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AS5245

Programmable 360º Magnetic Angle Encoder with Absolute SSI and PWM Output

General Description

The AS5245 is a contactless magnetic angle encoder for accurate measurement up to 360º and includes two AS5145 devices in a punched stacked leadframe.

It is a system-ON-chip, combining integrated Hall elements, analog front end and digital signal processing in a single device.

To measure the angle, only a simple two-pole magnet, rotating over the center of the chip is required. The magnet may be placed above or below the IC.

The absolute angle measurement provides instant indication of the magnet's angular position with a resolution of 0.0879º = 4096 positions per revolution. This digital data is available as a serial bit stream and as a PWM signal.

An internal voltage regulator allows operation of the AS5245 from 3.3V or 5.0V supplies.

The AS5245 is fully automotive qualified to AEC-Q100, grade 0.

Ordering Information and *Content Guide* appear at end of datasheet.

Key Benefits & Features

The benefits and features of AS5245, Programmable 360º Magnetic Angle Encoder with Absolute SSI and PWM Output are listed below:

Figure 1:
Added Value of Using AS5245

Benefits	Features
No mechanical wear	• Contactless high resolution rotational position encoding over a full turn of 360º
High resolution absolute position sensing	• Two digital 12-bit absolute outputs
Easy to use for motor control	• Quadrature A/B (10- or 12-bit) and Index output signal
Adjustable zero position	• User programmable zero position
Tolerant to magnet misalignment	• Failure detection mode for magnet placement monitoring and loss of power supply
Usable for high speed applications	• "Red-Yellow-Green" indicators display placement of magnet in Z-axis
Tolerant to airgap variations	• Tolerant to magnet misalignment and air gap variations

Benefits	Features
Operates up to 150°C ambient temperature	• Wide temperature range: - 40ºC to 150ºC
Supports daisy chain application	• Unique Chip Identifier
Fitting to automotive applications	• Fully automotive qualified to AEC-Q100, grade 0
Two sensors in one package	• Small package: QFN 32 LD (7x7)

Applications

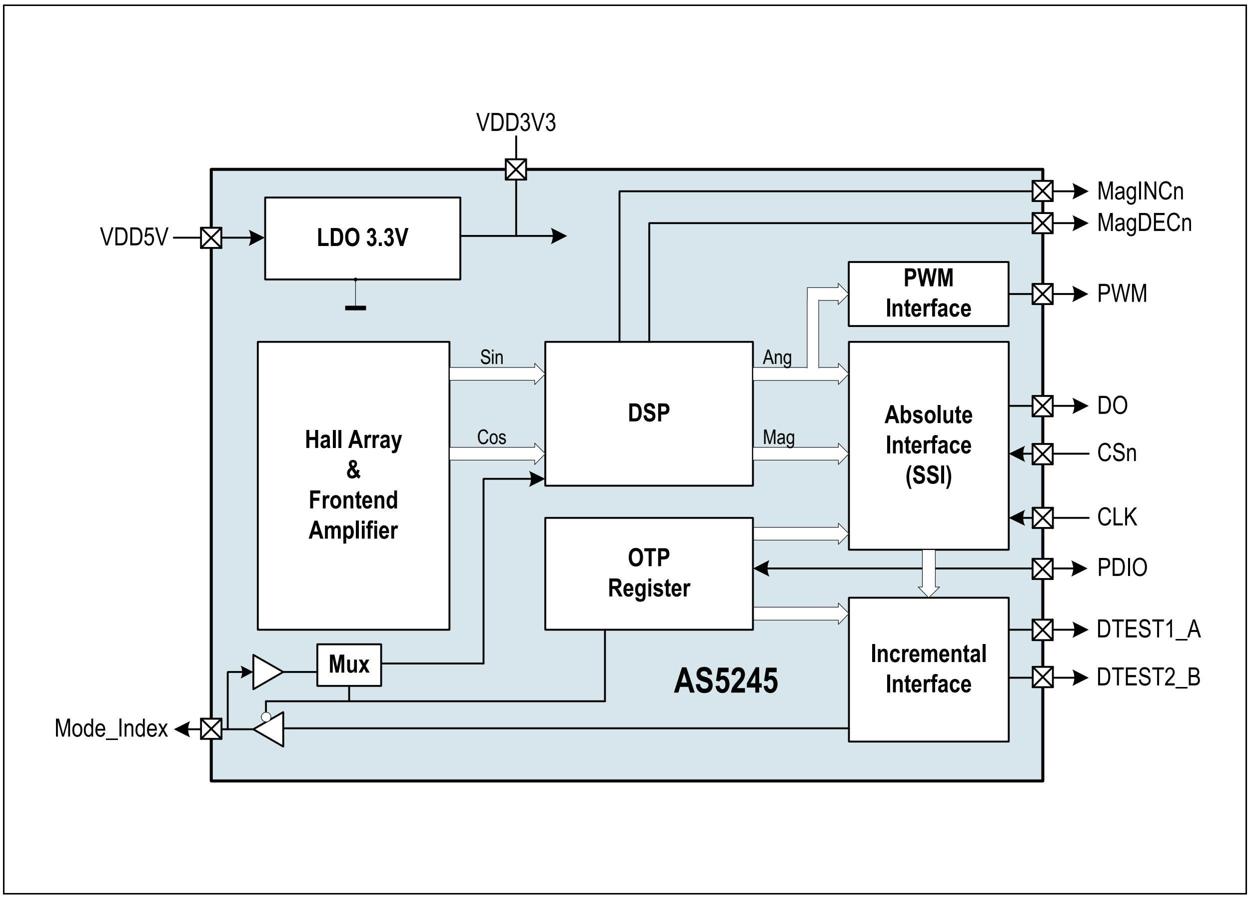
The AS5245 is ideal for applications with an angular travel range from a few degrees up to a full turn of 360º. The device is suitable for Automotive applications like

- Throttle position sensors
- Gas/brake pedal position sensing
- Headlight position control
- Contactless rotary position sensing
- Front panel rotary switches
- Replacement of potentiometer

Block Diagram

The functional blocks of this device for reference are shown below:

Figure 2:
AS5245 Block Diagram



Note(s) and/or Footnote(s):

1. This block diagram presents only one die

Pin Assignments

Figure 3:
Pin Assignments (Top View)

