Product Document

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Application Note

AS5x47y Interfaces

Communication Interfaces of AS5x47y Encoder Family

Content Guide

1 Introduction

The aim of this application note is to give more detailed information about the different interface options which are implemented in the AS5x47y magnetic position sensor series. Basic description is given in the according datasheet. The application note is placed as “add on” with more detailed information. Both documents should always be used in combination.

2 SPI Interface

The 16 bit SPI Interface enables read / write access to the register blocks and is compatible to a standard micro controller interface. The SPI module is active as soon as CSn pin is pulled low. The AS5x47y reads the digital value of the MOSI (master out slave in) input with every falling edge of SCK. Data value on the MISO (master in slave out) pin will be changed on the rising CLK edge. Master should read MISO as well on the falling edge of CLK. After 16 clock cycles CSn has to be forced again to high level, in order to close the communication frame.

For details on SPI pattern and timing diagram please check the actual datasheet of the according AS5x47y (http://ams.com/eng/Magnetic-Position-Sensors).

2.1 SPI Wire Modes

To connect the AS5x47y sensor to the SPI-Master several approaches are possible. Every method has its use cases, advantages and disadvantages. The following table gives you an overview of the different wiring methods.

Application	Mode	Wires	Configuration	Programming
Single device	4-Wire Mode	4	applicable	applicable
Single device	3-Wire Mode	3	not applicable	not applicable
Multiple devices	Multi Slave	3+n	applicable	applicable
Multiple devices	Daisy chain	4	applicable	applicable

2.1.1 4-Wire Mode

The 4-wire mode is the standard communication option, if only one sensor is used.

Access to all digital registers is given. The device can be programmed and configured to achieve best performance for individual application.

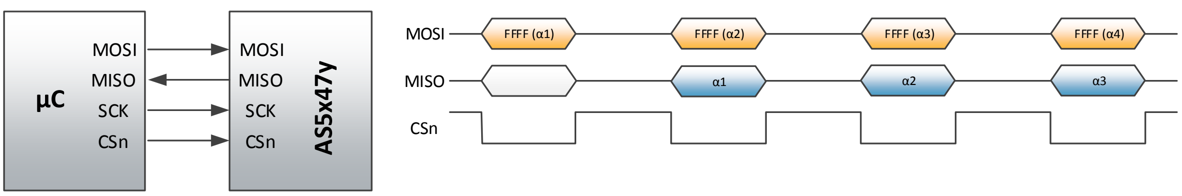

Figure 1: 4-wire mode

2.1.2 3-Wire Mode

The 3-wire mode is a read-only option of the digital interface. The MOSI pin is pulled via a resistor (e.g. 10 kΩ) permanently to VDD level. That means that the AS5x47y sensor always receives a read request on register 0x3FFF (ANGLECOM). Therefore only angle information could be read from MISO line.

A minimum amount of wires are required. As a drawback no configurations or programming, as well as no reading requests on other addresses could be done.

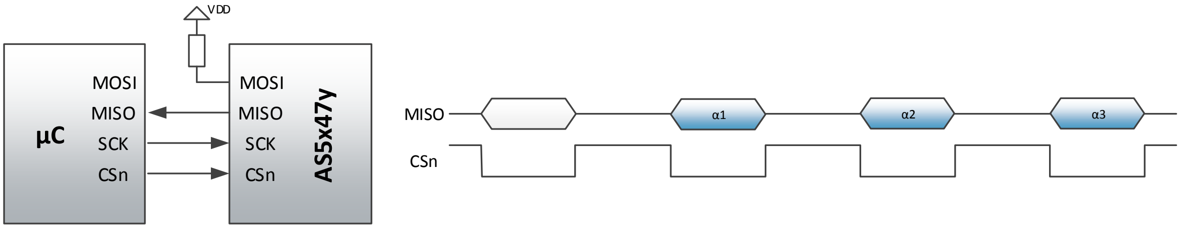

Figure 2: 3-wire mode (read only)

2.1.3 Multiple Slave

In this configuration the SPI master communicates with multiple sensors sharing the same MISO, MOSI and SCK line. CSn wires are separated to distinguish between the different sensors. Each AS5x47y is accessible like in basic 4-Wire Mode.

