ deg}{60\ s} = 0{,}0000019s \times \frac{14500 \times 360\ deg}{60\ s} = 0.165\ deg$$

During an acceleration the dynamic agle error will increase according to Equation 3 because of the deviation of the estimated position and the real position. It consists of the error during acceleration caused by the propagation delay and the speed measurement delay.

Equation 3: DAE during acceleration

$$DAE_{ACC} = \frac{acceleration(rad/s^2)}{2} \times (PD^2 + PD * \Delta t\_speed) = ((0{,}0002s)^2 + 0{,}0008 \times 0{,}0002) \times \frac{100000\ rad/s^2}{2} \times \frac{180}{\pi} = 0.6\ deg$$

5 DAEC for different outputs

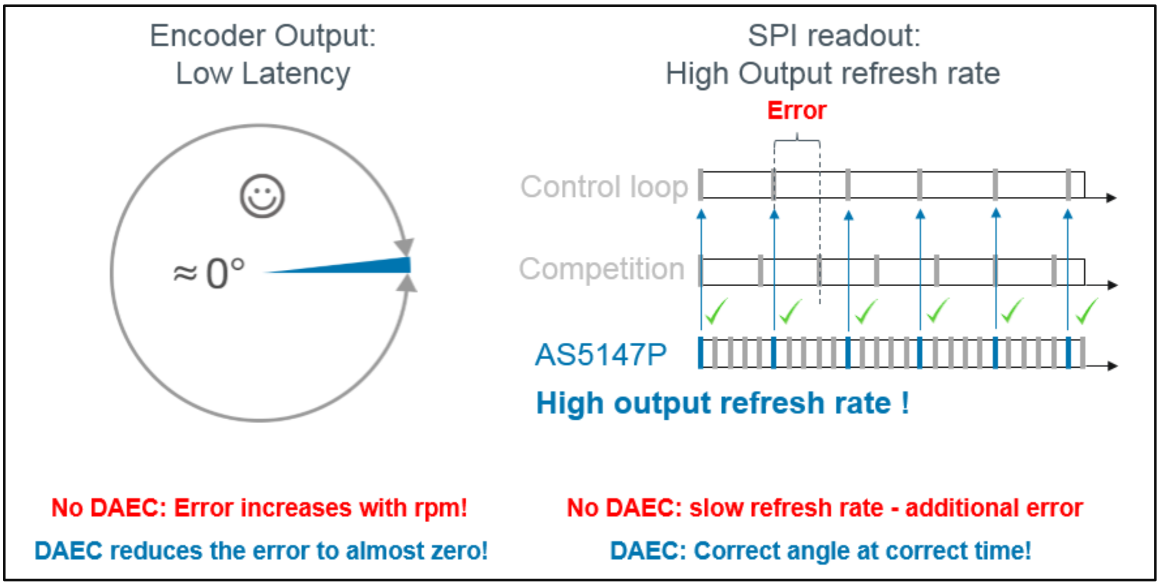
The latency-free encoder output is based on the DAEC and allows to use the magnetic position sensors in high-speed encoder applications where high robustness is required. The digital readout benefits a lot from this feature as shown in Table 1.

Table 1: Output interface performance

Output Type	Resolution	Refresh Rate	Latency
DAECANG (SPI)	14 bit	222ns	1.9µs
Encoder (ABI)	12 bit	222ns	1.9µs

While with other digital sensors require synchronization with the controller at high rotation speeds, the AS5x47y position sensor always outputs the latest compensated angle data over SPI which can direcly be used in the controller without synchronization. An illustration for the benefits for the Encoder Output and SPI ouput are shown in Figure 2.

Figure 2: Encoder output and SPI output profit from DAEC



6 Summary

The dynamic angle error compensation is an essential feature for position sensors which are used in applications that require high resolution angle feedback with low latency output. With the DEAC feature activated, the advantages of magnetic position sensors are as well applicable in high speed motor applications.

The dynamic angle error is reduced to a negligible value and can be calculated as explained in Equation 2. For high dynamic drives, the DAE present during an acceleration is calculated as shown in Equation 3.

The different interfaces available on the AS5x47y series position sensors make the device flexible to be used in different motor control applications in the automotive market and for industrial or consumer robotics.

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8 Copyrights & Disclaimer

9 Revision Information

Changes from previous version to current revision 1-02 (2015-Aug-27)	Page
Applied minor changes and corrected typos	
Updated section 1	

Note: Page numbers for the previous version may differ from page numbers in the current revision.
Correction of typographical errors is not explicitly mentioned.