MagAlpha MA820

8-Bit Contactless Angle Encoder with ABZ Output and Push Button Function

DESCRIPTION

The MA820 is an easy-to-use, magnetic, angle encoder designed to replace analogic potentiometers or rotary switches. The MA820 is designed for slow operation such as human-machine interface, manual controls, etc. where the rotating speed remains below 200 rpm. The sensor detects the absolute angular position of a permanent magnet attached to a rotating shaft and outputs incremental ABZ encoder data. The number of pulses per channel for each A or B output is programmable from 1 to 64 via an SPI interface.

Magnet shapes and configurations are very flexible. Typically, the MA820 is used with a diametrically magnetized cylinder of 2 - 8mm in diameter.

The MA820 features programmable magnetic field strength thresholds, which allow for the implementation of a push or pull button function. These are output as two logic signals.

On-chip non-volatile memory provides storage for configuration parameters, including the reference zero angle position, ABZ pulses per channel, and magnetic field detection threshold settings.

FEATURES

- 8-Bit Resolution Absolute Angle Encoder
- Contactless Sensing for Long Life with No Wear
- SPI Serial Interface for Chip Configuration
- Incremental ABZ Encoder Interface with 1 - 64 Programmable Pulses Per Channel
- Programmable Magnetic Field Strength Detection for Push/Pull Button Detection
- 3.3V, 12mA Supply
- -40 to +125°C Operating Temperature
- Available in a QFN-16 (3mmx3mm) Package

APPLICATIONS

- Rotary Knob Control Interfaces
- Manual Controls
- Encoders
- Automotive
- White Goods

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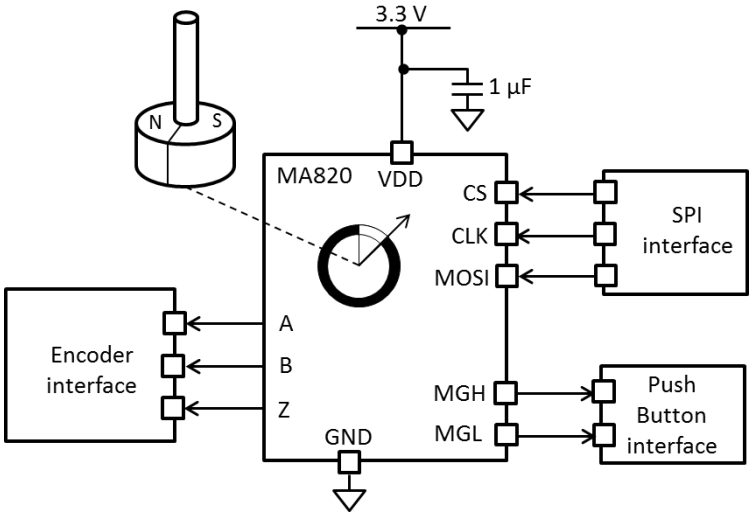
TYPICAL APPLICATION



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ORDERING INFORMATION

Part Number*	Package	Top Marking
MA820GQ	QFN-16 (3mmx3mm)	*See Below*

* For Tape & Reel, add suffix –Z (e.g. MA820GQ–Z)

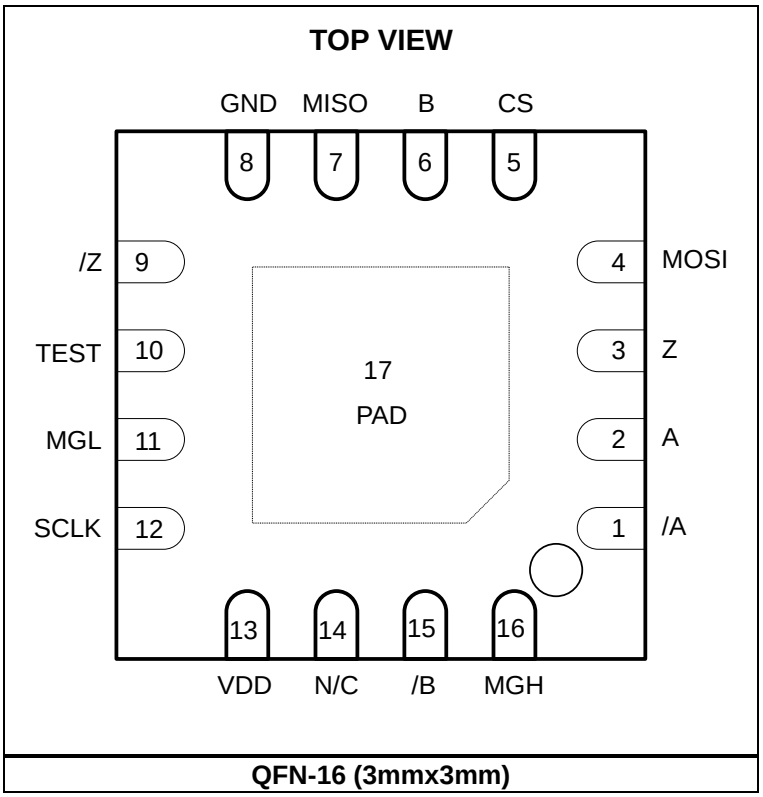
TOP MARKING

AXXY

LLL

AXX: product code of MA820GQ
Y: year code
LLL: lot number

PACKAGE REFERENCE



QFN-16 (3mmx3mm)

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ABSOLUTE MAXIMUM RATINGS (1)

Supply voltage ..... -0.5V to +4.6V
Input pin voltage (V_I) ..... -0.5V to +6.0V
Output pin voltage (V_O) ..... -0.5V to +4.6V
Continuous power dissipation (T_A = +25°C) (2) 2.0W
Junction temperature ..... 125°C
Lead temperature ..... 260°C
Storage temperature ..... -65°C to 150°C

Thermal Resistance (3)	θ_{JA}	θ_{JC}	
QFN-16 (3mmx3mm)	50	12 ...	°C/W

NOTES:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}.
3) Measured on JESD51-7, 4-layer PCB.

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ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Condition	Min	Typ	Max	Units
Recommended Operating Conditions						
Supply voltage	V_{DD}		3.0	3.3	3.6	V
Supply current	I_{DD}		10.2	11.7	13.8	mA
Operating temperature	Top		-40		125	°C
Applied magnetic field	B		30	60		mT

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GENERAL CHARACTERISTICS

VDD = 3.3V, 45mT < B < 100mT, Temp = -40°C to +125°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Response Time						
Power-up time (4)					20	ms
Latency (5)		Constant speed propagation delay		4		ms
Filter cutoff frequency (4)	Fcutoff			90		Hz
Accuracy						
INL at 25°C		At room temperature over the full field range		0.7		deg
INL between -40°C to +125°C (5)		Over the full temperature range and field range		1.1		deg
Output Drift						
Temperature induced drift at room temperature (5)				0.015	0.04	deg/°C
Temperature induced variation (5)		From 25°C to 85°C		0.5	1.2	deg
		From 25°C to 125°C		1.0	2.1	deg
Magnetic field induced (5)				0.005		deg/mT
Voltage supply induced (5)					0.3	deg/V
Incremental Output – ABZ						
ABZ update rate				16		MHz
Resolution - edges per turn		Programmable	4		256	
Pulses per channel per turn	PPT+1	Programmable	1		64	
ABZ hysteresis (5)	H				2.1	deg
Systematic jitter (5)		For PPT = 63, 0 - 100krpm			6.0	%
Random jitter (3σ)		For PPT = 63, 0 - 100krpm			0.6	%
Overall ABZ jitter					0.4	deg
Absolute Output – Serial						
Refresh rate			850	980	1100	kHz
Data output length			8		8	bit
Magnetic Field Detection Thresholds						
Accuracy (5)				5		mT
Hysteresis (5)	MagHys			6		mT
Temperature drift (5)				-600		ppm/°C
Digital I/O						
Input high voltage	V_{IH}		2.5		5.5	V
Input low voltage	V_{IL}		-0.3		0.8	V
Pull-up resistor	R_{PU}		46	66	97	kΩ
Pull-down resistor	R_{PD}		43	55	97	kΩ
Rising edge slew rate(4)	T_R	CL = 50pF		0.7		V/ns
Falling edge slew rate(4)	T_F	CL = 50pF		0.7		V/ns

NOTES:

4) Guaranteed by design.