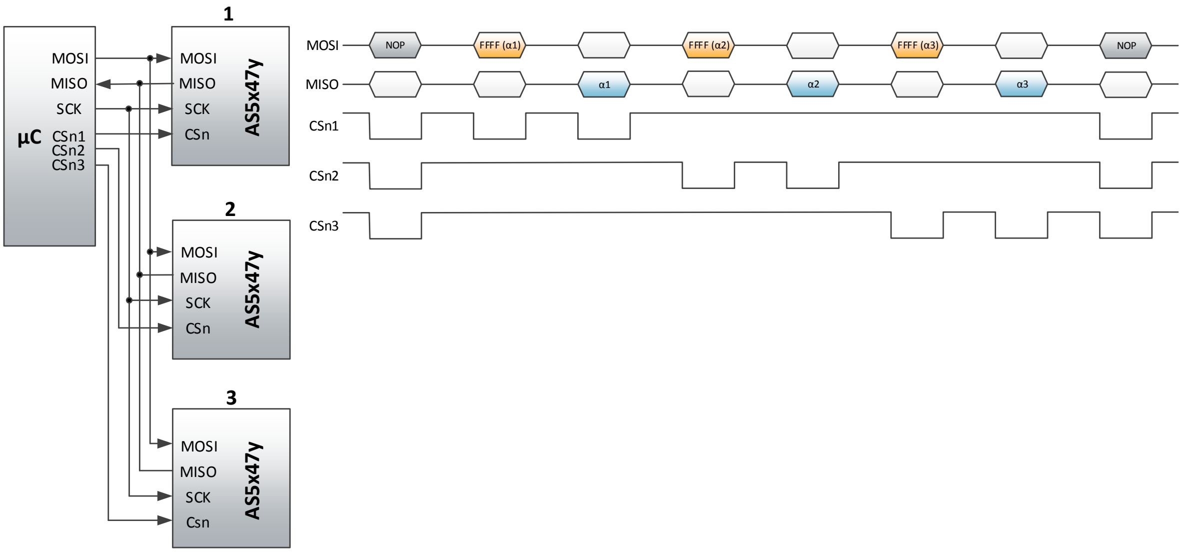

Figure 3: Three AS5x47y in Multiple Slave configuration

The multi slave configuration provides direct access to every sensor. Configurations and programming could be done separately. The efficiency of the interface is the same as in 4-wire mode.

Amount of wires to SPI master:

$$W_{Nr} = 3 + n \qquad n \ldots \text{Number of used sensors}$$

2.1.4 Daisy Chain

In this configuration the microcontroller can read multiple (n) sensor chips using only 4 wires (MISO, MOSI, SCK, CSn). One transmission consists of n frames. CSn stays low, as long as all frames are stepped through (all registers are filled). In the next communication cycle the requested date will be shifted out to the master. Configuration and programming of the sensors, as well as reading form all registers could be done.

