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MagAlpha MA800

8-Bit Contactless Angle Encoder with Push Button Function

The Future of Analog IC Technology®

DESCRIPTION

The MA800 is an easy-to-use, magnetic, angle encoder with a digital output designed to replace analogic potentiometers or rotary switches. The sensor detects the absolute angular position of a permanent magnet attached to a rotating shaft.

The magnet shapes and configurations are very flexible. Typically, the MA800 is used with a diametrically magnetized cylinder of 2 to 8mm in diameter.

The MA800 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 and magnetic field detection threshold settings.

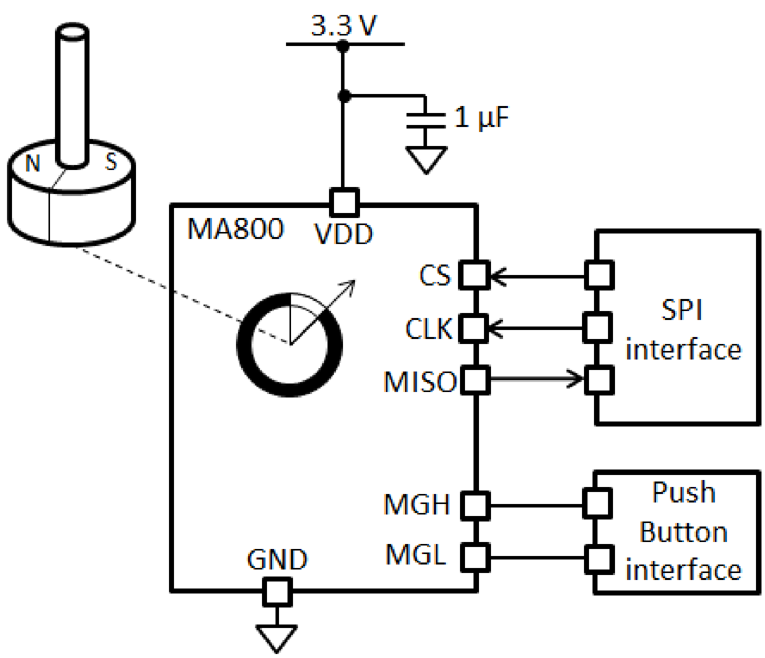
FEATURES

- 8-Bit Resolution Absolute Angle Encoder
- Contactless Sensing for Long Life with No Wear
- SPI and SSI Serial Interface
- 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
- Encoders
- Automotive
- White Goods

TYPICAL APPLICATION

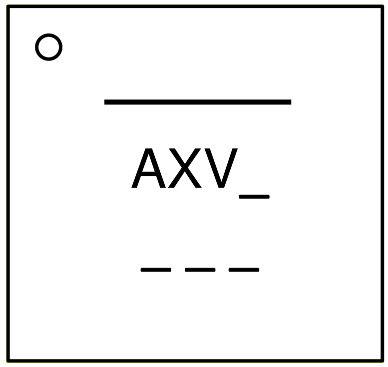


ORDERING INFORMATION

Part Number*	Package	Top Marking
MA800GQ	QFN-16 (3mmx3mm)	*See Below*

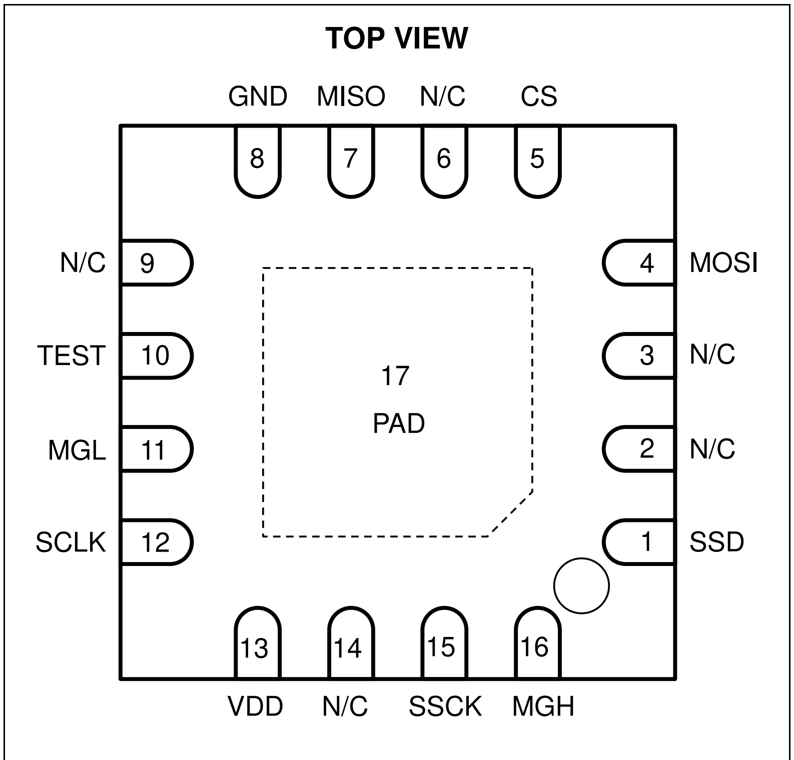
* For Tape & Reel, add suffix –Z (e.g. MA800GQ–Z)

TOP MARKING



Underscore sign (_): Internal identifiers

PACKAGE REFERENCE



QFN-16 (3mmx3mm)

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

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.

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

GENERAL CHARACTERISTICS

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

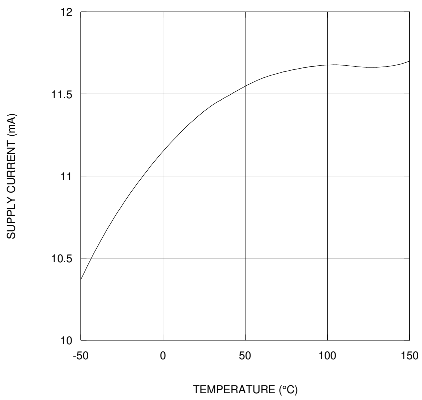
Parameter	Symbol	Condition	Min	Typ	Max	Units
Resolution						
Effective resolution		3σ deviation of the noise distribution	8			bit
Noise rms			0.005	0.01	0.02	deg
Refresh rate			850	980	1100	kHz
Data output length			8		8	bit
Response Time						
Power-up time (4)					20	ms
Latency (5)		Constant speed propagation delay		2		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
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}		2.0		5.5	V
Input low voltage	V_{IL}		-0.3		0.8	V
Low-level output current	I_{OL}	V_{OL} = 0.4V	4.9	7.8		mA
High-level output current	I_{OH}	V_{OH} = 2.4V	5.8	11.7		mA
Input leakage current	I_L				10	µA
Pull-down resistor	R_{PD}		43	55	97	kΩ
Rising edge slew rate	T_R	CL = 50pF		0.7		V/ns
Falling edge slew rate	T_F	CL = 50pF		0.7		V/ns

NOTES:
4) Guaranteed by design.
5) Guaranteed by characteristic test.