5) Guaranteed by characteristic test.

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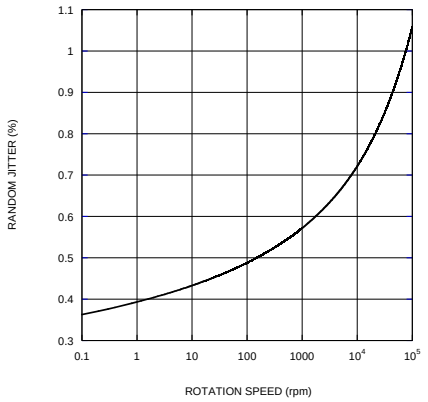
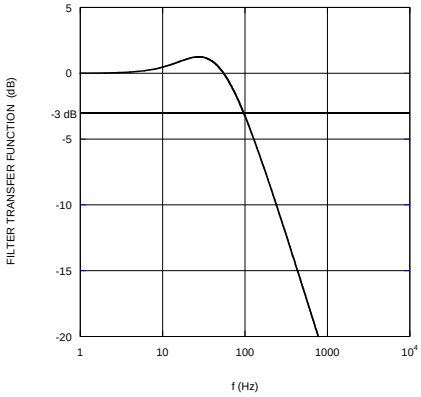
TYPICAL CHARACTERISTICS

VDD = 3.3V, Temp = 25°C, unless otherwise noted.

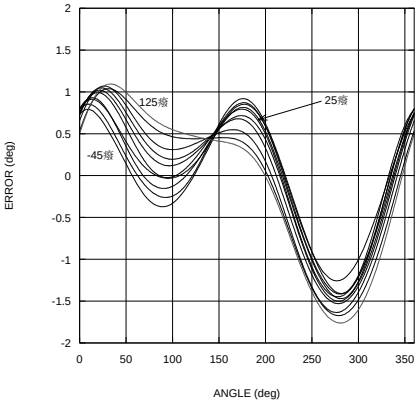
ABZ Jitter at PPT = 63



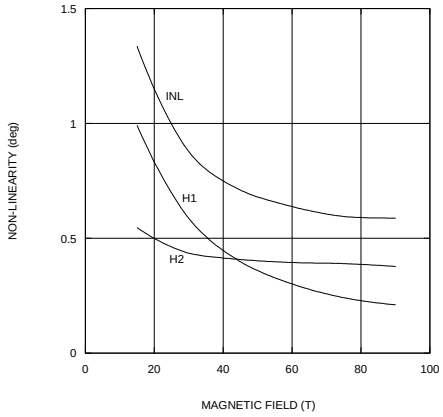
Filter Transfer Function



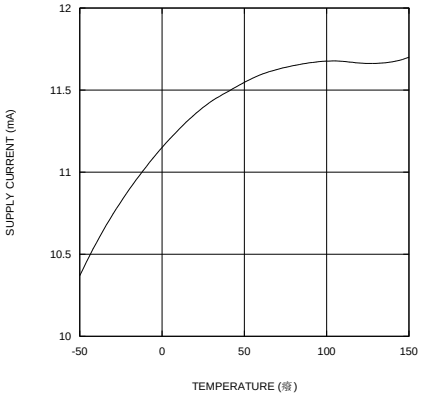
Error Curves at 50mT



Non-Linearity (INL and Harmonics)



Current Consumption at VDD = 3.3V



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PIN FUNCTIONS

Package Pin #	Name	Description
1	/A	**Channel A inverted.** A is the output of the incremental interface.
2	A	**Channel A.** A is the output of the incremental interface.
3	Z	**Index pulse Z.** Z is the output of the incremental interface.
4	MOSI	**Data in (SPI).** MOSI has an internal pull-down resistor.
5	CS	**Chip select (SPI).** CS has an internal pull-up resistor.
6	B	**Channel B.** B is the output of the incremental interface.
7	MISO	**Data out (SPI).** MISO has an internal pull-down resistor that is enabled at a high impedance state.
8	GND	**Supply ground.**
9	/Z	**Index pulse Z inverted.** Z is the output of the incremental interface.
10	TEST	**Connect to ground.**
11	MGL	**Digital output indicating field strength below MGLT level.**
12	SCLK	**Clock (SPI).** SCLK has an internal pull-down resistor.
13	VDD	**Supply 3.3V.**
14	N/C	**No connection.** Leave N/C unconnected.
15	/B	**Channel B inverted.** B is the output of the incremental interface.
16	MGH	**Digital output indicating field strength above MGHT level.**

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BLOCK DIAGRAM

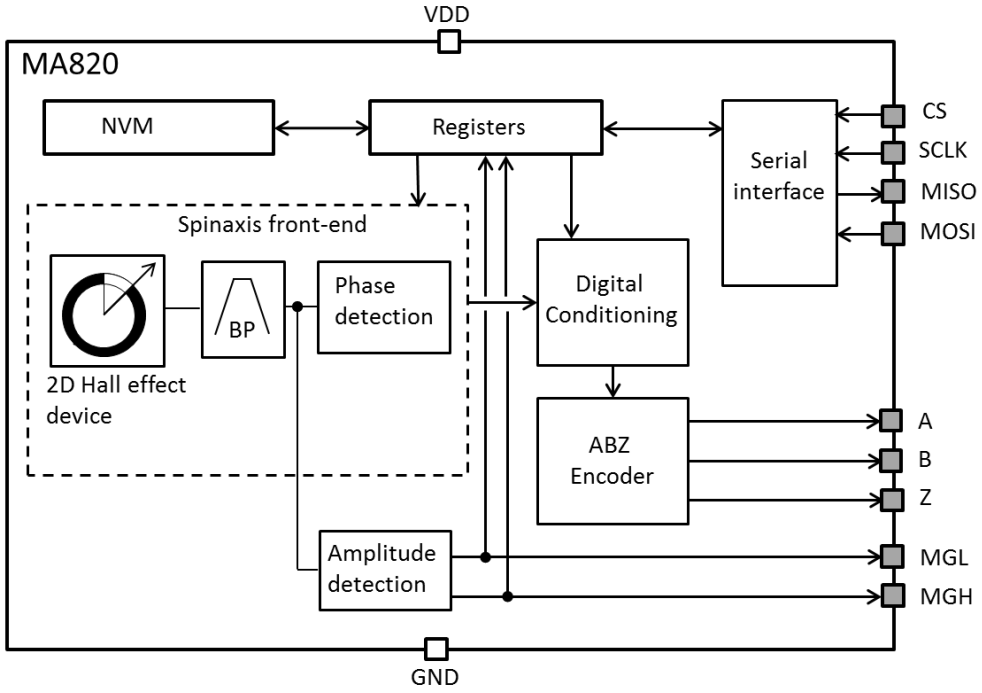

Figure 1: Functional Block Diagram

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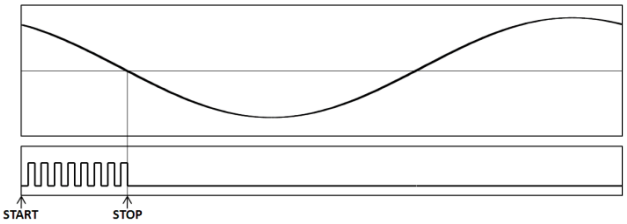
OPERATION

Sensor Front-End

The magnetic field is detected with integrated Hall devices located in the center of the package. The angle is measured using the *Spin*axis™ method, which digitizes the direction of the field directly without complex arctangent computation or feedback loop-based circuits (interpolators).