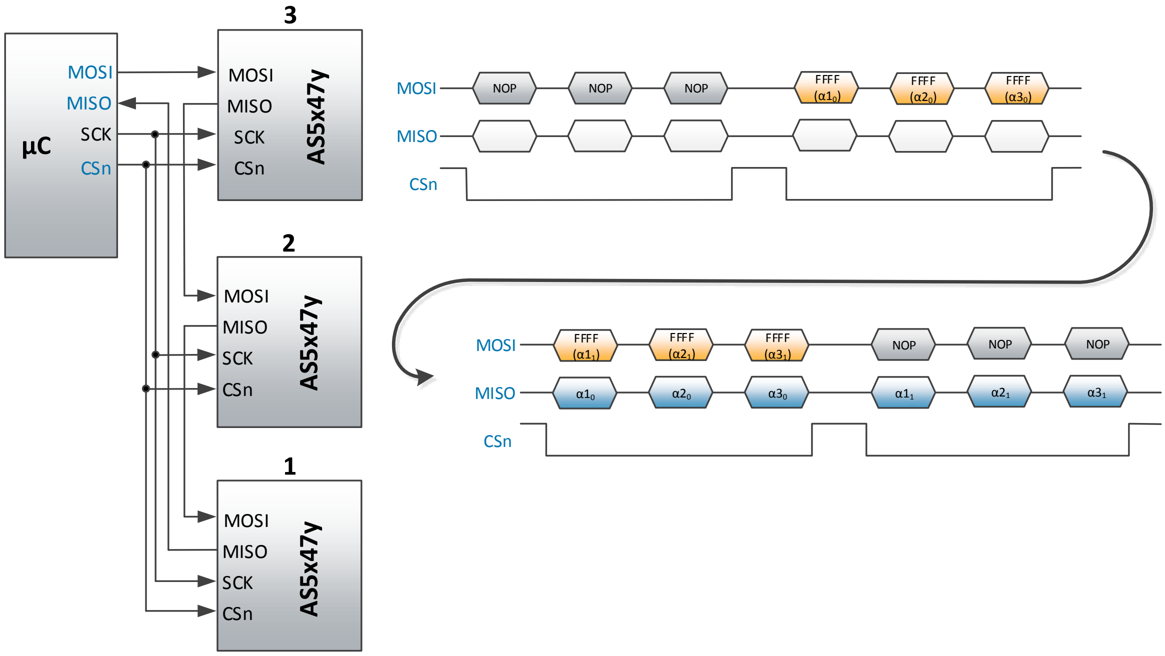

Figure 4: Daisy chain configuration

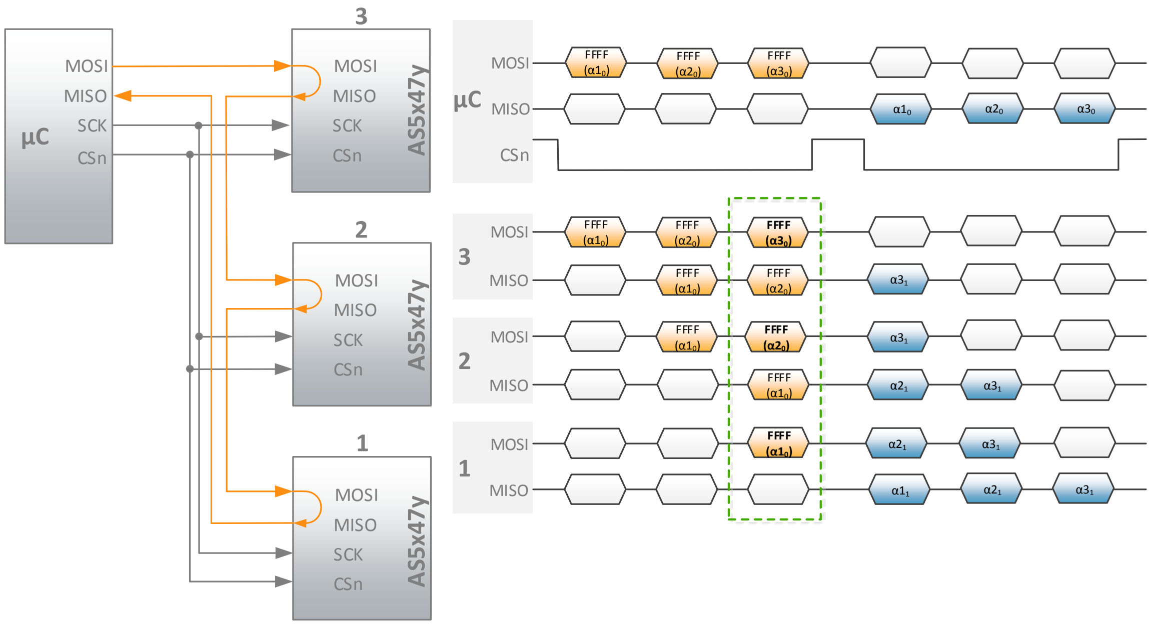

Figure 5 shows the data flow in the shift registers in detail. First MOSI data package will be shifted to the last sensor in the chain. Fist MISO data package gives as well the register content of the last sensor in chain.

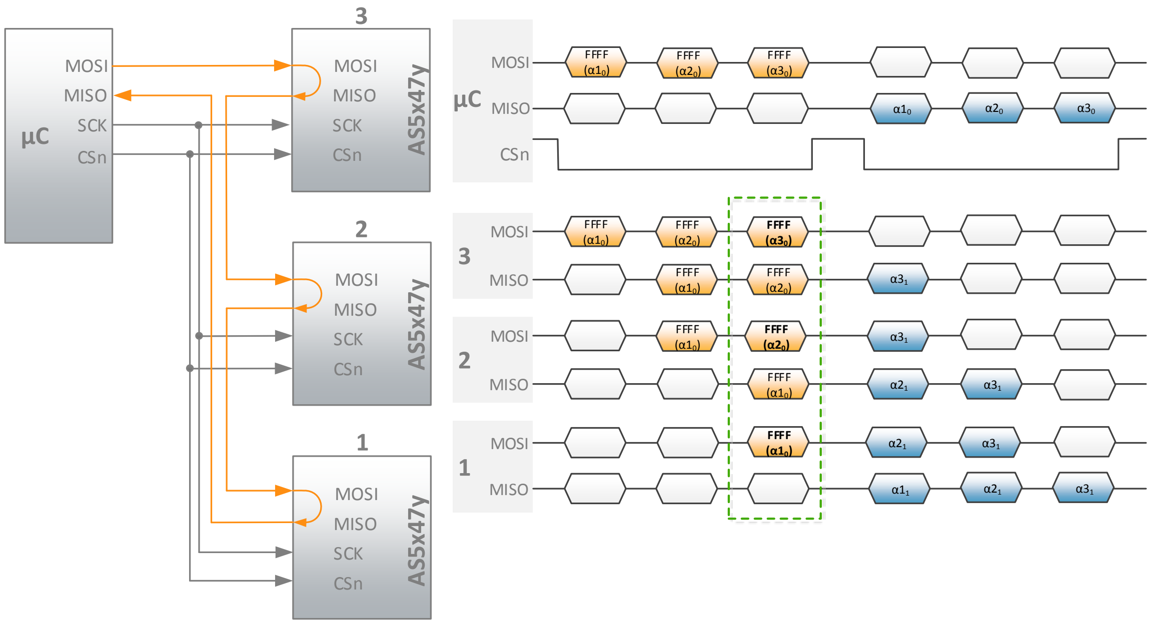

Figure 5: Daisy Chain - Communication Flow

It is beneficial that only four wires are required to communicate with n sensors in chain. On the other hand the data efficiency of the interface decreases, because the requested data content has always to be shifted trough all sensors.

3 ABI - Incremental Interface

The ABI quadrature interface is a very common interface in the field of digital encoders. The signals are available via three digital output pins on the sensor simultaneously with the other interface options.

The number of pulses/steps of the AB outputs can be configured to different resolutions.

For details on step resolution see datasheet AS5x47y_Vx_xx.

In the following example setting one revolution (360° turn) consists of 2048 steps (LSB).