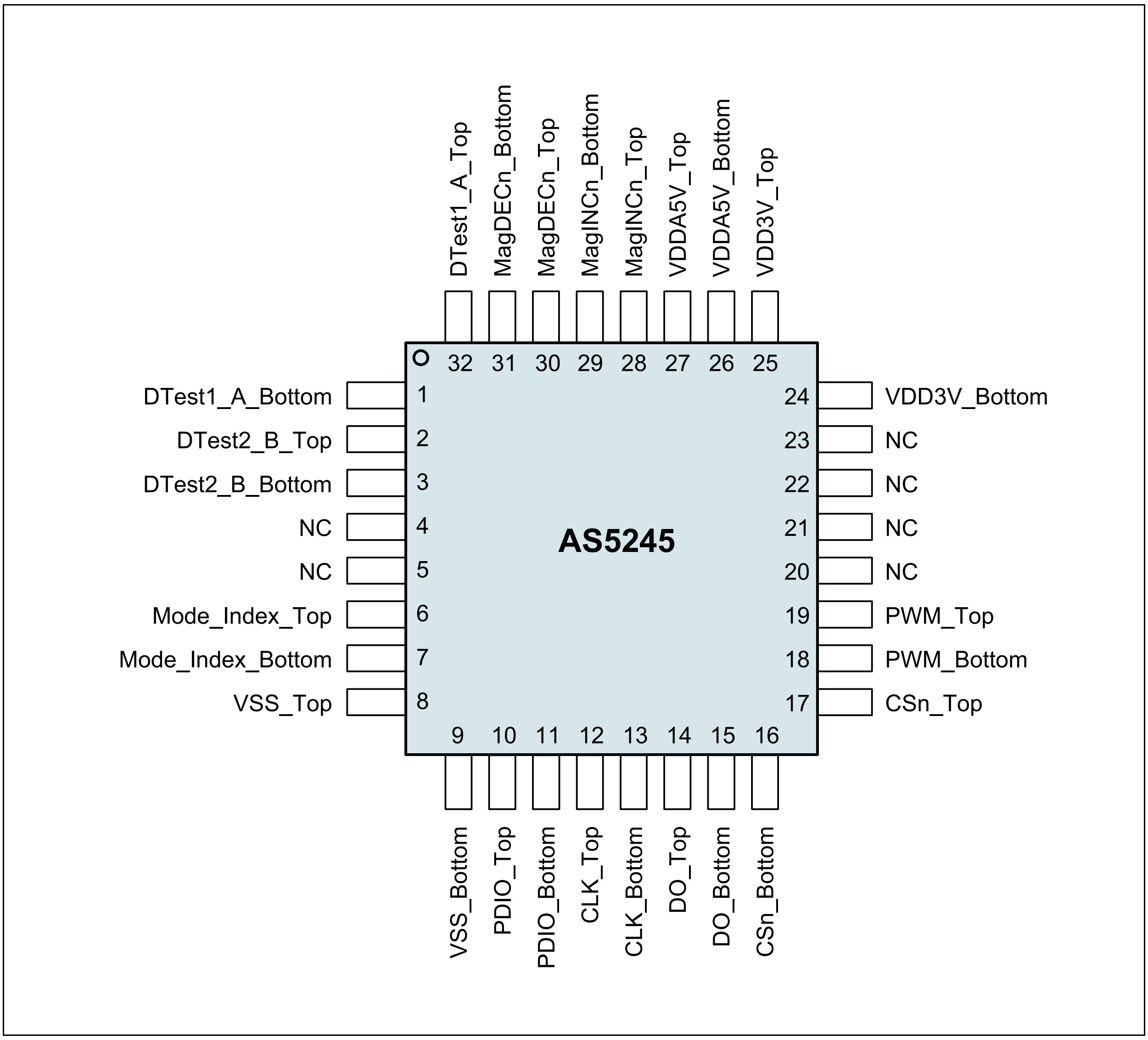


Figure 4:
Pin Descriptions

Pin Name	Pin Number	Pin Type	Description
DTest1_A	1, 32	Digital output	Test output in default mode
DTest2_B	2, 3	Digital output	Test output in default mode
NC	4, 5	-	For internal use. Must be left unconnected
Mode_Index	6, 7	Digital I/O pull-down	Select between slow (open, low: VSS) and fast (high) mode. Internal pull-down resistor. Hard wired connection to VDD or GND recommended.
VSS	8, 9	Supply pin	Negative Supply Voltage (GND)
PDIO	10, 11	Digital input pull-down	**OTP Programming Input and Data Input for Daisy Chain mode.** Internal pull-down resistor (74kΩ). Should be connected to VSS if programming is not used.
CLK	12, 13	Digital input, Schmitt-trigger input	**Clock Input** of Synchronous Serial Interface; Schmitt-Trigger input
DO	14, 15	Digital output / tri-state	**Data Output** of Synchronous Serial Interface
CSn	16, 17	Digital input pull-up, Schmitt-trigger input	**Chip Select.** Active low. Schmitt-Trigger input, internal pull-up resistor (50kΩ)
PWM	18, 19	Digital output	**Pulse Width Modulation**
NC	20, 21	-	For internal use. Must be left unconnected
NC	22, 23	-	For internal use. Must be left unconnected
VDD3V3	24, 25	Supply pin	3V-Regulator Output for internal core, regulated from VDD5V. Connect to VDD5V for 3V supply voltage. Do not load externally.
VDD5V	26, 27	Supply pin	Positive Supply Voltage, 3.0V to 5.5V
MagINCn	28, 29	Digital output open drain	**Magnet Field Magnitude Increase.** Active low. Indicates a distance reduction between the magnet and the device surface.
MagDECn	30, 31	Digital output open drain	**Magnet Field Magnitude Decrease.** Active low. Indicates a distance increase between the device and the magnet.

Absolute Maximum Ratings

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure 5:
Absolute Maximum Ratings

Parameter	Min	Max	Units	Comments
DC supply voltage at pin VDD5V	-0.3	7	V	
DC supply voltage at pin VDD3V3	-0.3	5	V	
Input pin voltage	-0.3	7	V	Pins Prog, MagINCn, MagDECn, CLK, CSn
Input current (latchup immunity)	-100	100	mA	Norm: EIA/JESD78 Class II Level A
Electrostatic discharge	±2		kV	Norm: JESD22-A114E
Storage temperature	-55	150	ºC	
Body temperature (Lead-free package)		260	ºC	t=20 to 40s, Norm: IPC/JEDEC J-Std-020C Lead finish 100% Sn "matte tin"
Humidity non-condensing	5	85	%	
Ambient temperature	-40	150	ºC	
Moisture sensitivity level	3			Represents a maximum floor time of 168h

Electrical Characteristics

T_{AMB} = -40 to 150°C, $V_{DD}5V$ = 3.0-3.6V (3V operation)
VDD5V = 4.5-5.5V (5V operation) unless otherwise noted.

Figure 6:
Electrical Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Unit
Operating Conditions						
T_{AMB}	Ambient temperature		-40		150	°C
I_{supp}	Supply current	(one die only)		16	21	mA
$V_{DD}5V$	Supply voltage at pin $V_{DD}5V$	5V Operation	4.5	5.0	5.5	V
$V_{DD}3V3$	Voltage regulator output voltage at pin $V_{DD}3V3$		3.0	3.3	3.6	
$V_{DD}5V$	Supply voltage at pin $V_{DD}5V$	3.3V Operation (pin $V_{DD}5V$ and $V_{DD}3V3$ connected)	3.0	3.3	3.6	V
$V_{DD}3V3$	Supply voltage at pin $V_{DD}3V3$		3.0	3.3	3.6	
V_{ON}	Power-ON reset thresholds ON voltage; 300mV typ. hysteresis	DC supply voltage 3.3V ($V_{DD}3V3$)	1.37	2.2	2.9	V
V_{OFF}	Power-ON reset thresholds OFF voltage; 300mV typ. hysteresis		1.08	1.9	2.6	
Programming Conditions						
V_{PROG}	Programming voltage	Voltage applied during programming	3.3		3.6	V
$V_{ProgOff}$	Programming voltage OFF level	Line must be discharged to this level	0		1	V
I_{PROG}	Programming current	Current during programming			100	mA
$R_{programmed}$	Programmed fuse resistance (log 1)	10µA maximum current@100mV	100k		∞	Ω
$R_{unprogrammed}$	Unprogrammed fuse resistance (log 0)	2mA maximum current@100mV	50		100	Ω