The *Spin*axis™ method is based on phase detection and generates a sinusoidal signal with a phase that represents the angle of the magnetic field. The angle is then obtained by a time-to-digital converter, which measures the time between the zero crossing of the sinusoidal signal and the edge of a constant waveform (see Figure 2). The time-to-digital is output from the front-end to the digital conditioning block.



Top: Sine Waveform
Bottom: Clock of Time-to-Digital Converter
Figure 2: Phase Detection Method

The output of the front-end delivers a digital number proportional to the angle of the magnetic field at the rate of 1MHz in a straightforward and open-loop manner.

Digital Filtering

The front-end signal is further treated to achieve the final effective resolution. This treatment does not add any latency in steady conditions. The filter transfer function can be calculated with Equation (1):

$$H(s) = \frac{1+2\tau s}{(1+\tau s)^2} \quad (1)$$

Where τ is the filter time constant related to the cutoff frequency by: τ = 0.38/*Fcutoff*. See the General Characteristics table on page 5 for the value of *Fcutoff*.

Sensor – Magnet Mounting

The sensitive volume of the MA820 is confined in a region less than 100µm wide and has multiple integrated Hall devices. This volume is located both horizontally and vertically within 50µm of the center of the QFN package. The sensor detects the angle of the magnetic field projected in a plane parallel to the package's upper surface. This means that the only relevant magnetic field is the in-plane component (X and Y components) in the middle point of the package.

By default, when looking at the top of the package, the angle increases when the magnetic field rotates clockwise. Figure 3 shows the zero angle of the unprogrammed sensor, where the cross indicates the sensitive point. Both the rotation direction and the zero angle can be programmed.

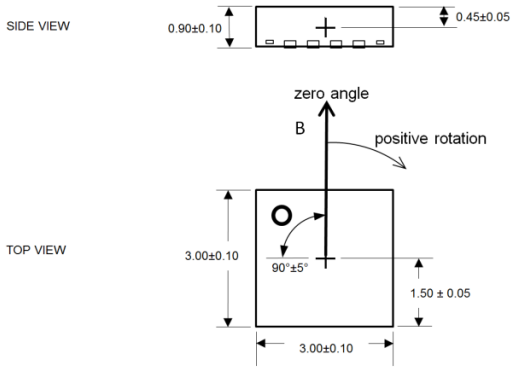


Figure 3: Detection Point and Default Positive Direction

This type of detection provides flexibility for the design of an angular encoder. The sensor only requires the magnetic vector to lie essentially within the sensor plane with a field amplitude of at least 30mT. Note that the MA820 can work with fields smaller than 30mT, but the linearity and resolution performance may deviate from the specifications. The most straightforward mounting method is to place the MA820 sensor on the rotation axis of a permanent magnet (i.e.: a diametrically magnetized cylinder) (see Figure 4). The recommended magnet is a Neodymium alloy (N35) cylinder with dimensions Ø5x3mm inserted into an aluminum shaft with a 1.5mm air gap between the magnet and the sensor (surface of package). For good linearity, the sensor is positioned with a precision of 0.5mm.

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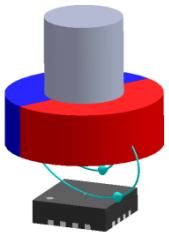

Figure 4: End-of-Shaft Mounting

Figure 5 shows an example of sensor and magnet mounting in a contactless switch assembly. A Neodymium alloy magnet is inserted into an aluminum shaft. The air gap between the magnet and the sensor is 1.0mm. The sensor is positioned on the rotation axis with a precision of 0.5mm.

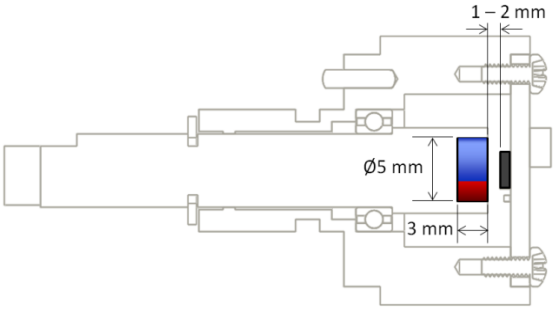

Figure 5: Example of Potentiometer-Like Assembly

Electrical Mounting and Power Supply Decoupling

It is recommended to place a 1µF decoupling capacitor close to the sensor with a low impedance path to GND (see Figure 6).

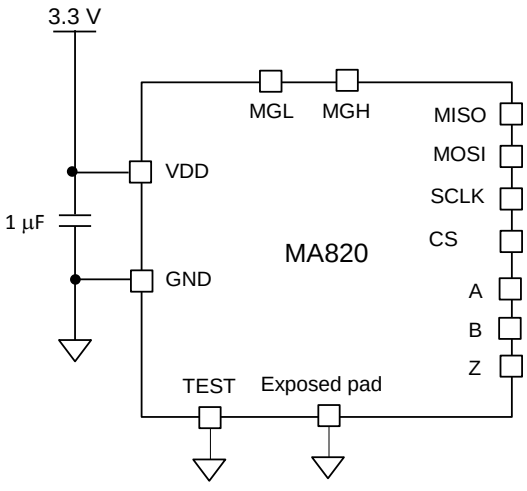

Figure 5: Connection for Supply Decoupling

In general, the MagAlpha works well with or without the exposed pad connected to anything. For optimum conditions (electrically, thermally, and mechanically), it is recommended that the exposed pad be connected to ground.

Serial Interface

The sensor supports the SPI serial interface for register programming. SPI is a four-wire, synchronous, serial communication interface. The MagAlpha supports SPI Mode 3 and Mode 0 (see Table 1 and Table 2). The SPI Mode (0 or 3) is detected automatically by the sensor and therefore does not require any action from the user. The maximum clock rate supported on SPI is 25MHz. There is no minimum clock rate. Note that real-life data rates depend on the PCB layout quality and signal trace length. See Figure 7 and Table 3 for SPI timing.

All commands to the MagAlpha (whether for writing or reading a register content) must be transferred through the SPI MOSI pin and must be 16 bits long. See the SPI Communication section on page 12 for details.

Table 1: SPI Specification

	Mode 0	Mode 3
SCLK idle state	Low	High
Data capture	On SCLK rising edge	
Data transmission	On SCLK falling edge	
CS idle state	High	
Data order	MSB first	

Table 2: SPI Standard

	Mode 0	Mode 3
CPOL	0	1
CPHA	0	1
Data order (DORD)	0 (MSB first)	

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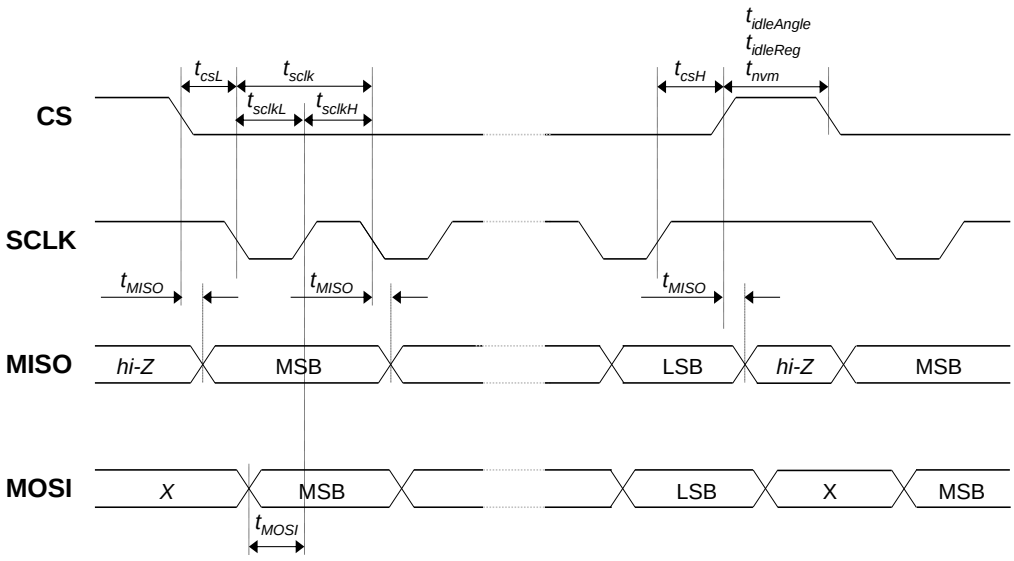