Setting: (default configuration of AS5147)

Steps per revolution = 2048

Pulses per revolution = 512

ABIRES = 000 (resolution setting)

ABIBIN = 1 (binary selection)

IWIDTH = 0 (3 LSB)

DIR = 0 (A leads, B follows)

$$1\ LSB = \frac{360°}{2048} = 0.176°$$

In this case the resolution is 0.176° per LSB.

3.1 Index Width

In the automotive version of the sensor AS5147y, index pulse width can be configured to 1 LSB (IWIDTH=1) or 3 LSB (IWIDTH=0), within SETTINGS 1 register (0x0018).

In the industry version of the sensor AS5047y, the index width is fixed to 1 LSB and cannot be reconfigured.

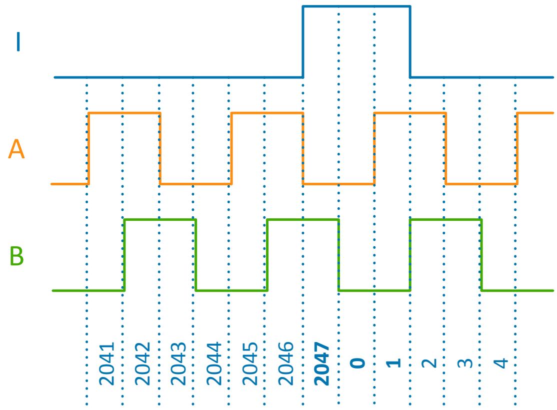

Figure 6: ABI outputs, Index Width = 3 LSB

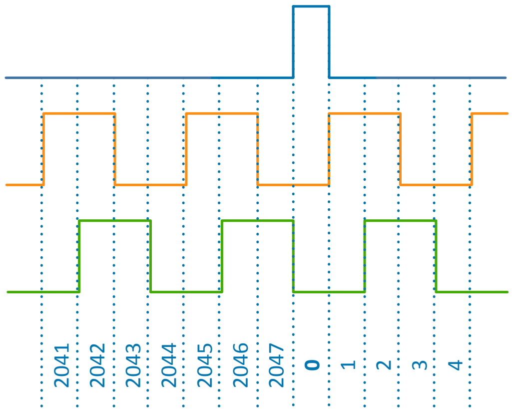

Figure 7: ABI outputs, Index Width = 1 LSB

3.2 Rotation Direction

To distinguish between CW (clock wise) and CCW (counter clock wise) rotation, the sequence of the rising edges on A and B has to be taken into account.

At CW rotation, rising edge of A signal leads and B signal follows as shown in Figure 8.

At CCW rotation rising edge of B signal leads and A signal follows as shown in Figure 9.

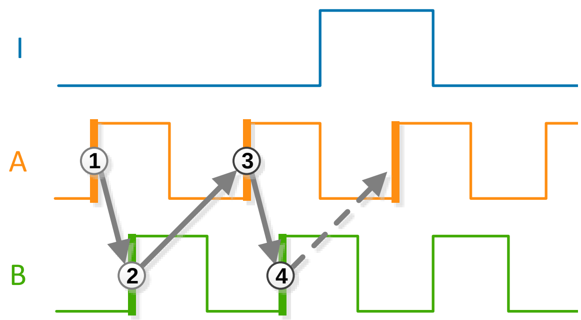

Figure 8: ABI clock wise rotation.

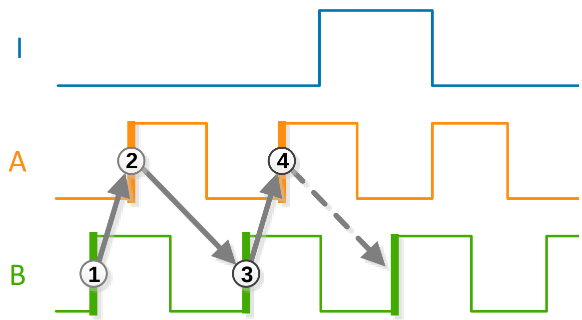

Figure 9: ABI counter clock wise rotation.