Symbol	Parameter	Condition	Min	Typ	Max	Unit
DC Characteristics CMOS Schmitt-Trigger Inputs: CLK, CSn (CSn = Internal Pull-Up)						
V_{IH}	High level input voltage	Normal operation	0.7 * V_{DD}5V			V
V_{IL}	Low level input voltage				0.3 * V_{DD}5V	V
V_{Ion}-V_{Ioff}	Schmitt Trigger hysteresis		1			V
I_{LEAK}	Input leakage current	CLK only	-1		1	µA
I_{IL}	Pull-up low level input current	CSn only, V_{DD}5V: 5.0V	-30		-100	µA
DC Characteristics CMOS / Program Input: PDIO						
V_{IH}	High level input voltage		0.7 * V_{DD}5V		V_{DD}5V	V
V_{PROG}	High level input voltage	During programming, Either with 3.3V or 5V supply	3.3		3.6	V
V_{IL}	Low level input voltage				0.3 * V_{DD}5V	V
I_{IL}	Low level input current	V_{DD}5V: 5.5V	30		100	µA
DC Characteristics CMOS Output Open Drain: MagINCn, MagDECn						
I_{OZ}	Open drain leakage current				1	µA
V_{OL}	Low level output voltage				V_{SS} +0.4	V
I_O	Output current	V_{DD}5V: 4.5V			4	mA
		V_{DD}5V: 3V			2	mA
DC Characteristics CMOS Output: PWM						
V_{OH}	High level output voltage		V_{DD}5V – 0.5			V
V_{OL}	Low level output voltage				V_{SS} +0.4	V
I_O	Output current	V_{DD}5V: 4.5V			4	mA
		V_{DD}5V: 3V			2	mA

Symbol	Parameter	Condition	Min	Typ	Max	Unit
DC Characteristics CMOS Output: A, B, Index						
V_{OH}	High level output voltage		V_{DD}5V – 0.5			V
V_{OL}	Low level output voltage				V_{SS} +0.4	V
I_O	Output current	V_{DD}5V: 4.5V			4	mA
		V_{DD}5V: 3V			2	
DC Characteristics Tri-State CMOS Output: DO						
V_{OH}	High level output voltage		V_{DD}5V – 0.5			V
V_{OL}	Low level output voltage				V_{SS} +0.4	V
I_O	Output current	V_{DD}5V: 4.5V			4	mA
		V_{DD}5V: 3V			2	
I_{OZ}	Tri-state leakage current				1	µA

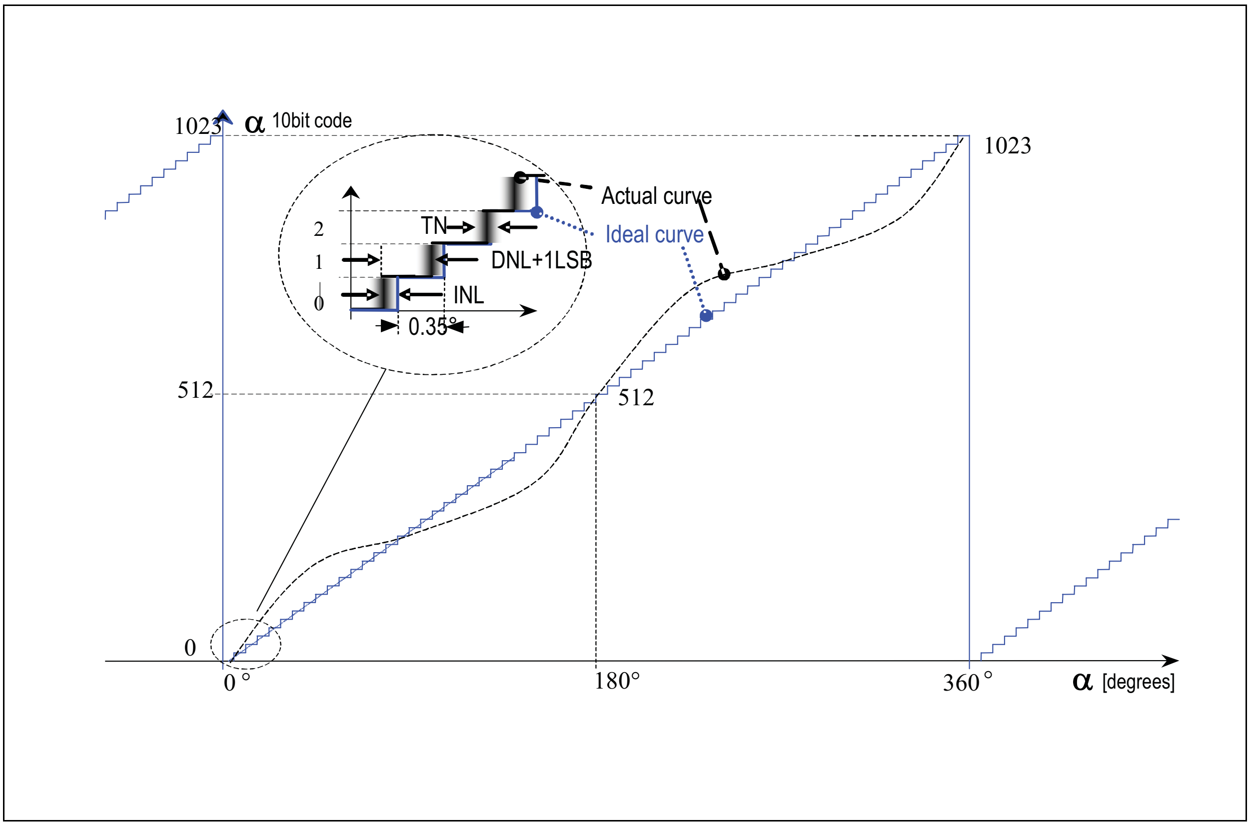
System Specifications

T_{AMB} = -40 to 150°C, V_{DD}5V = 3.0 to 3.6V (3V operation)
V_{DD}5V = 4.5 to 5.5V (5V operation) unless otherwise noted.