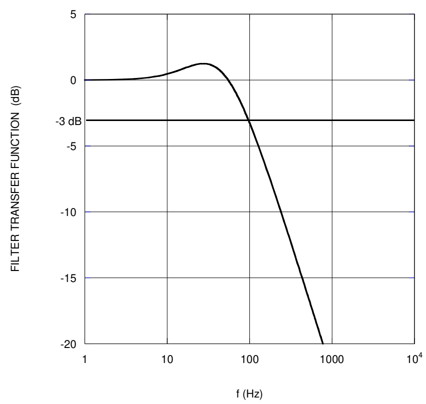
TYPICAL CHARACTERISTICS

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

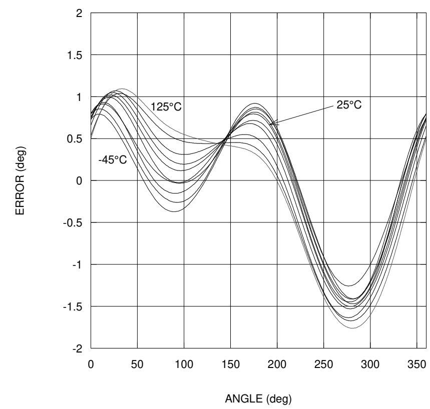
Current Consumption at VDD = 3.3V



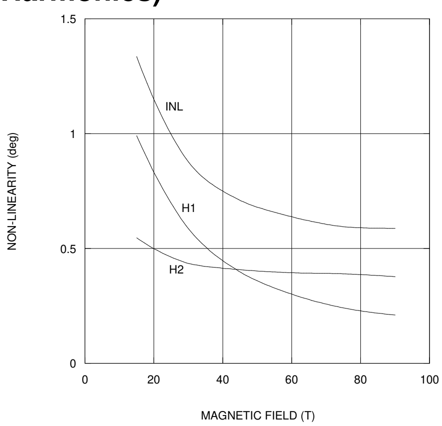
Filter Transfer Function



Error Curves at 50mT



Non-Linearity (INL and Harmonics)



PIN FUNCTIONS

Package Pin #	Name	Description
1	SSD	**Data out (SSI).**
2, 3, 6, 9, 14	NC	**No connection.** Leave NC unconnected.
4	MOSI	**Data in (SPI).** Internal pull-down.
5	CS	**Chip select (SPI).** Internal pull-up.
7	MISO	**Data out (SPI).** Internal pull-down at Hi-Z.
8	GND	**Supply ground.**
10	TEST	**Connect to ground.**
11	MGL	**Digital output indicating field strength below MGLT level.**
12	SCLK	**Clock (SPI).** Internal pull-down.
13	VDD	**Supply 3.3V.**
15	SSCK	**Clock (SSI).** Internal pull-down.
16	MGH	**Digital output indicating field strength above MGHT level.**