If the rotation output pattern is not comfortable for the application, direction can be changed by a programming option within the sensor.

DIR bit in SETTINGS1 (0x0018) register should be set, if rotation direction should be exchanged to the opposite direction. The DIR bit setting will affect every interface type of the sensor.

4 UVW Interface

The UVW signals provide a low resolution absolute interface. This interface emulates the commutation signals for the motor controller, which are usually generated by three discrete Hall Switches commonly used in BLDC motors. The step resolution between the edges stays always 60° electrically.

The UVW signals can be configured suitable to the PP_{Nr} (pole pair number) of the motor within SETTINGS2 register (0x0019). Motors up to 7 pole pairs can be used directly with the UVW outputs of AS5x47y sensors.

In this example pole pair setting is configured to 4. This ends up in a final resolution of 15° mechanically. The electrical resolution of 60°e stays always the same between the pulses.

Settings (example):

UVWPP = 011 (4 pole pairs)

IWIDTH = 1 (3LSB)

DIR = 0

$$RES_{mech} = \frac{360°}{2_{Edges} \cdot 4_{Periods} \cdot 3_{Signals}} = 15°$$

The 360° turn is divided into 24 sectors. Therefore one sector has a width of 15°, which represents directly the mechanic resolution of UVW.

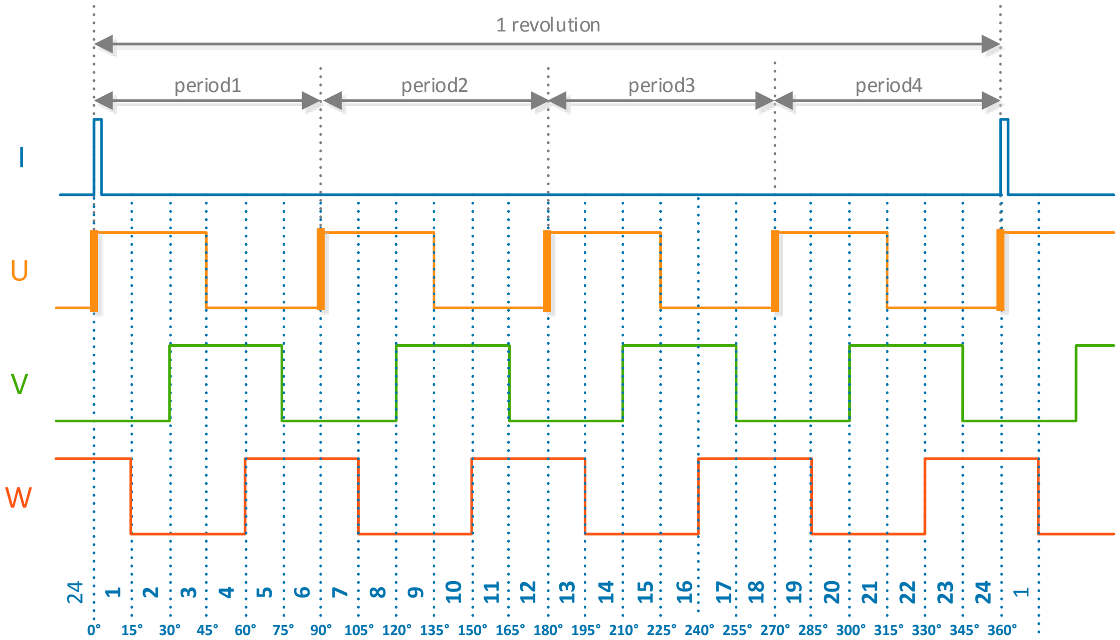

Figure 10: UVW patter configured to 4 pole pairs, CW rotation of the shaft.

4.1 Rotation Direction

At CW rotation rising edge of U is leading, V follows U and W follows V (see Figure 1).