Figure 7:
Input Specification

Symbol	Parameter	Condition	Min	Typ	Max	Unit
RES	Resolution	0.088 deg			12	bit
INL_{opt}	Integral non-linearity (optimum)	Maximum error with respect to the best line fit. Centered magnet without calibration, T_{AMB} =25°C.			±0.5	deg
INL_{temp}	Integral non-linearity (optimum)	Maximum error with respect to the best line fit. Centered magnet without calibration, T_{AMB} = -40 to 150°C			±0.9	deg
INL	Integral non-linearity	Best line fit = (Err_{max} – Err_{min}) / 2 Over displacement tolerance with 6mm diameter magnet, without calibration, T_{AMB} = -40 to 150°C			±1.4	deg
DNL	Differential non-linearity	12bit, no missing codes			±0.044	deg
TN	Transition noise	1 sigma, fast mode (MODE = 1)			0.06	Deg RMS
		1 sigma, slow mode (MODE = 0 or open)			0.03	
t_{PwrUp}	Power-up time	Fast mode (Mode = 1); Until status bit OCF = 1			20	ms
		Slow mode (Mode = 0 or open); Until OCF = 1			80	
t_{delay}	System propagation delay absolute output : delay of ADC, DSP and absolute interface	Fast mode (MODE = 1)			96	µs
		Slow mode (MODE = 0 or open)			384	
f_S	Internal sampling rate for absolute output:	T_{AMB} = 25°C, slow mode (MODE=0 or open)	2.48	2.61	2.74	kHz
		T_{AMB} = -40 to 150°C, slow mode (MODE=0 or open)	2.35	2.61	2.87	
f_S	Internal sampling rate for absolute output	T_{AMB} = 25°C, fast mode (MODE = 1)	9.90	10.42	10.94	kHz
		T_{AMB} = -40 to 150°C, fast mode (MODE=1)	9.38	10.42	11.46	
CLK/SEL	Read-out frequency	Maximum clock frequency to read out serial data			1	MHz

Figure 8:
Integral and Differential Non-Linearity Example



Integral Non-Linearity (INL) is the maximum deviation between actual position and indicated position.

Differential Non-Linearity (DNL) is the maximum deviation of the step length from one position to the next.

Transition Noise (TN) is the repeatability of an indicated position.

Timing Characteristics

T_{AMB} = -40 to 150ºC, VDD5V = 3.0-3.6V (3V operation)
VDD5V = 4.5-5.5V (5V operation) unless otherwise noted.

Figure 9:
Timing Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Synchronous Serial Interface (SSI)						
$t_{DOactive}$	Data output activated (logic high)	Time between falling edge of CSn and data output activated			100	ns
t_{CLKFE}	First data shifted to output register	Time between falling edge of CSn and first falling edge of CLK	500			ns
$T_{CLK/2}$	Start of data output	Rising edge of CLK shifts out one bit at a time	500			ns
$t_{DOvalid}$	Data output valid	Time between rising edge of CLK and data output valid			413	ns
$t_{DOtristate}$	Data output tri-state	After the last bit DO changes back to "tri-state"			100	ns
t_{CSn}	Pulse width of CSn	CSn =high; To initiate read-out of next angular position	500			ns
f_{CLK}	Read-out frequency	Clock frequency to read out serial data	>0		1	MHz
Pulse Width Modulation Output						
f_{PWM}	PWM frequency	Signal period = 4098µs ±10% at T_{AMB} = -40 to 150ºC	220	244	268	Hz
PW_{MIN}	Minimum pulse width	Position 0d; angle 0 degree	0.90	1	1.10	µs
PW_{MAX}	Maximum pulse width	Position 4098d; angle 359.91 degrees	3686	4096	4506	µs
Programming Conditions						
t_{PROG}	Programming time per bit	Time to prog. a singe fuse bit	10		20	µs
t_{CHARGE}	Refresh time per bit	Time to charge the cap after t_{PROG}	1			µs
f_{LOAD}	LOAD frequency	Data can be loaded at n x 2µs			500	kHz
f_{READ}	READ frequency	Read the data from the latch			2.5	MHz
f_{WRITE}	WRITE frequency	Write the data to the latch			2.5	MHz

Detailed Description

The AS5245 is manufactured in a CMOS standard process and uses a spinning current Hall technology for sensing the magnetic field distribution across the surface of the chip. The integrated Hall elements are placed around the center of the device and deliver a voltage representation of the magnetic field at the surface of the IC.

Through Sigma-Delta Analog / Digital Conversion and Digital Signal-Processing (DSP) algorithms, the AS5245 provides accurate high-resolution absolute angular position information. For this purpose, a Coordinate Rotation Digital Computer (CORDIC) calculates the angle and the magnitude of the Hall array signals. The DSP is also used to provide digital information at the outputs MagINCn and MagDECn that indicate movements of the used magnet towards or away from the device's surface. A small low cost diametrically magnetized (two-pole) standard magnet provides the angular position information (see Figure 30).

The AS5245 senses the orientation of the magnetic field and calculates a 12-bit binary code. This code can be accessed via. a Synchronous Serial Interface (SSI). In addition, an absolute angular representation is given by a Pulse Width Modulated signal at pin 12 (PWM). This PWM signal output also allows the generation of a direct proportional analog voltage, by using an external Low-Pass-Filter. The AS5245 is tolerant to magnet misalignment and magnetic stray fields due to differential measurement technique and Hall sensor conditioning circuitry.

Figure 10:
Typical Arrangement of AS5245 and Magnet

Mode_Index Pin

The Mode_Index pin activates or deactivates an internal filter that is used to reduce the analog output noise. Activating the filter (Mode pin = LOW or open) provides a reduced output noise of 0.03º rms. At the same time, the output delay is increased to 384µs. This mode is recommended for high precision, low speed applications.

Deactivating the filter (Mode pin = HIGH) reduces the output delay to 96µs and provides an output noise of 0.06º rms. This mode is recommended for higher speed applications.

Setting up the Mode pin affects the following parameters:

Figure 11:
Slow and Fast Mode Parameters

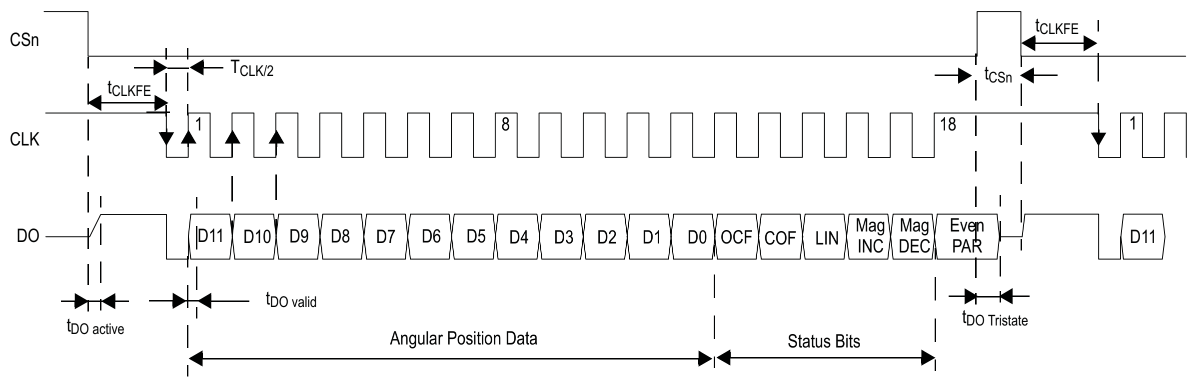
Parameter	Slow Mode (mode=low or open)	Fast Mode (mode=high, V_{DD}=5V)
Sampling rate	2.61 kHz (384 µs)	10.42 kHz (96µs)
Transition noise (1 sigma)	≤ 0.03º rms	≤ 0.06º rms
Output delay	384µs	96µs
Maximum speed @ 4096 samples/rev	38 rpm	153 rpm
Maximum speed @ 1024 samples/rev	153 rpm	610 rpm
Maximum speed @ 256 samples/rev	610 rpm	2441 rpm
Maximum speed @ 64 samples/rev	2441 rpm	9766 rpm

Note(s) and/or Footnote(s):

1. A change of the Mode during operation is not allowed. The setup must be constant during power up and during operation.