BLOCK DIAGRAM

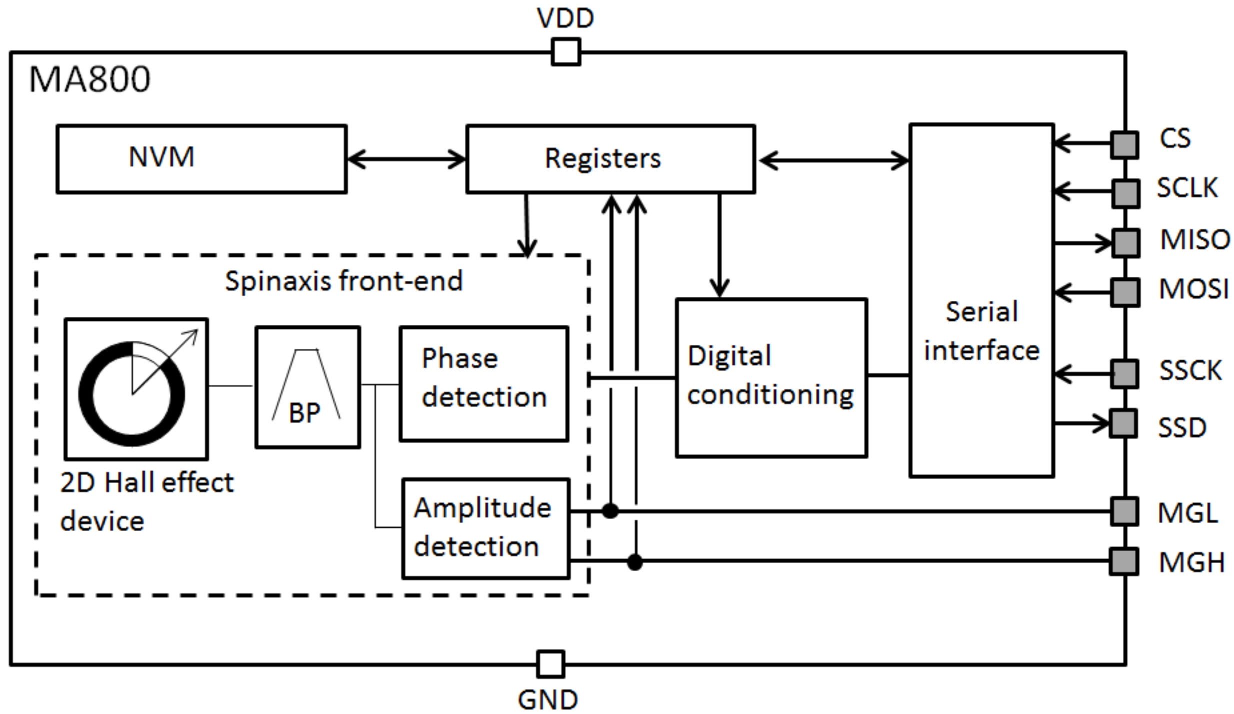


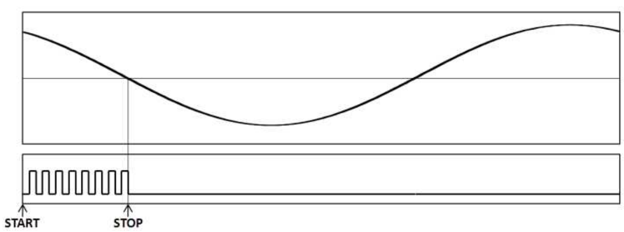
Figure 1: Functional Block Diagram

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 computations 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):

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

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

Sensor – Magnet Mounting

The sensitive volume of the MA800 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.

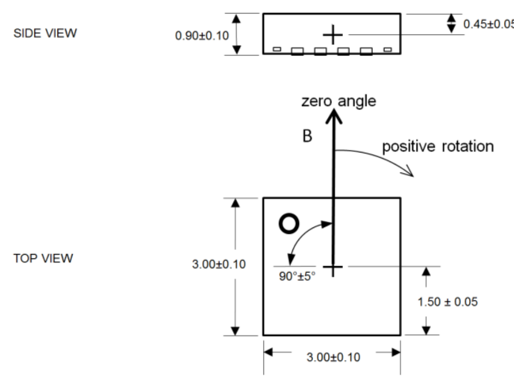


Figure 3: Detection Point and Default Positive Direction

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 MA800 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 MA800 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.

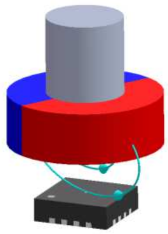


Figure 4: End-of-Shaft Mounting

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.

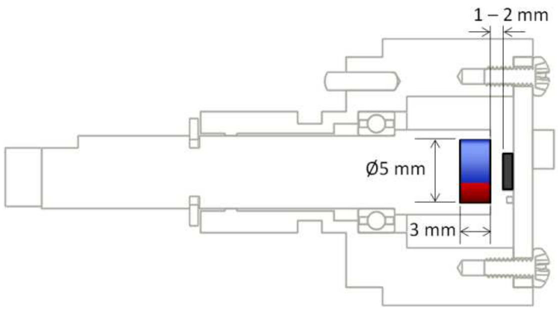


Figure 5: Example of Potentiometer-Like Assembly

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).

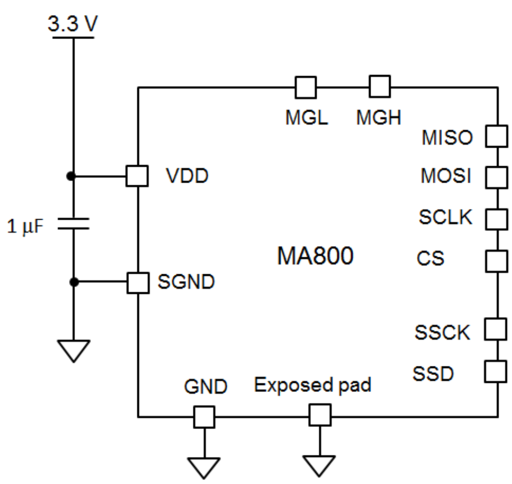


Figure 6: Connection for Supply Decoupling

In general, the MagAlpha works well with or without the exposed pad connected. 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 angle reading and register programming. Alternatively, the SSI bus can be used for angle reading (programming through SSI is not supported).

SPI

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 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)	

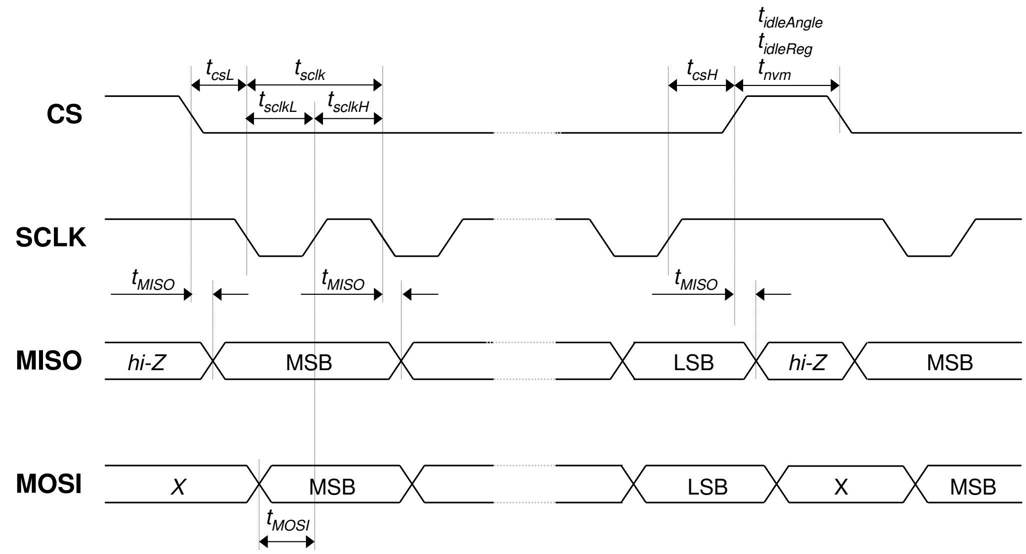


Figure 7: SPI Timing Diagram

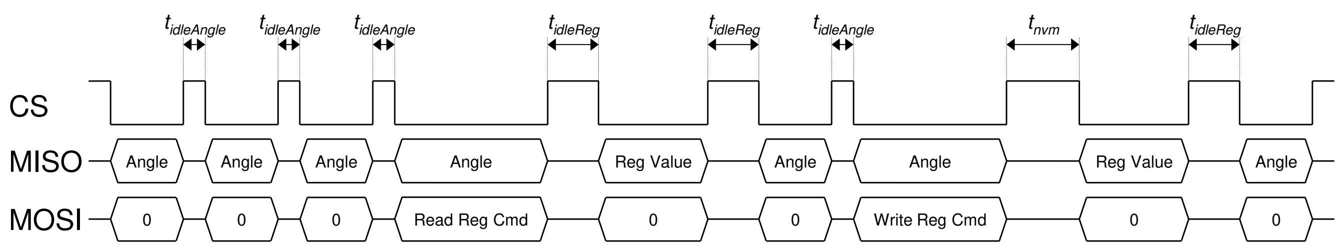


Figure 8: Minimum Idle Time

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.