Figure 6: SPI Timing Diagram

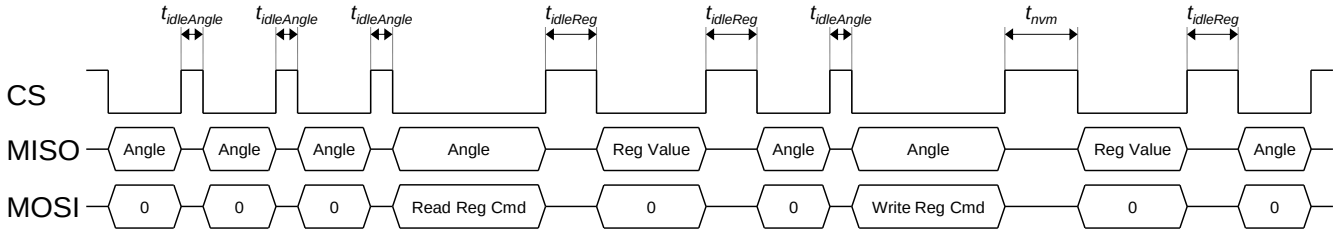

Figure 7: Minimum Idle Time

Table 3: SPI Timing

Parameter [6]	Description	Min	Max	Unit
$t_{idleAngle}$	Idle time between two subsequent angle transmissions	150		ns
$t_{idleReg}$	Idle time before and after a register readout	750		ns
t_{nvm}	Idle time between a write command and a register readout (delay necessary for non-volatile memory update)	20		ms
t_{csL}	Time between CS falling edge and SCLK falling edge	80		ns
t_{sclk}	SCLK period	40		ns
t_{sclkL}	Low level of SCLK signal	20		ns
t_{sclkH}	High level of SCLK signal	20		ns
t_{csH}	Time between SCLK rising edge and CS rising edge	25		ns
t_{MISO}	SCLK setting edge to data output valid		15	ns
t_{MOSI}	Data input valid to SCLK reading edge	15		ns

NOTE:
6) All values are guaranteed by design.

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SPI Communication

The sensor supports three types of SPI operation:

- Read angle
- Read configuration register
- Write configuration register

Each operation has a specific frame structure described below.

SPI Read Angle

See Figure 8 for the diagram of a full SPI angle reading. See Figure 10 for a partial SPI angle reading. A full angle reading requires 16 clock pulses. The sensor MISO line returns:

	MSB															*LSB*
MISO	***Angle(15:0)***															
MOSI	***0***															

The MagAlpha family has sensors with different features and levels of resolution. See the data output length section in the General Characteristics table on page 5 for the number of useful bits delivered at the serial output. If the data length is smaller than 16, the rest of the bits sent are zeros.

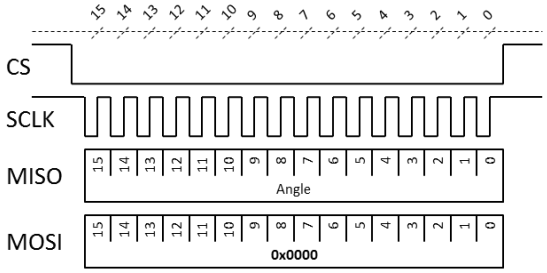

Figure 8: Full 16-Bit SPI Angle Reading

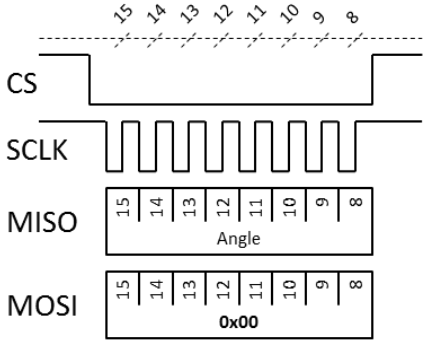

Figure 9: Partial 8-Bit SPI Angle Reading

SPI Read Register

A read register operation is constituted of two 16-bit frames. The first frame sends a read request, which contains the 3-bit read command (010) followed by the 5-bit register address. The second frame returns the 8-bit register value (MSB byte). The last eight bits of the frame must all be set to zero.

The first 16-bit SPI frame (read request) is:

	MSB															*LSB*
MISO	***Angle(15:0)***															

	command			*reg. address*												
MOSI	***0***	***1***	***0***	***A_4***	***A_3***	***A_2***	***A_1***	***A_0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

The second 16-bit SPI frame (response) is:

	reg. value															
MISO	***V_7***	***V_6***	***V_5***	***V_4***	***V_3***	***V_2***	***V_1***	***V_0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

	MSB															*LSB*
MOSI	***0***															

See Figure for a complete transmission overview.

For example, to get the value of the magnetic level high and low flags (MGH and MGL), read register 27 (bit 6, bit 7) by sending the following first frame:

	MSB															*LSB*
MISO	***Angle(15:0)***															

	command			*reg. address*												
MOSI	***0***	***1***	***0***	***1***	***1***	***0***	***1***	***1***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

In the second frame, the MagAlpha replies:

	reg. value															
MISO	***MGH***	***MGL***	***X***	***X***	***X***	***X***	***X***	***X***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

	MSB															*LSB*
MOSI	***0***															

See Figure for a complete example.

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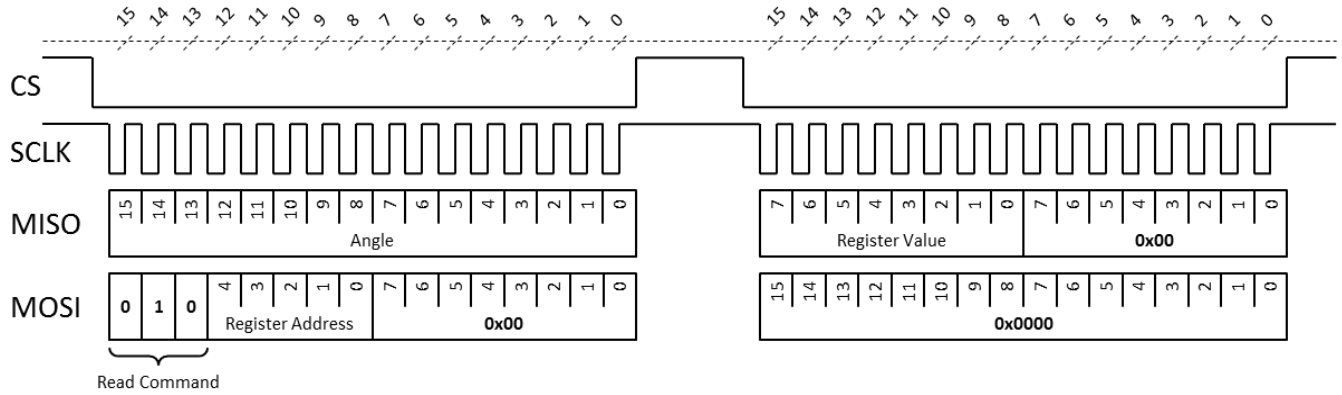