Synchronous Serial Interface (SSI)

Figure 12:
Synchronous Serial Interface with Absolute Angular Position Data



If CSn changes to logic low, Data Out (DO) will change from high impedance (tri-state) to logic high and the read-out will be initiated.

- After a minimum time $t_{CLK\ FE}$, data is latched into the output shift register with the first falling edge of CLK.
- Each subsequent rising CLK edge shifts out one bit of data.
- The serial word contains 18 bits, the first 12 bits are the angular information D[11:0], the subsequent 6 bits contain system information, about the validity of data such as OCF, COF, LIN, Parity and Magnetic Field status (increase/decrease).
- A subsequent measurement is initiated by a "high" pulse at CSn with a minimum duration of t_{CSn}.

Serial Data Contents

D11:D0 – Absolute angular position data (MSB is clocked out first).

OCF – (Offset Compensation Finished). Logic high indicates the finished Offset Compensation Algorithm.

COF – (Cordic Overflow). Logic high indicates an out of range error in the CORDIC part. When this bit is set, the data at D9:D0 is invalid. The absolute output maintains the last valid angular value. This alarm may be resolved by bringing the magnet within the X-Y-Z tolerance limits.

LIN – (Linearity Alarm). Logic high indicates that the input field generates a critical output linearity. When this bit is set, the data at D9:D0 may still be used, but can contain invalid data. This warning may be resolved by bringing the magnet within the X-Y-Z tolerance limits.

Even Parity – Bit for transmission error detection of bits 1…17 (D11…D0, OCF, COF, LIN, MagINC, MagDEC). Placing the magnet above the chip, angular values increase in clockwise direction by default.

Data D11:D0 is valid, when the status bits have the following configurations:

Figure 13:
Status Bit Outputs

OCF	COF	LIN	Mag INC	Mag DEC	Parity
1	0	0	0	0	Even checksum of bits 1:15
			0	1	
			1	0	
			1	1	

Note(s) and/or Footnote(s):

1. MagInc=MagDec=1 is only recommended in YELLOW mode (see Figure 14)

Z-Axis Range Indication (Push Button Feature, Red/Yellow/Green Indicator)

The AS5245 provides several options of detecting movement and distance of the magnet in the Z-direction. Signal indicators MagINCn and MagDECn are available both as hardware pins (pins #1 and 2) and as status bits in the serial data stream (see Figure 12). Additionally, an OTP programming option is available with bit MagCompEn that enables additional features:

In the default state, the status bits MagINC, MagDec and pins MagINCn, MagDECn have the following function:

Figure 14:
Magnetic Field Strength Red-Yellow-Green Indicator (OTP Option)

Status Bits			Hardware Pins		OTP: MagCompEn = 1 (Red-Yellow-Green Programming Option)
Mag INC	Mag DEC	LIN	Mag INCn	Mag DECn	Description
0	0	0	OFF	OFF	No distance change Magnetic input field OK (GREEN range, ~45…75mT)
1	1	0	ON	OFF	YELLOW range: magnetic field is ~ 25…45mT or ~75…135mT. The AS5245 may still be operated in this range, but with slightly reduced accuracy.
1	1	1	ON	ON	RED range: magnetic field is ~<25mT or >~135mT. It is still possible to operate the AS5245 in the red range, but not recommended.
All other combinations			n/a	n/a	Not available

Note(s) and/or Footnote(s):

1. Pin 1 (MagINCn) and pin 2 (MagDECn) are active low via. open drain output and require an external pull-up resistor. If the magnetic field is in range, both outputs are turned OFF.

The two pins may also be combined with a single pull-up resistor. In this case, the signal is high when the magnetic field is in range. It is low in all other cases (see Figure 14).

Incremental Mode

The AS5245 has an internal interpolator block. This function is used if the input magnetic field is too fast and a code position is missing. In this case an interpolation is done.

With the OTP bits OutputMd0 and OutputMd1 a specific mode can be selected. For the available pre-programmed incremental versions (10bit and 12bit), these bits are set during test at **ams**. These settings are permanent and can not be recovered.

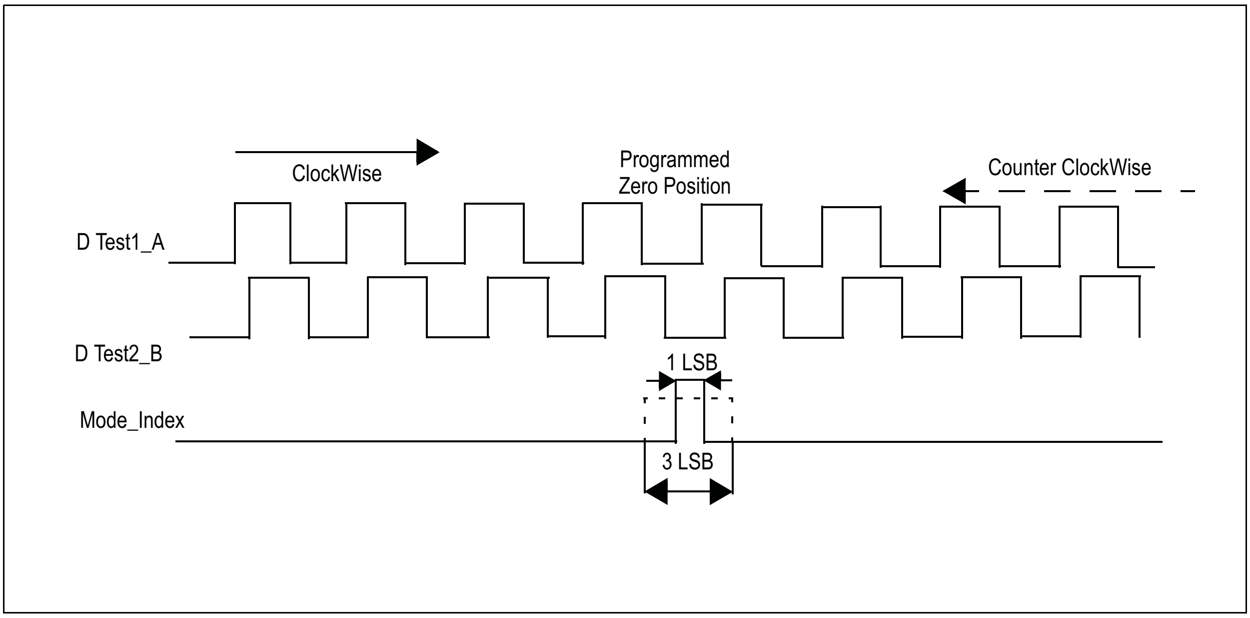
A change of the incremental mode (WRITE command) during operation could cause problems. A power-ON-reset in between is recommended.

During operation in incremental mode it is recommended setting CSn = High, to disable the SSI-Interface.