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

Every 1µs, new data is transferred into the output buffer. The master device triggers the reading by pulling CS low. When a trigger event is detected, the data remains in the output buffer until the CS signal is de-asserted (see Table 4).

Table 4: Sensor Data Timing

Event	Action
CS falling edge	Start reading and freeze output buffer
CS rising edge	Release of the output buffer

See Figure for a diagram of a full SPI angle reading. See Figure 10 for a diagram of 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. Check the data output length 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.

For example, a data output length of 12 bits means that the serial output delivers a 12-bit angle value with 4 bits of zeros padded at the end (MISO state remains zero). If the master sends 16 clock counts, the MagAlpha replies with:

	MSB				LSB
MISO	***Angle(15:4)***	*0*	*0*	*0*	*0*
MOSI	***0***				

Therefore, angle reading can be optimized without any loss of information by reducing the number of clock counts. In the case of a 12-bit data output length, only 12 clock counts are required to get the full sensor resolution.

	MSB … LSB
MISO	***Angle(15:4)***
MOSI	***0***

If less resolution is needed, the angle can be read by sending even fewer clock counts (since MSB is first).

In case of fast reading, the MagAlpha keeps sending the same data until the data is refreshed (see the refresh rate in the General Characteristics table on page 5).

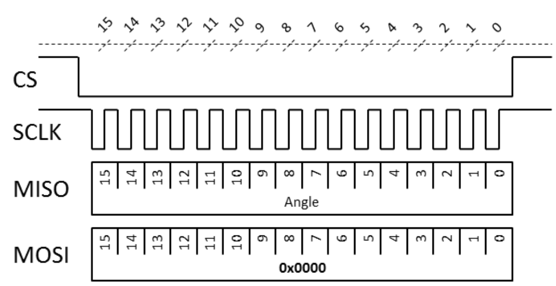


Figure 9: Diagram of a Full 16-Bit SPI Angle Reading

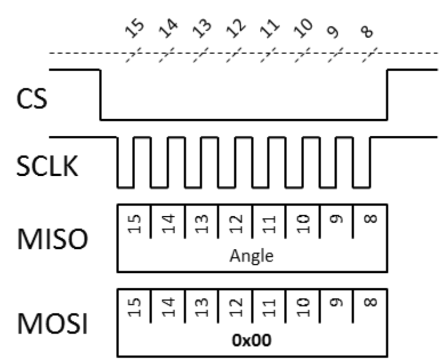


Figure 10: Diagram of a Partial 8-Bit SPI Angle Reading

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 last eight bits of the frame must all be set to zero. The second frame returns the 8-bit register value (MSB byte).

First 16-bit SPI frame (read request):

	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*

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*

See Figure for a complete transmission.

For example, to get the value of the magnetic level high and low flags (MGH and MGL), read register 27 (bit 6, 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.

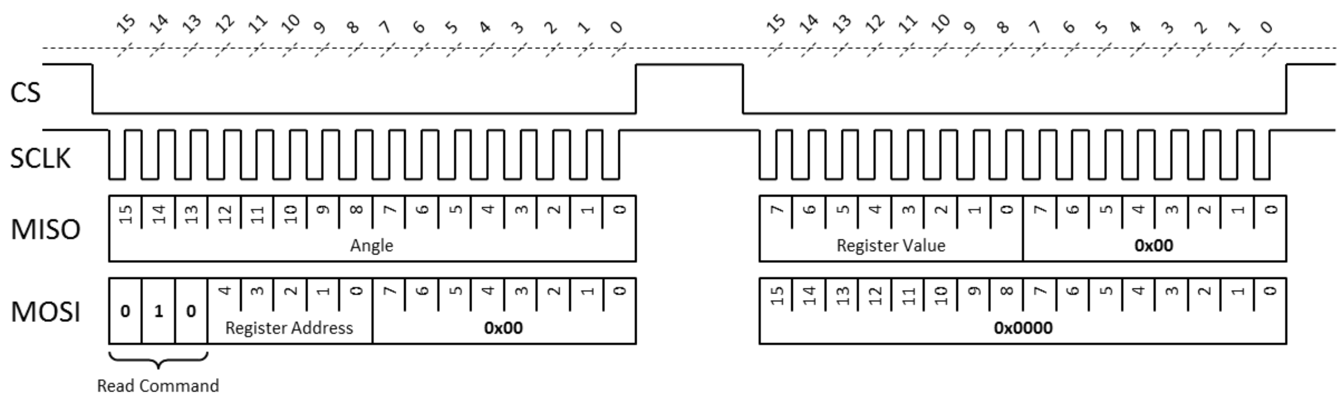


Figure 11: 16-Bit Frames Read Register Operation

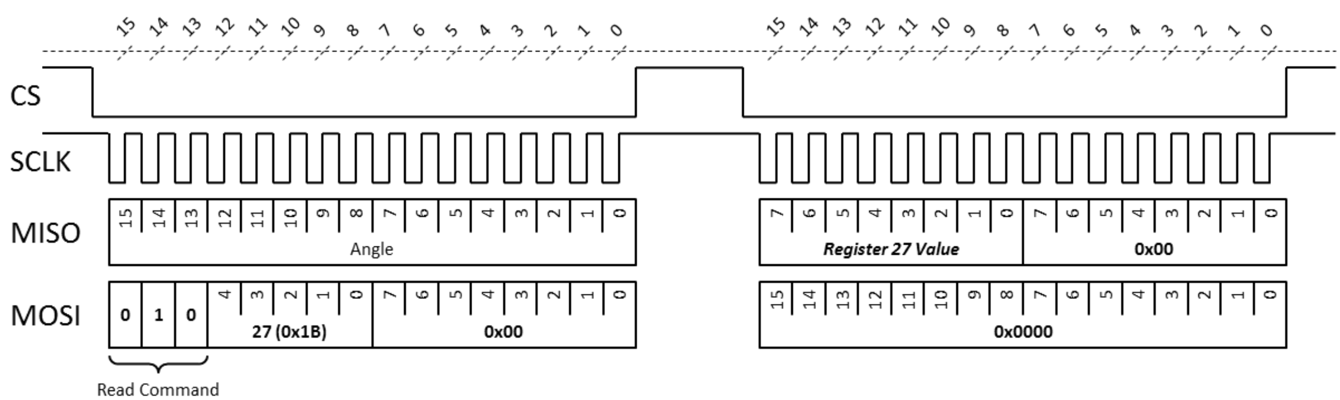


Figure 12: Example Read Magnetic Level Flags High and Low (MGH, MGH) on Register 27, Bit 7-6