Figure 11: Two 16-Bit Frames Read Register Operation

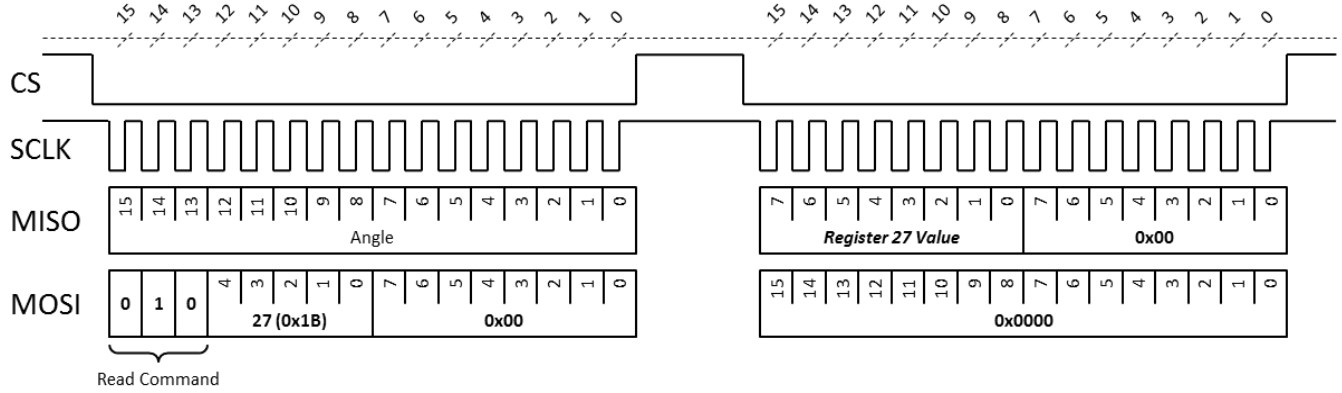

Figure 12: Example Read Magnetic Level Flags High and Low (MGH, MGH) on Register 27, Bit 7-6

SPI Write Register

Table 4 shows the programmable 8-bit registers. Data written to these registers are stored in the on-chip non-volatile memory and reloaded during power-on automatically. The factory default register values are shown in Table 5.

A write register operation is constituted of two 16-bit frames. The first frame sends a write request, which contains the 3-bit write command (100) followed by the 5-bit register address and the 8-bit value (MSB first). The second frame returns the newly written register value (acknowledge).

The on-chip memory is guaranteed to endure 1,000 write cycles at 25°C.

It is critical to wait 20ms between the first and second frame. This is the time taken to write the non-volatile memory. Failure to implement this wait period results in the register's previous value being read. Note that this delay is only required after a write request. A read register request and read angle do not require this wait time.

First 16-bit SPI frame (write request):

	MSB															*LSB*
MISO	***Angle(15:0)***															

	command			*reg. address*					*reg. value*							
MOSI	*1*	*0*	*0*	A_4	A_3	A_2	A_1	A_0	V_7	V_6	V_5	V_4	V_3	V_2	V_1	V_0

Second 16-bit SPI frame (response):

	reg. value															
MISO	V_7	V_6	V_5	V_4	V_3	V_2	V_1	V_0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

	MSB															*LSB*
MOSI	***0***															

The read-back register content can be used to verify the register programming. Figure 13 complete transmission overview.

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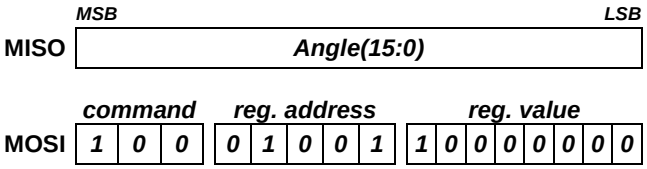
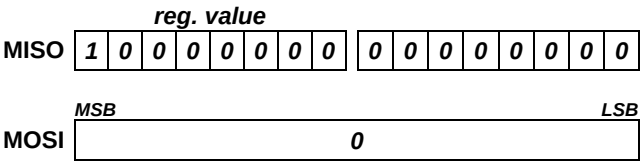
For example, to set the value of the output rotation direction (RD) to counterclockwise (high), write register 9 by sending the following first frame:



Send the second frame after a 20ms wait time. If the register is written correctly, the reply is:



See Figure 14 for a complete example.

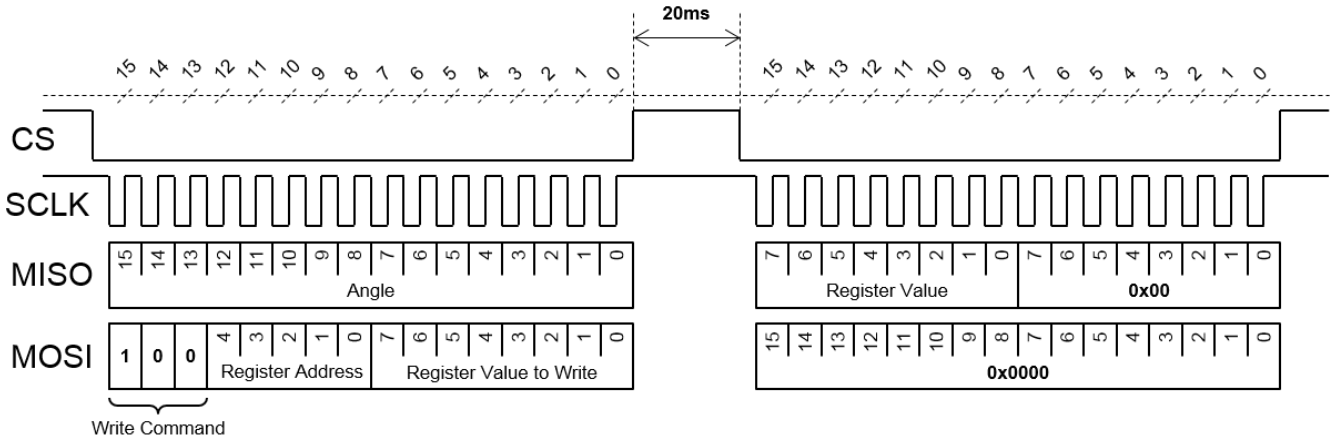


Figure 13: Overview of Two 16-Bit Frames Write Register Operation

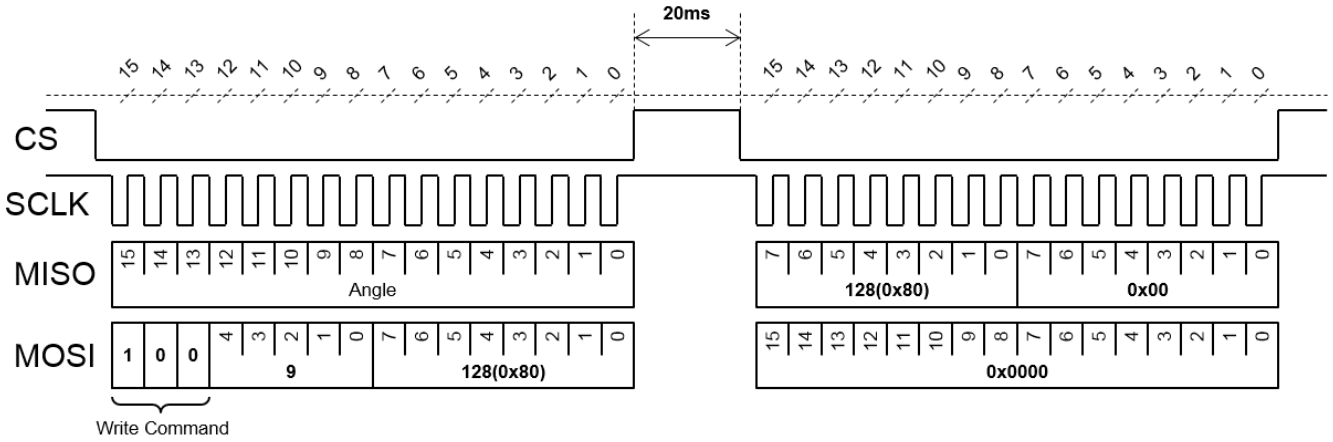


Figure 14: Example Write Output Rotation Direction (RD) to Counterclockwise (High), on Register 9, Bit 7

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REGISTER MAP

Table 4: Register Map

No	Hex	Bin	Bit 7 MSB	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 LSB
0	0x0	00000	Z(7:0)							
1	0x1	00001	Z(15:8)							
4 (7)	0x4	00100	PPT(1:0)		0	0	0	0	0	0
5	0x5	00101	-	-	-	-	PPT(5:2)			
6	0x6	00110	MGLT(2:0)			MGHT(2:0)			-	-
9	0x9	01001	RD	-	-	-	-	-	-	-
27	0x1B	11011	MGH	MGL	-	-	-	-	-	-

NOTE:
7) Bits (5:0) must be set to 000000.