Figure 15:
Incremental Resolution

Mode	Description	Output Md1	Output Md0	Resolution	DTest1_A & DTest2_B Pulses	Index Width
Default mode	AS5245 function **DTEST1_A** and **DTEST2_B** are not used. The Mode_Index pin is used for selection of the decimation rate (low speed/high speed).	0	0			
10 bit Incremental mode (low DNL)	**DTEST1_A** and **DTEST2_B** are used as **A** and **B** signal. In this mode the **Mode_Index** Pin is switched from input to output and will be the **Index** Pin. The decimation rate is set to 64 (fast mode) and cannot be changed from external.	0	1	10	256	1/3 LSB
12 bit Incremental mode (high DNL)		1	0	12	1024	
Sync mode	In this mode a control signal is switched to **DTEST1_A** and **DTEST2_B**.	1	1			

Figure 16:
Incremental Output

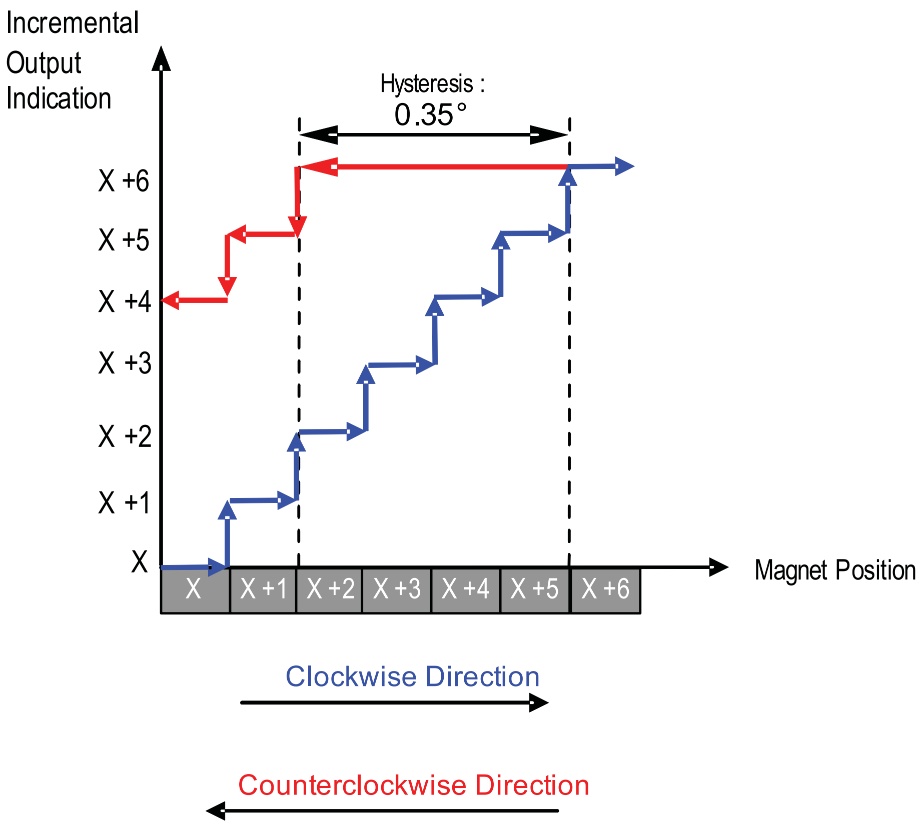


The hysteresis trimming is done at the final test (factory trimming) and set to 4 LSB, related to a 12 bit number.

Incremental Output Hysteresis.

To avoid flickering incremental outputs at a stationary magnet position, a hysteresis is introduced. In case of a rotational direction change, the incremental outputs have a hysteresis of 4 LSB. Regardless of the programmed incremental resolution, the hysteresis of 4 LSB always corresponds to the highest resolution of 12 bit. In absolute terms, the hysteresis is set to 0.35 degrees for all resolutions. For constant rotational directions, every magnet position change is indicated at the incremental outputs (see Figure 17). For example, if the magnet turns clockwise from position “x+3“ to “x+4“, the incremental output would also indicate this position accordingly. A change of the magnet’s rotational direction back to position “x+3“ means that the incremental output still remains unchanged for the duration of 4 LSB, until position “x+2“is reached. Following this direction, the incremental outputs will again be updated with every change of the magnet position.

Figure 17:
Hysteresis Window for Incremental Outputs



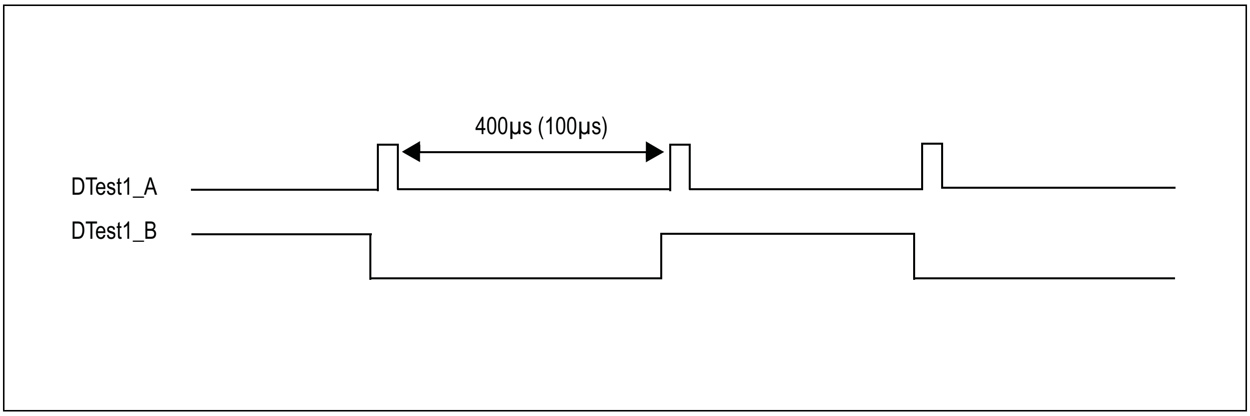
Incremental Output Validity.

During power ON the incremental output is kept stable high until the offset compensation is finished and the CSn is low (internal Pull Up) the first time. In quadrature mode A = B = Index = high indicates an invalid output. If the interpolator recognizes a difference larger than 128 steps between two samples, it holds the last valid state. The interpolator synchronizes up again with the next valid difference. This avoids undefined output burst, e.g. if no magnet is present.

Sync Mode

This mode is used to synchronize the external electronic with the AS5245. In this mode, two signals are provided at the pins DTEST1_A and DTEST2_B. By setting of Md0=1 and Md1=1 in the OTP register, the Sync mode will be activated.

Figure 18:
DTest1_A and DTest2_B



Every rising edge at DTEST1_A indicates that new data in the device is available. With this signal it is possible to trigger an external customer Microcontroller (interrupt) and start the SSI readout. DTEST2_B indicates the phase of available data.

Sine/Cosine Mode

This mode can be enabled by setting the OTP Factory-bit FS2. If this mode is activated, the 16 bit sinus and 16 bit cosines digital data of both channels will be switched out. Due to the high resolution of 16 bits of the data stream, an accurate calculation can be done externally. In this mode, the open drain outputs of DTEST1_A and DTEST2_B are switched to push-pull mode. At Pin MagDECn the clock impulse, at Pin MagINCn the Enable pulse will be switched out. The pin PWM indicates, which phase of signal is being presented. The mode is not available in the default mode.