SPI Write Register

Table 7 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 8.

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. See Figure for a complete transmission overview.

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

	MSB … LSB
MISO	*Angle(15:0)*

	command			reg. address					reg. value							
MOSI	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0

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

	reg. value															
MISO	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	MSB … LSB
MOSI	*0*

See Figure for a complete example.

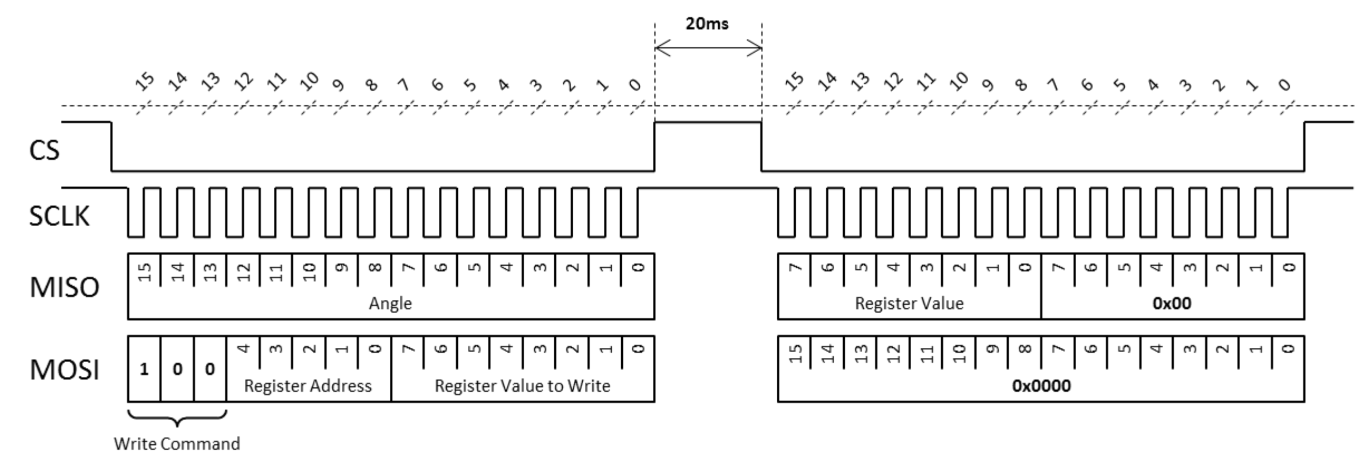


Figure 13: Overview of Two 16-Bit Frames Write Register Operation

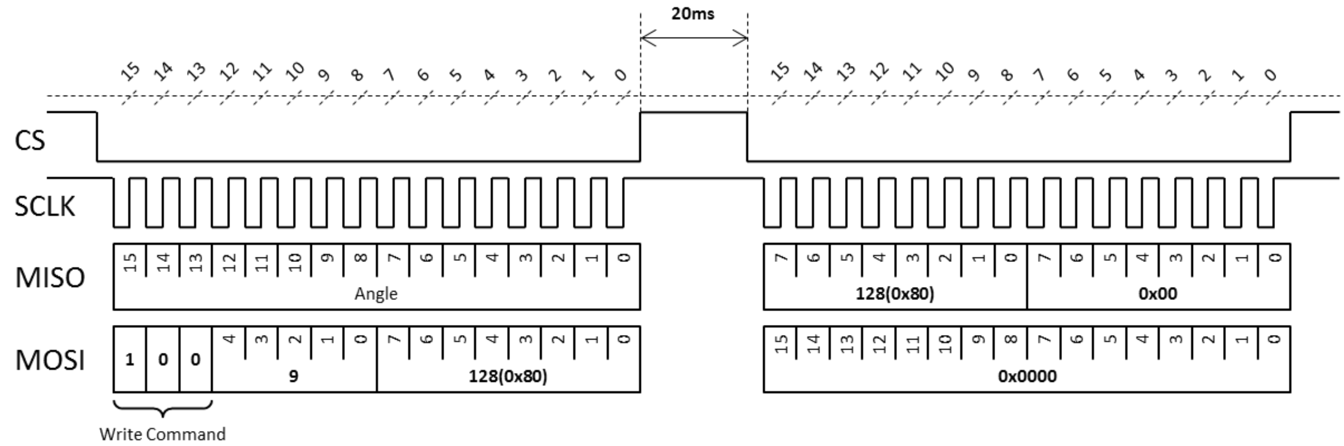


Figure 14: Example Write Output Rotation Direction (RD) to Counterclockwise (High) on Register 9, Bit 7

SSI

SSI is a 2-wire synchronous serial interface for data reading only. The sensor operates as a slave to the external SSI master and supports only angle reading. It is not possible to read or write registers using SSI.

SSI Communication

Unlike SPI, the sensor SSI only supports angle reading operation. It is not possible to read or write registers using SSI. SSI timing communication is shown in Figure 15 and Table 5.