Table 5: Factory Default Values

No	Hex	Bin	Bit 7 MSB	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 LSB
0	0x0	00000	0	0	0	0	0	0	0	0
1	0x1	00001	0	0	0	0	0	0	0	0
4	0x4	00100	1	1	0	0	0	0	0	0
5	0x5	00101	0	0	0	0	1	1	1	1
6	0x6	00110	0	0	0	1	1	1	0	0
9	0x9	01001	0	0	0	0	0	0	0	0

Table 6: Programming Parameters

Parameters	Symbol	Number of Bits	Description	See Table
Zero setting	Z	16	Set the zero position	7
ABZ pulses per 360 deg turn	PPT	6	Sets the pulses per turn on each channel	10
Magnetic field high threshold	MGHT	3	Sets the field strength high threshold.	13
Magnetic field low threshold	MGLT	3	Sets the field strength low threshold.	13
Rotation direction	RD	1	Determines the sensor positive direction	9

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REGISTER SETTINGS

Zero Setting

The zero position of the MagAlpha (a_0) can be programmed with 16 bits of resolution. The angle streamed out by the MagAlpha (a_{out}) is given by Equation (2):

$$a_{out} = a_{raw} - a_0 \quad (2)$$

Where a_{raw} is the raw angle provided by the MagAlpha front-end.

The parameter Z(15:0), which is zero by default, is the complementary angle of the zero setting. In decimals, it can be written as shown in Equation (3):

$$a_0 = 2^{16} - Z(15:0) \quad (3)$$

Table 7 shows the zero setting parameter.

Table 7: Zero Setting Parameter

Z(15:0)	Zero pos. a_0 (16 bit dec)	Zero pos. a_0 (deg)
0	65536	360.000
1	65535	359.995
2	65534	359.989
…	…	…
65534	2	0.011
65535	1	0.005

Example

To set the zero position to 20 deg, the Z(15:0) parameter must be equal to the complementary angle shown in Equation (4):

$$Z(15:0) = 2^{16} - \frac{20\,\text{deg}}{360\,\text{deg}} 2^{16} = 61895 \quad (4)$$

In binary, it is written as 1111 0001 1100 0111.

Table 8 shows the content of registers 0 and 1.

Table 8: Register Content

Reg	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	1	1	0	0	0	1	1	1
1	1	1	1	1	0	0	0	1

Rotation Direction

By default, when looking at the top of the package, the angle increases when the magnetic field rotates clockwise (CW) (see Figure 15 and Table 9).

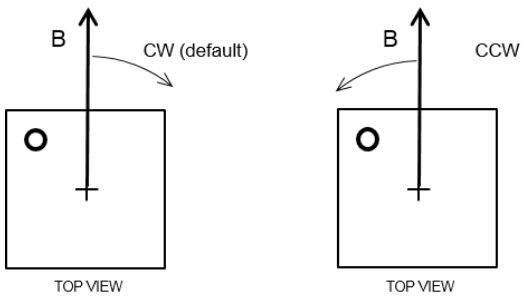

Figure 15: Positive Rotation Direction of the Magnetic Field

Table 9: Rotation Direction Parameter

RD	Positive Direction
0	Clockwise (CW)
1	Counterclockwise (CCW)

ABZ Incremental Encoder Output

The MA820 ABZ output emulates an 8-bit incremental encoder (such as an optical encoder) providing logic pulses in quadrature (see Figure 16). Compared to signal A, signal B is shifted by a quarter of the pulse period. Over one revolution, signal A pulses *N* times, where *N* is programmable from 1 to 64 pulses per revolution. The number of pulses per channel per revolution is programmed by setting the parameter PPT, which consists of six bits split between registers 0x4 and 0x5 (see Table 4). The factory default value is 64. Table 10 describes how to program PPT(5:0) to set the required resolution.

Table 10: PPT

PPT(5:0)	Pulses per Revolution	Edges per Revolution	
000000	1	4	MIN
000001	2	8	
000010	3	12	
000011	4	16	
…	…	…	…
111100	61	244	
111101	62	248	
111110	63	252	
111111	64	256	MAX

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For example, to set 30 pulses per revolution (120 edges), set PPT(5:0) to 30 - 1 = 29. In binary, this is written as 011101. The registers 0x4 and 0x5 must be set as shown in Table 11.

Table 11: Register Setting for 30 Pulses Per Turn

Reg	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
4	0	1	0	0	0	0	0	0
5	0	0	0	0	0	1	1	1

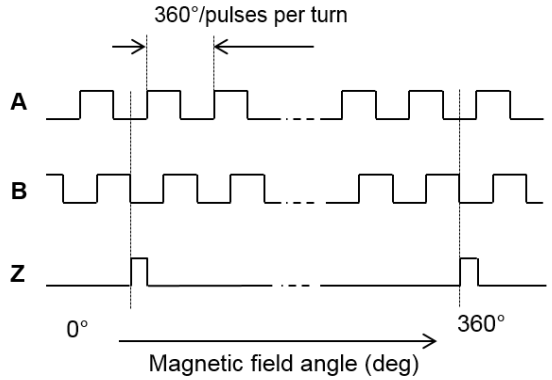

Figure 16: Timing of the ABZ Output

Signal Z (zero or index) raises only once per turn at the zero-angle position. The position and length of the Z pulse is programmable via bits ILIP(3:0) in register 0x5 (see Figure 17).

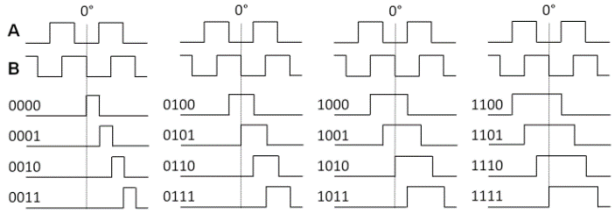

Figure 17: ILIP Parameter Effect on Index Shape

By default, the ILIP parameter is 0000. The index rising edge is aligned with the channel B falling edge. The index length is half the A or B pulse length.

ABZ Hysteresis

A hysteresis larger than the output noise is introduced on the ABZ output to avoid any spurious transitions (see Figure 18).

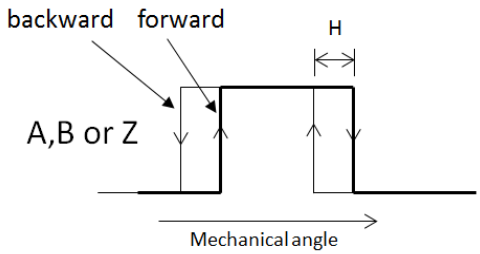

Figure 18: Hysteresis of the Incremental Output ABZ Jitter

The ABZ state is updated at a frequency of 16MHz.

The jitter characterizes how far a particular ABZ edge can occur at an angular position different from the ideal position (see Figure 19).

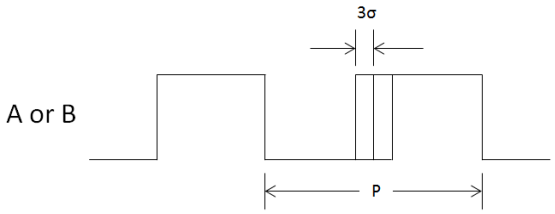

Figure 19: ABZ Jitter

The measurable jitter is composed by a systematic jitter (i.e.: always the same deviation at a given angle) and a random jitter.

The random jitter reflects the sensor noise. Therefore, the edge distribution is the same as the SPI output noise. Like the sensor resolution, it is defined as the 3σ width of this distribution.