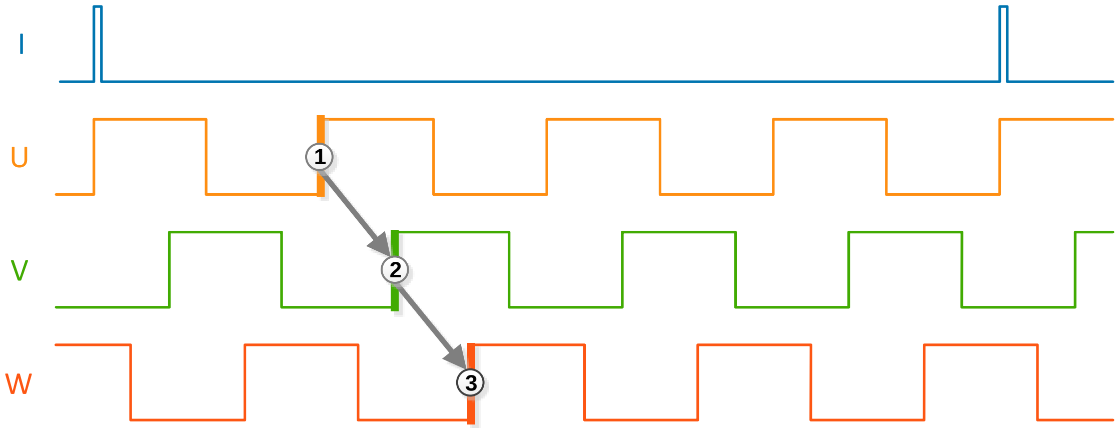

Figure 11: clockwise rotation direction

At CCW rotation rising edge of W is leading, V follows W and U follows V (shown in Figure 12).

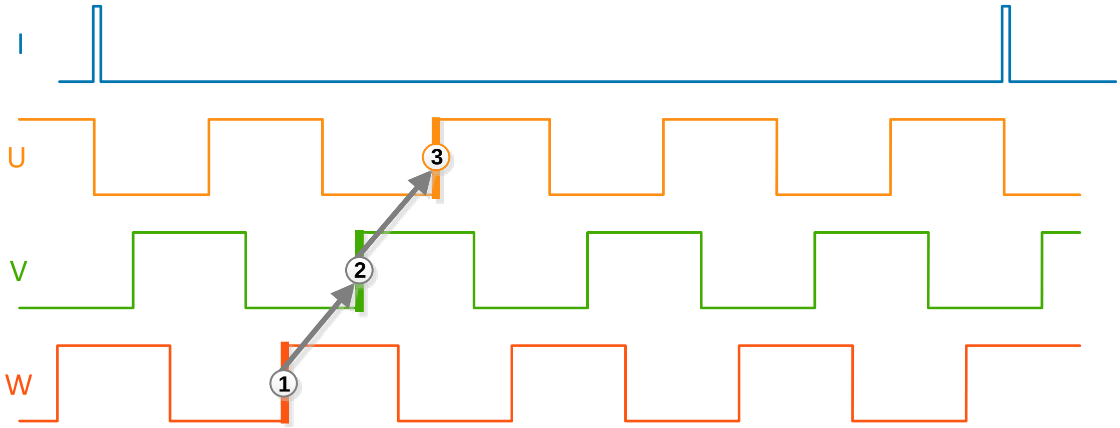

Figure 12: UVW-Pattern at counter clockwise rotation direction

Also for the UVW interface the rotation direction could be changed within the sensor, by setting the DIR bit in SETTING1 register (0x0018).

5 PWM

The PWM output represents absolute angular information with 12-bit resolution via a pulse width modulated signal. PWM frequency is typically 546 Hz (min. 490 Hz, max 603 Hz).

In default configuration the PWM signal is not mapped to a pin of the sensor. By setting bit PWM on in SETTING1 register to 1, PWM is present on pin 8 (W) of the sensor. With bit UVW_ABI in SETTING1 register, PWM can be rerouted to pin 14(I).