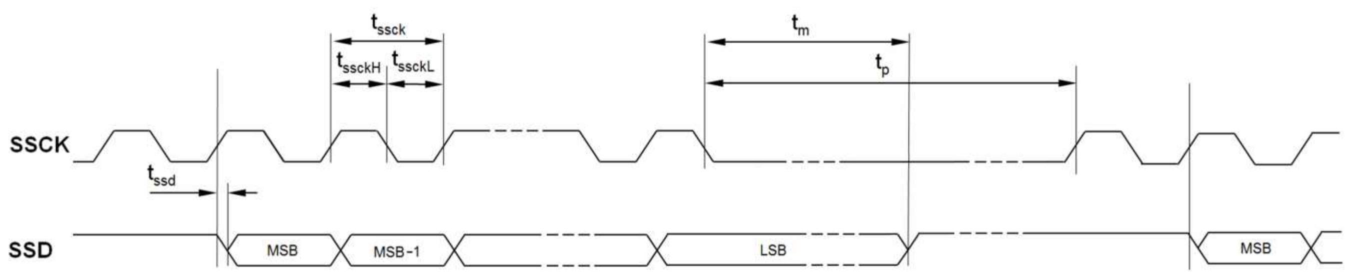


Figure 15: SSI Timing

Table 5: SSI Timing

Parameter	Description	Min	Max	Unit
t_{ssd}			15	ns
t_{ssck}	SSCK period	0.04	16	µs
t_{ssckL}	Low level of SSCK signal	0.02	8	µs
t_{ssckH}	High level of SSCK signal	0.02	8	µs
t_m	Transfer Timeout (Monoflop time)	25		µs
t_p	Dead-time: SSCK high time for next data reading	40		µs

SSI Read Angle

The bit order of the transmitted data is MSB first and LSB last. Every 1µs, new data is transferred into the output buffer. The master device triggers the reading by pulling SSCK down. Just like an SPI reading, a full reading requires 16 clock counts, but if the data length is less than 16, the 16-bit output word is completed by zeros. Therefore, reading can also be performed with fewer than 16 clock counts (see Figure 16).

When a trigger event is detected, the data remains in the output buffer until the clock rising edge for the LSB bit 0 and the transfer time out time has passed.

See Table 6 for sensor data timing.

Table 6: Sensor Data Timing

Trigger event	Release of the output buffer
First SSCK falling edge	SSCK rising edge + time out t_m (Fig 15)

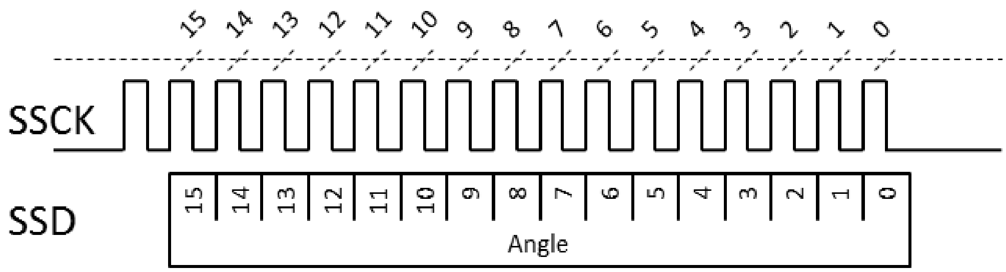


Figure 16: Full 16-Bit SSI Angle Reading

For consecutive angle readings, see the timing in Figure 17.

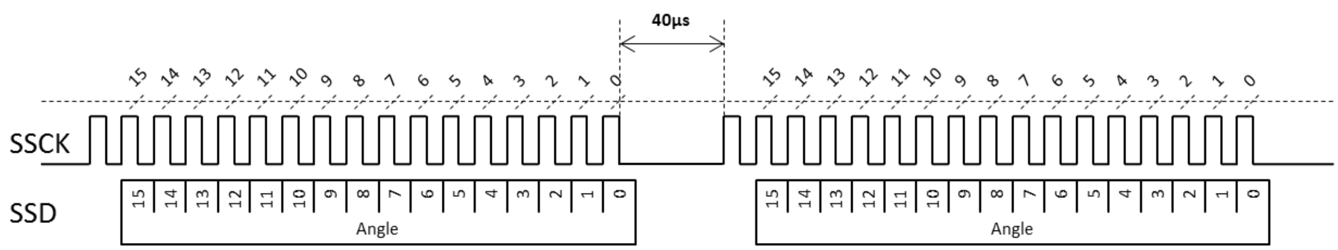


Figure 17: Two Consecutive 16-Bit SSI Angle Reading with the Required Dead-Time between the Frames

REGISTER MAP

Table 7: 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)							
6	0x6	00110	MGLT(2:0)			MGHT(2:0)			-	-
9	0x9	01001	RD	-	-	-	-	-	-	-
27	0x1B	11011	MGH	MGL	-	-	-	-	-	-

Table 8: 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
6	0x6	00110	0	0	0	1	1	1	0	0
9	0x9	01001	0	0	0	0	0	0	0	0

Table 9: Programming Parameters

Parameters	Symbol	Number of Bits	Description	See Table
Zero setting	Z	16	Set the zero position	10
Magnetic field high threshold	MGHT	3	Sets the field strength high threshold.	14
Magnetic field low threshold	MGLT	3	Sets the field strength low threshold.	14
Rotation direction	RD	1	Determines the sensor positive direction	12

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 10 shows the zero setting parameter.

Table 10: 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	65536	359.989
…	…	…
65535	2	0.011
65536	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):

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

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

Table 11 shows the content of registers 0 and 1.

Table 11: Register Content

Reg	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
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 18 and Table 12).

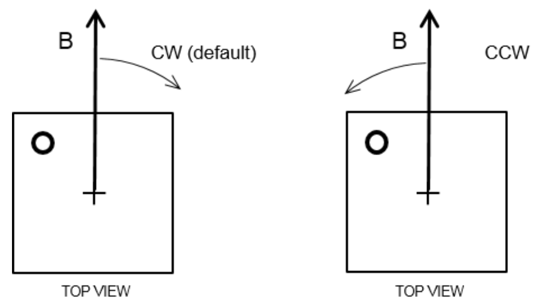


Figure 18: Positive Rotation Direction of the Magnetic Field

Table 12: Rotation Direction Parameter

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

Magnetic Field Thresholds

Push Button Detection

The MA800 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 19).