Daisy Chain Mode

The Daisy Chain mode allows connection of several AS5245s in series, while still keeping just one digital input for data transfer (see "Data IN" in Figure 19). This mode is accomplished by connecting the data output (DO; pin 9) to the data input (PDIO; pin 8) of the subsequent device. The serial data of all connected devices is read from the DO pin of the first device in the chain. The length of the serial bit stream increases with every connected device, it is n * (18+1) bits: n= number of devices. E.g. 38 bit for two devices, 57 bit for three devices, etc.

The last data bit of the first device (Parity) is followed by a dummy bit and the first data bit of the second device (D11), etc. (see Figure 20).

Figure 19:
Daisy Chain Hardware Configuration

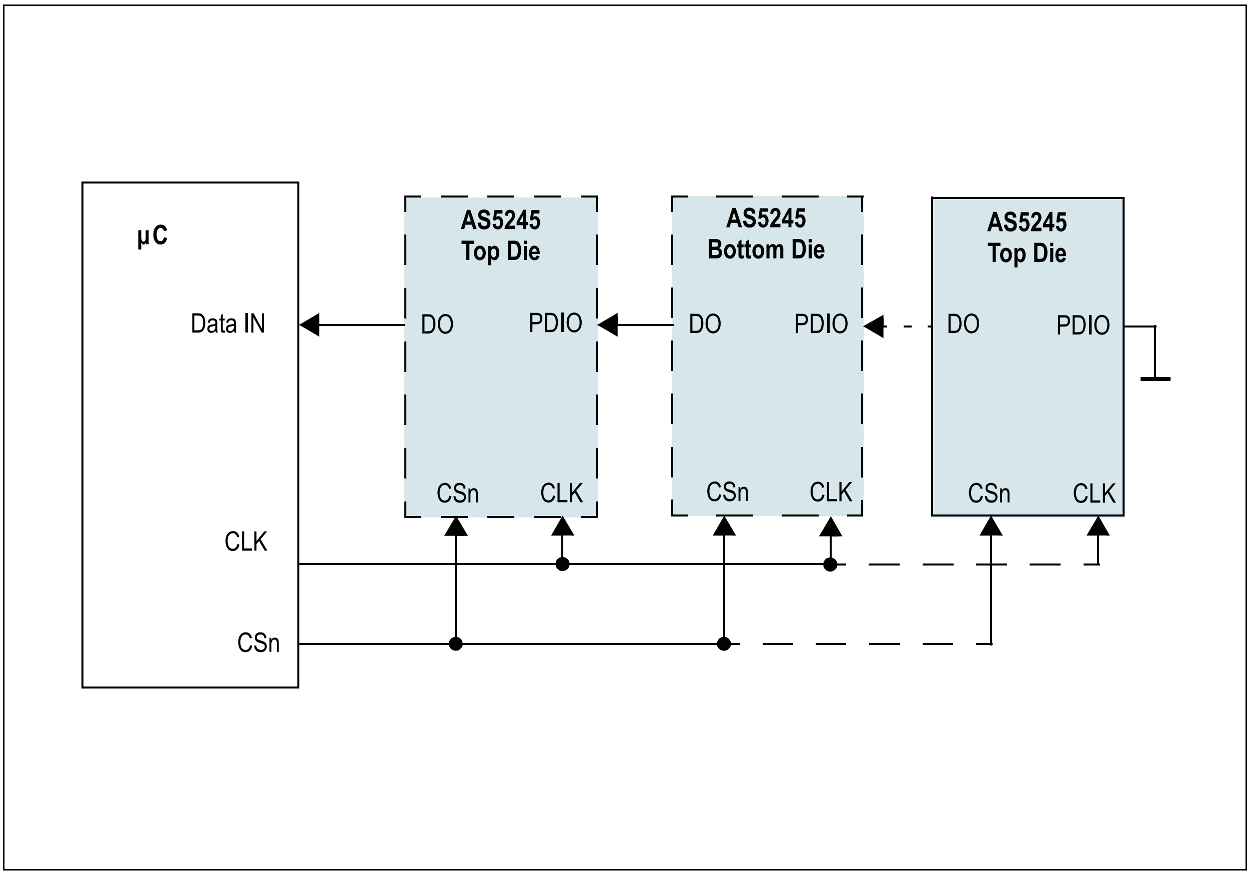
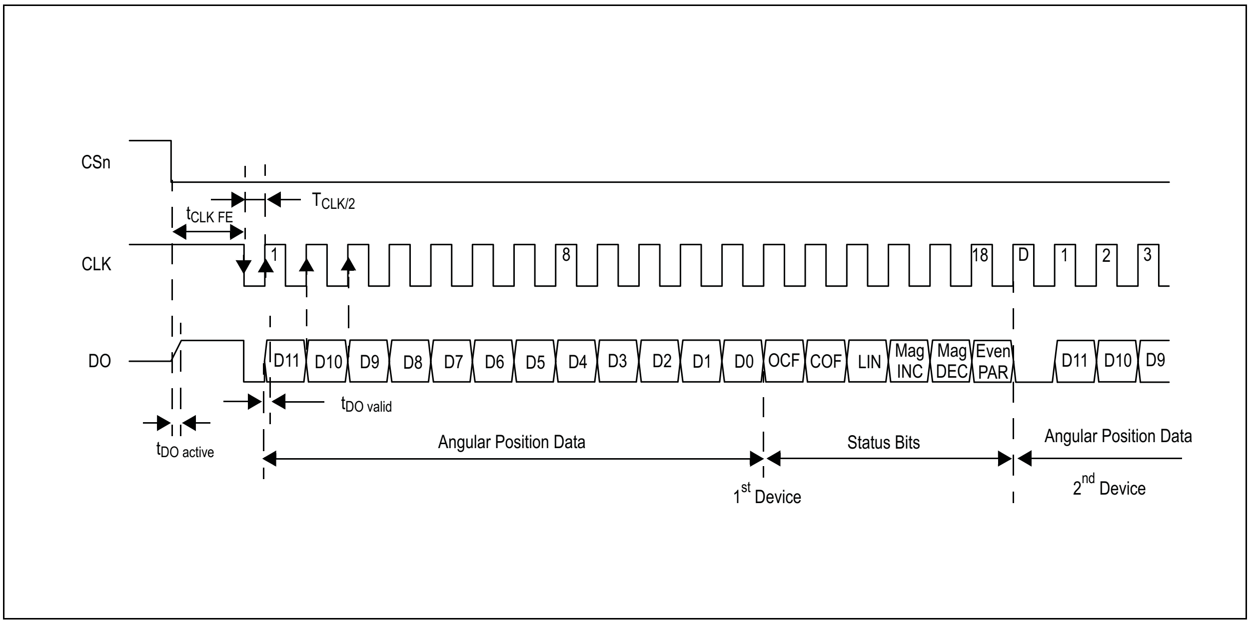