One PWM frame is build out of 4119 PWM periods and consists of following sections:

12 PWM pulses	INIT	Indicates start of frame with 12 pulses high
4 PWM pulses	Error_n	Error detection section
4095 PWM pulses	data	Data section
8 PWM pulses	end	Indicates end of frame with 8 pulses low

In this example the PWM output is mapped to pin 8.

Setting:

PWMon = 1 (enable PWM)

UVW_ABI = 0

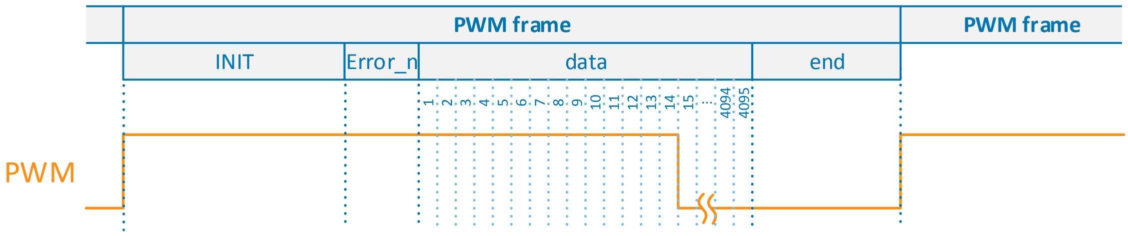

Figure 13: PWM signal representing an angle of 1.23°.

$$Angle° = \frac{360°}{2^{12}} \cdot 14\ pulses = 1{,}23°$$

$$DutyCycle = \frac{30_{\ pulses\ high}}{4119_{\ frame\ width}} = 0{,}007\%$$

5.1 Error detection

The error detection indicates if the spotted magnet is in a valid range. If field strength is not high enough (magnet too far away from sensor), or field strength is higher than allowed (magnet is too close to sensor) PWM will go in an error state. This error indication has to be enabled with comp_l_error_en and comp_h_error_en bit within ZPOSL register (0x0017).

Setting:

Comp_l_error_en = 1 (error indication of MAGH enabled)

Comp_h_error_en = 1 (error indication of MAGL enabled)

Magnet is too far away from sensor (not within 35-70 mT range)

Due to the too weak field, the 4 Error_n pulses in the PWM frame will be forced to low. Also all data bits stay at low level.

This ends up in a duty cycle of 0,003%, which is always an indicator that something is wrong with the magnet.

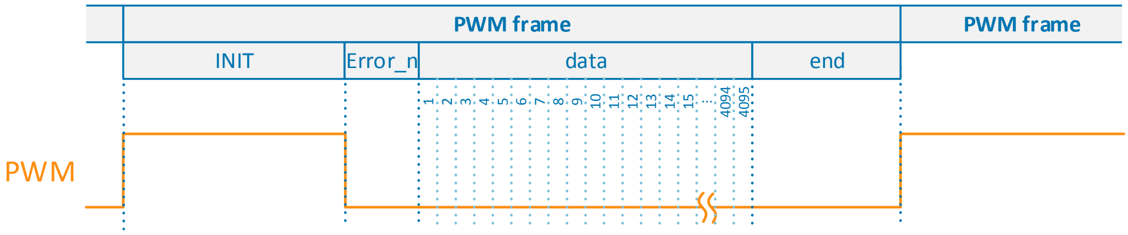

Figure 14: PWM signal is in error mode

$$DutyCycle_{Error} = \frac{12_{\ pulses\ high}}{4119_{\ frame\ width}} = 0{,}003\%$$

If error detection is disabled, these errors will not be displayed. In this case a random jittering on the PWM signal will occur, if the sensor magnet is too far away.

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8 Revision Information

Changes from previous version to current revision 1-01 (2016-Mar-18)	Page
Initial version 1-00	
PWM Frequency adapted	10

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