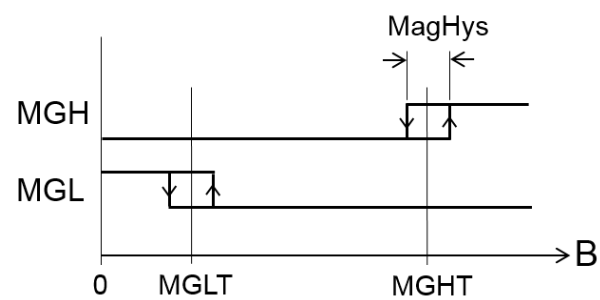


Figure 19: MGH and MGL Signals as a Function of the Field Strength

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 20).

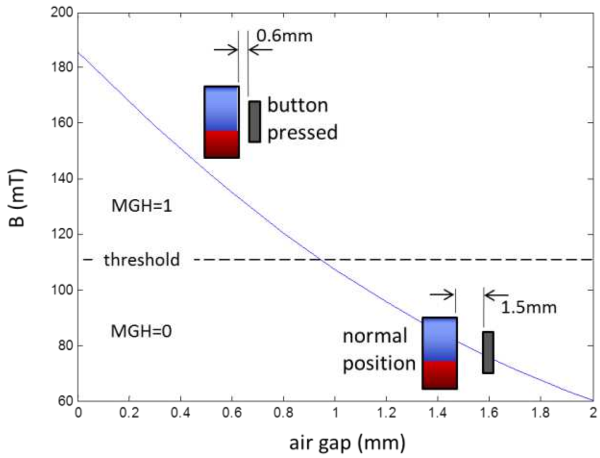


Figure 20: Magnetic Field Produced by a 5mmx3mm N35 Magnet as a Function of the Airgap with Threshold Set to 110mT

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 Characterisitcs table on page 5. The MGLT and MGHT thresholds are coded on three bits and stored in register 6 (see Table 13).

Table 13: Register 6

Reg	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
6	MGLT			MGHT			-	-

The 3-bit values of MGLT and MGHT correspond to the magnetic field (see Table 14).

Table 14: MGLT and MGHT Binary to mT Relation

MGLT or MGHT [8]	Field threshold in mT [7]	
	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:
7) Valid for VDD = 3.3V. If different, then the field threshold is scaled by the factor VDD/3.3V.
8) 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 MA answers with the register 27 content in the next transmission:

Reg	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
27	MGH	MGL	x	x	x	x	x	x

TYPICAL APPLICATION CIRCUITS

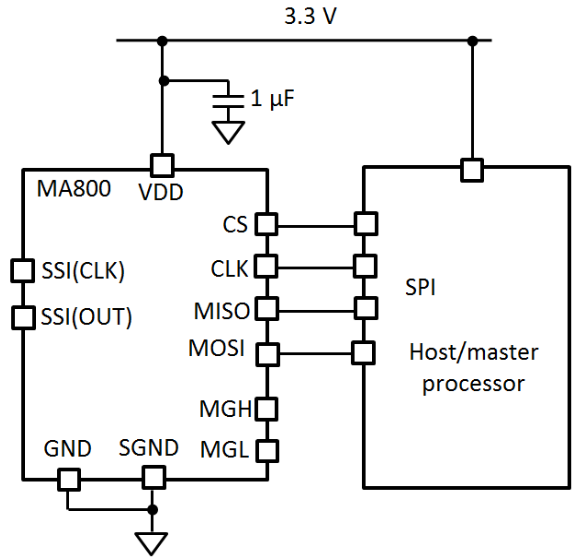


Figure 21: Typical Configurations using SPI Interface

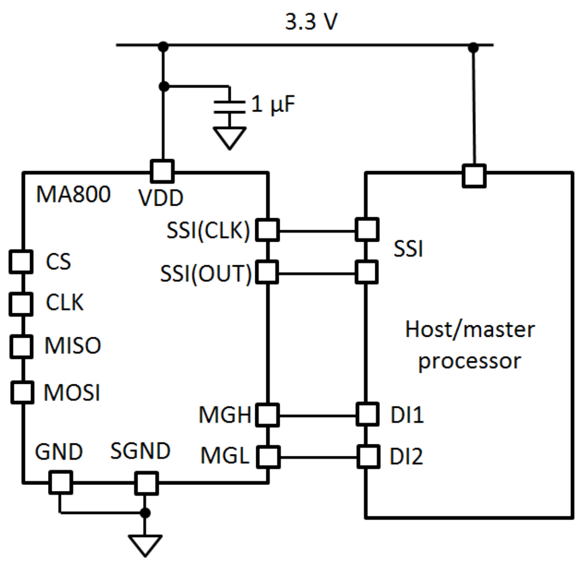
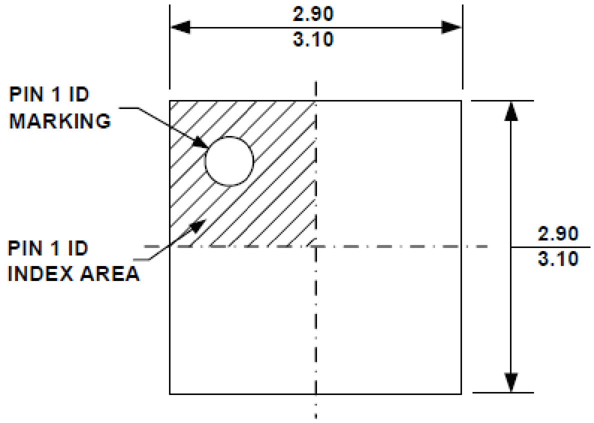


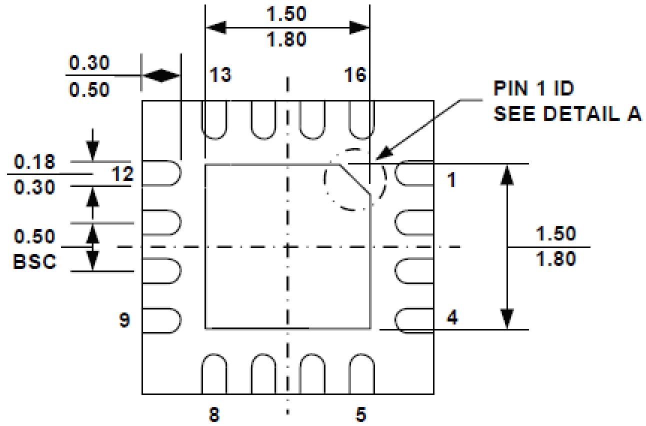
Figure 22: Typical Configuration Using SSI Interface and Output Signals MGL, MGH