In fact, the random jitter is a function of the rotation speed. At a lower speed, the random jitter is smaller than the sensor noise.

This is a consequence of the fact that the probability of measuring an edge at a certain distance from the ideal position depends on the number of ABZ updates at this position.

The minimum field for ABZ reading is 30mT.

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Magnetic Field Thresholds

Push Button Detection

The MA820 has two threshold options (MGHT or MGLT), which are complementary in operation. The flag MGH becomes true (logic 1) if the magnetic field increases above MGHT. The flag MGL becomes true (logic 1) if the magnetic field falls below MGLT (see Figure 20).

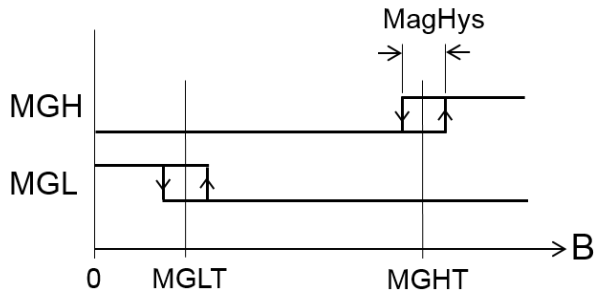

Figure 20: MGH and MGL Signals as a Function of the Field Strength

The MGL/MGH flags can be used for detecting an approaching magnet (e.g.: when a button is pressed). With the 5mmx3mm magnet example, if the MGHT threshold is set to binary 110 (106 - 112mT), the MGH signal is set to logic high when the sensor-magnet airgap is smaller than 1.0mm (see Figure 21).

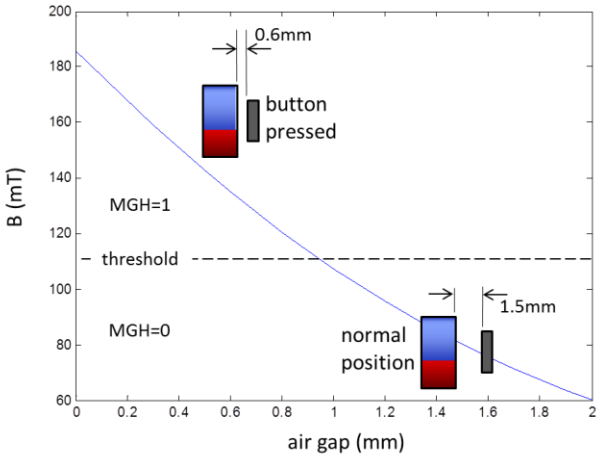

Figure 21: Magnetic Field Produced by a 5mmx3mm N35 Magnet as a Function of the Airgap with Threshold Set to 110mT

In this way, it is possible to implement both a push or pull action.

MagHys, the hysteresis on the signals MGH and MGL, is indicated in the General Characteristics table on page 5. The MGLT and MGHT thresholds are coded on three bits and stored in register 6 (see Table 12).

Table 12: Register 6

Reg	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
6	MGLT			MGHT			-	-

The 3-bit values of MGLT and MGHT correspond to the magnetic field (see Table 13).

Table 13: MGLT and MGHT Binary to mT Relation

MGLT or MGHT (9)	Field threshold in mT (8)	
	From low to high magnetic field	From high to low magnetic field
000	26	20
001	41	35
010	56	50
011	70	64
100	84	78
101	98	92
110	112	106
111	126	120

NOTES:

8) Valid for VDD = 3.3V. If different, then the field threshold is scaled by the factor VDD/3.3V.

9) MGLT can have a larger value than MGHT.

The alarm flags MGL and MGH can be read in register 27 (bit 6 and bit 7), and their logic state is also given at the digital output pins 11 and 16.

To read the MGL and MGH flags by SPI, send the 8-bit command write to register 27:

command			*reg. address*				*MSB*			*value*				*LSB*
0	***1***	***0***	***1***	***1***	***0***	***1***	***1***	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

The MA820 answers with the register 27 content in the next transmission:

Reg	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
27	MGH	MGL	x	x	x	x	x	x

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TYPICAL APPLICATION CIRCUIT

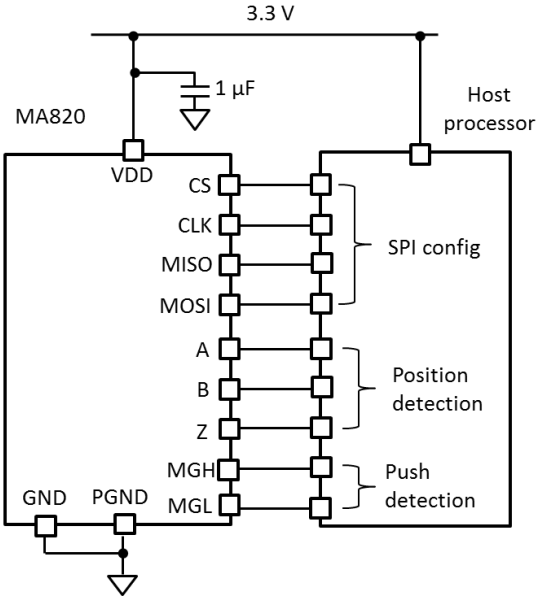

Figure 22: Typical Connecton to a Host Microprocessor

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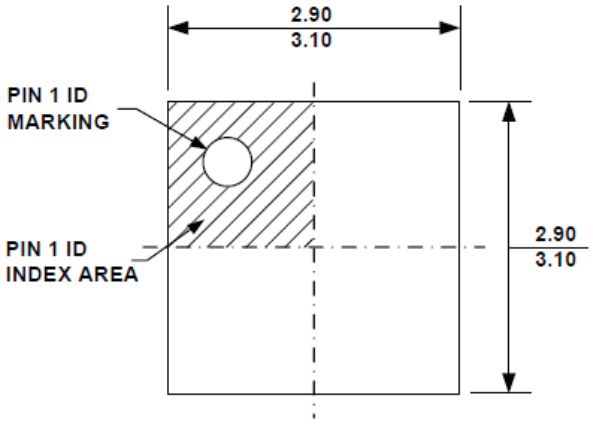
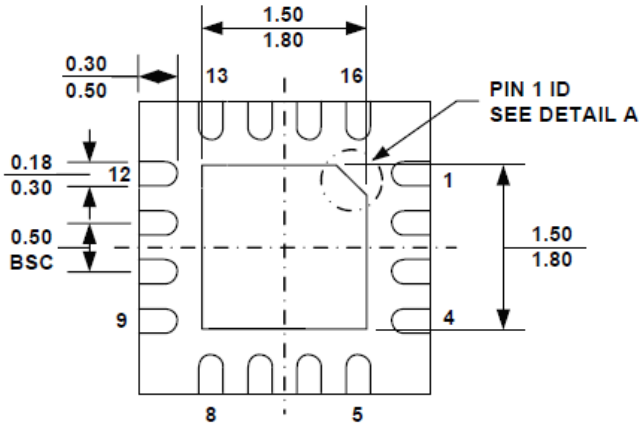
PACKAGE INFORMATION

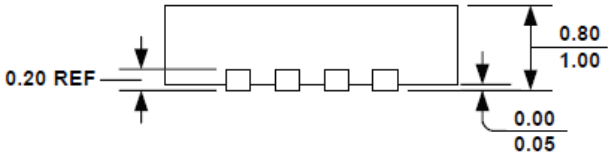
QFN-16 (3mmx3mm)



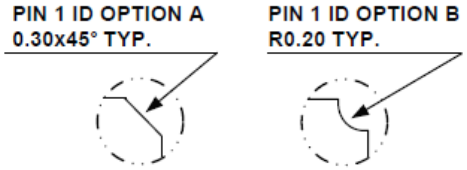
TOP VIEW



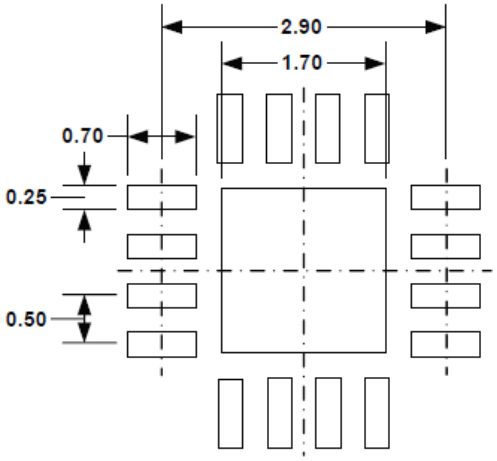
BOTTOM VIEW



SIDE VIEW



DETAIL A



RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
4) DRAWING CONFORMS TO JEDEC MO-220, VARIATION VEED-4.
5) DRAWING IS NOT TO SCALE.