Figure 20:
Daisy Chain Mode Data Transfer



Pulse Width Modulation (PWM) Output

The AS5245 provides a pulse width modulated output (PWM), whose duty cycle is proportional to the measured angle. For angle position 0 to 4094:

(EQ1) $$\text{Position} = \frac{t_{ON} \times 4098}{(t_{ON} + t_{OFF})} - 1$$

Examples:

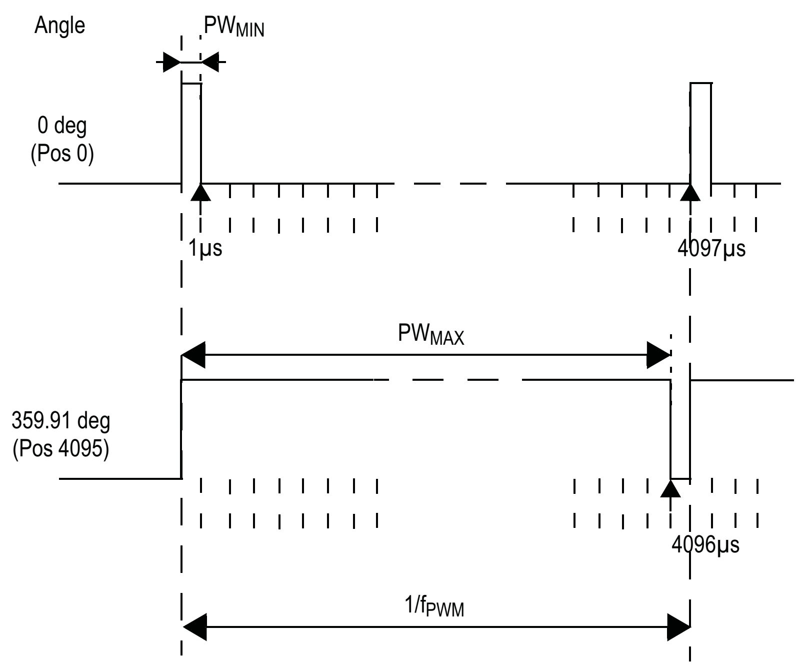
1. An angle position of 180° will generate a pulse width t_{ON} = 2049µs and a pause t_{OFF} of 2049µs resulting in Position = 2048 after the calculation:
   2049 * 4098 / (2049 + 2049) -1 = 2048
2. An angle position of 359.8° will generate a pulse width t_{ON} = 4095µs and a pause t_{OFF} of 3 µs resulting in Position = 4094 after the calculation:
   4095 * 4098 / (4095 + 3) -1 = 4094

Exception:

1. An angle position of 359.9° will generate a pulse width t_{ON} = 4097µs and a pause t_{OFF} of 1µs resulting in Position = 4096 after the calculation:
   4097 * 4098 / (4097 + 1) -1 = 4096

The PWM frequency is internally trimmed to an accuracy of ±5% (±10% over full temperature range). This tolerance can be cancelled by measuring the complete duty cycle as shown above.

Figure 21:
PWM Output Signal



Changing the PWM Frequency

The PWM frequency of the AS5245 can be divided by two by setting a bit (PWMhalfEN) in the OTP register (see Programming the AS5245). With PWMhalfEN = 0, the PWM timing is as shown in Figure 22:

Figure 22:
PWM Signal Parameters (Default mode)

Symbol	Parameter	Typ	Unit	Note
f_{PWM}	PWM frequency	244	Hz	Signal period: 4097 µs
PW_{MIN}	MIN pulse width	1	µs	• Position 0d • Angle 0 deg
PW_{MAX}	MAX pulse width	4096	µs	• Position 4095d • Angle 359,91 deg

When PWMhalfEN = 1, the PWM timing is as shown in Figure 23:

Figure 23:
PWM Signal Parameters with Half Frequency (OTP option)

Symbol	Parameter	Typ	Unit	Note
f_{PWM}	PWM frequency	122	Hz	• Position 0d • Angle 0 deg
PW_{MIN}	MIN pulse width	2	µs	• Position 4095d • Angle 359,91 deg
PW_{MAX}	MAX pulse width	8192	µs	• Position 0d • Angle 0 deg

Analog Output

An analog output can be generated by averaging the PWM signal, using an external active or passive low pass filter. The analog output voltage is proportional to the angle:
0º= 0V; 360º = VDD5V.

Using this method, the AS5245 can be used as direct replacement of potentiometers.

Figure 24:
Simple 2nd Order Passive RC Low Pass Filter

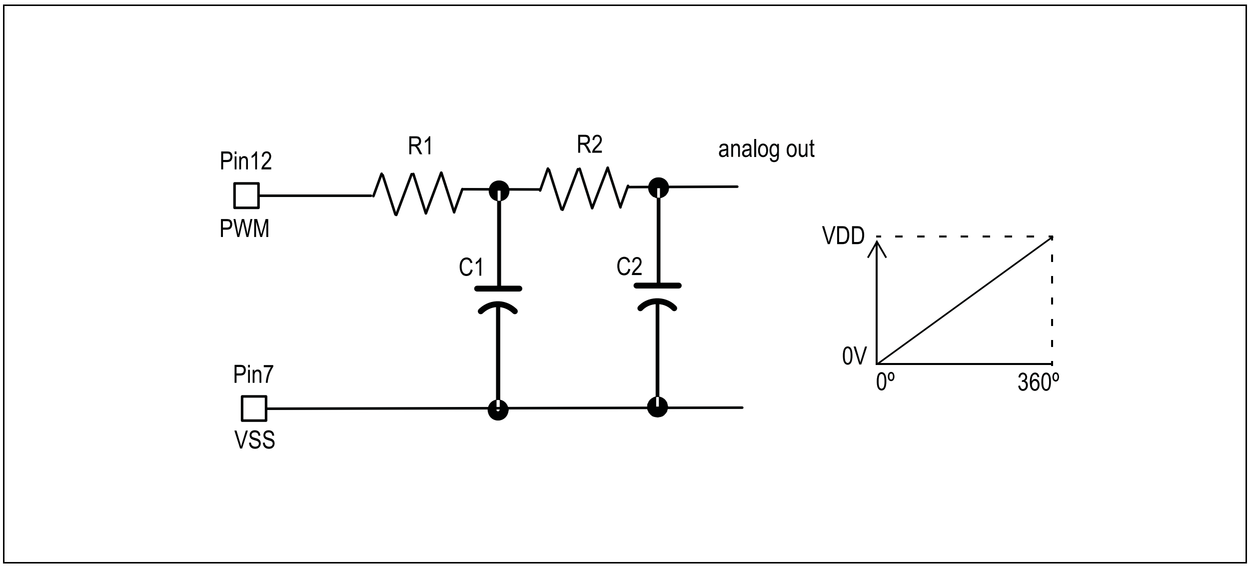


Figure 24 shows an example of a simple passive low pass filter to generate the analog output.

(EQ2) $$R1, R2 \geq 4.7k\Omega \quad C1, C2 \geq 1\mu F/6V$$

R1 should be greater than or equal to 4.7kΩ to avoid loading of the PWM output. Larger values of Rx and Cx will provide better filtering and less ripple, but will also slow down the response time.