PACKAGE INFORMATION

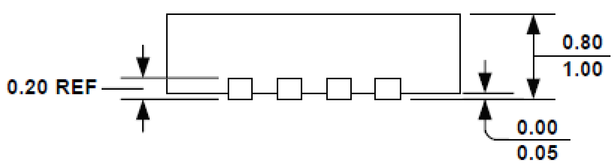
QFN-16 (3mmx3mm)



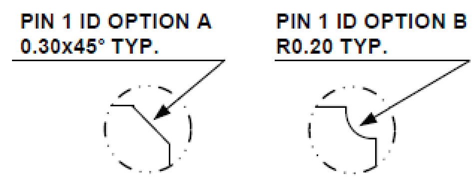
TOP VIEW



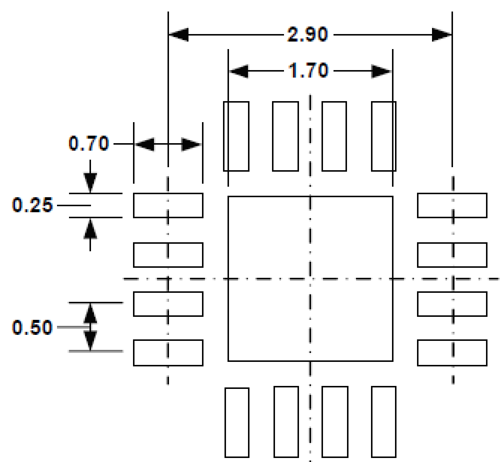
BOTTOM VIEW



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.

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.

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.

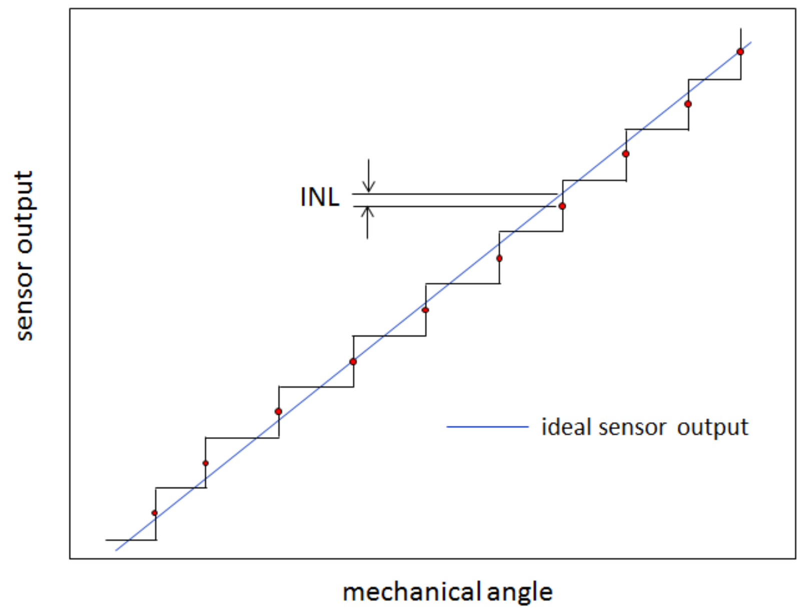
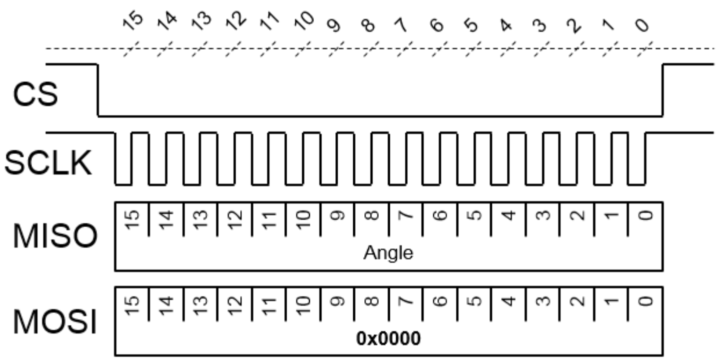


Figure A1: Integral Non-Linearity

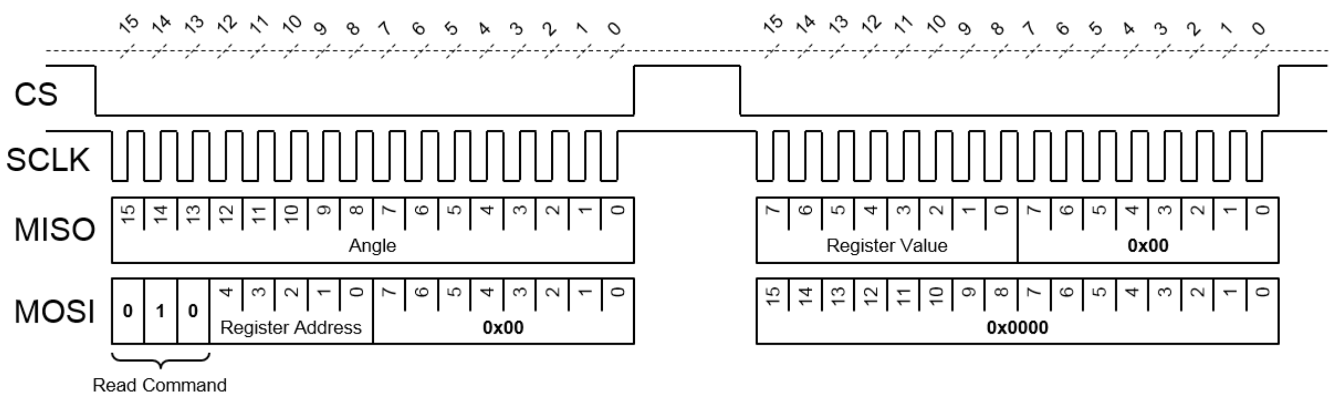
Drift Angle variation rate when one parameter is changed (e.g.: temperature, VDD) and all the others, including the shaft angle, are maintained constant.

APPENDIX B: SPI COMMUNICATION CHEATSHEET

Read Angle



Read Register



Write Register