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APPENDIX A: DEFINITIONS

Resolution (3σ noise level) This is the smallest angle increment distinguishable from the noise. The resolution is measured by computing three times σ (the standard deviation in degrees) taken over 1,000 data points at a constant position. The resolution in bits is obtained with $\log_2(360/6\sigma)$.

Refresh Rate Rate at which new data points are stored in the output buffer.

ABZ Update Rate Rate at which a new ABZ sate is computed. The inverse of this rate is the minimum time between two ABZ edges.

Latency The time elapsed between the instant when the data is ready to be read and the instant at which the shaft passes that position. The lag in degrees is $lag = lantency \cdot v$, where v is the angular velocity in deg/s.

Power-Up Time Time until the sensor delivers valid data starting at power up.

Integral Non-Linearity (INL) Maximum deviation between the average sensor output (at a fixed position) and the true mechanical angle.

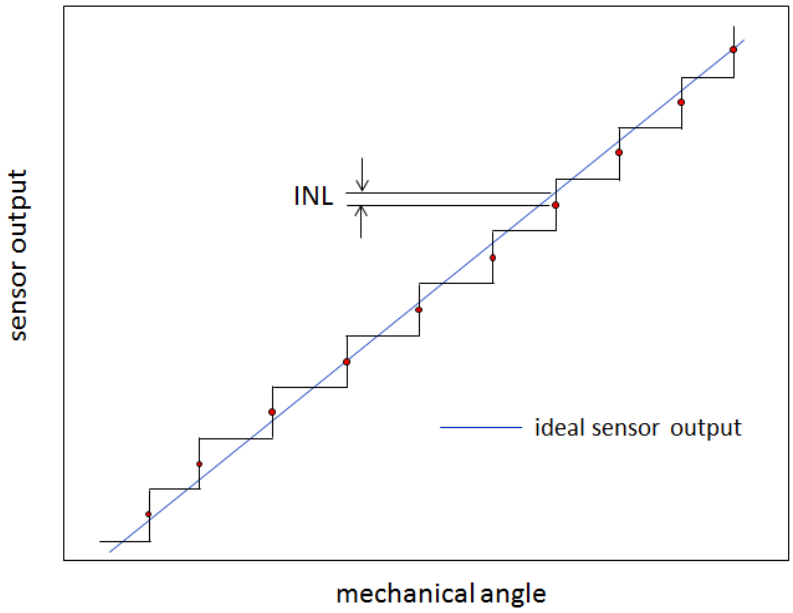

Figure A1: Integral Non-linearity

Drift Angle variation rate when one parameter is changed (e.g.: temperature, VDD) and all the others, including the shaft angle, are maintained constant.

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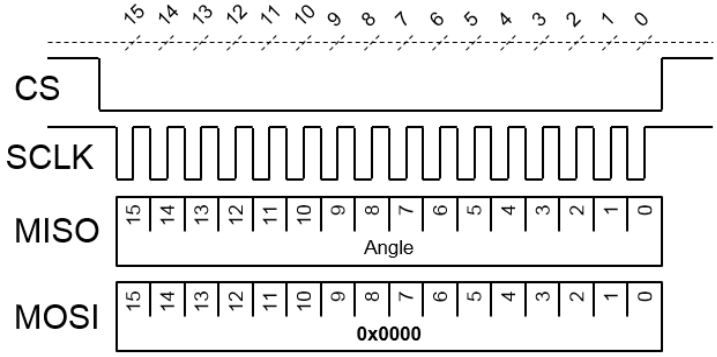
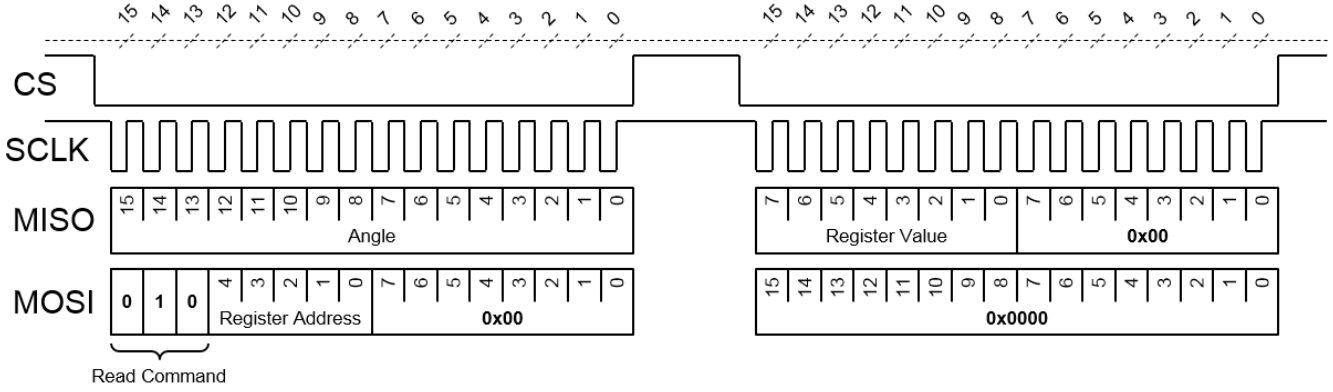
APPENDIX B: SPI COMMUNICATION CHEATSHEET

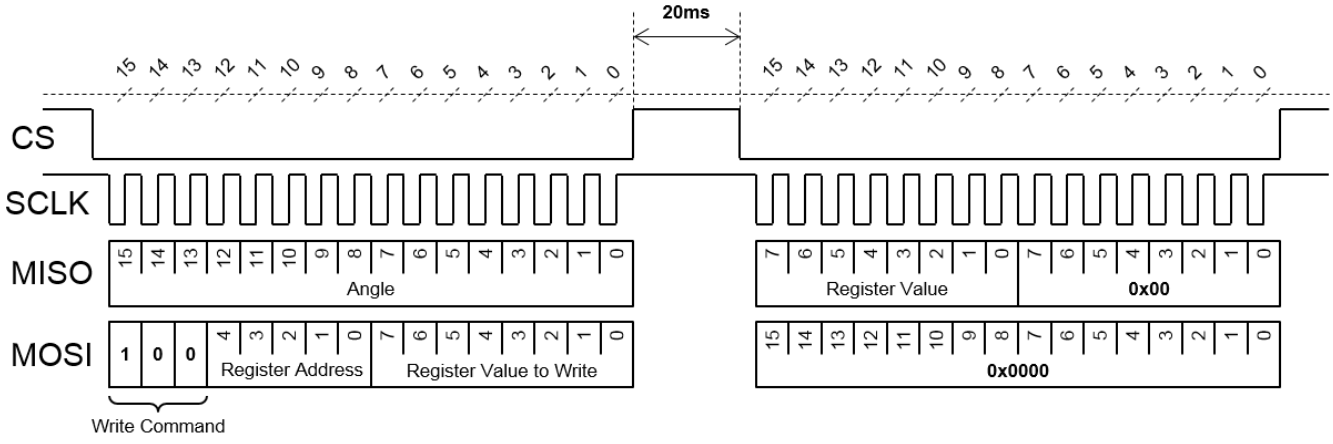
Read Angle



Read Register



Write Register



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