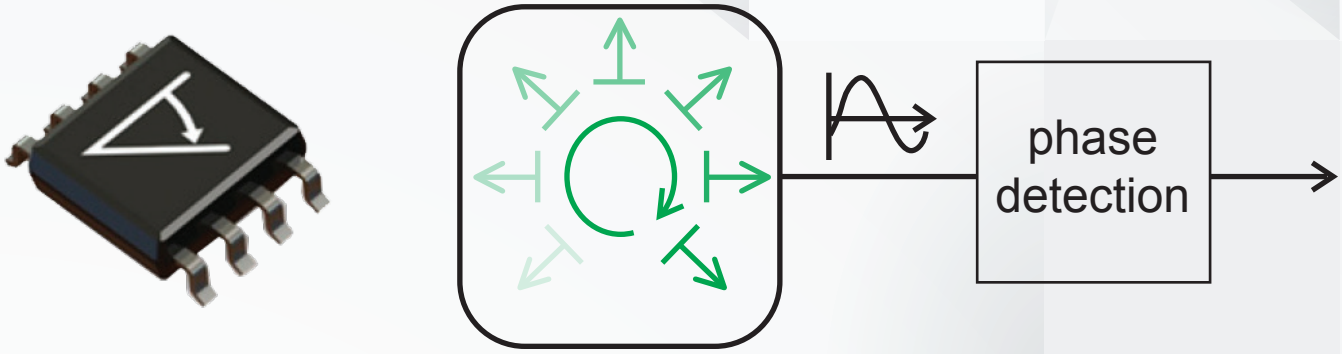
Magnetic Angular Position Sensors

Product & Applications Brochure



SPINAXIS™

A REVOLUTION IN ANGLE SENSING

Monolithic Power Systems

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The MPS Quality Assurance organization develops, coordinates, and champions strategic, quality initiatives throughout MPS Inc., its foundries, and sub-contractors. Its mission is to enable MPS to design, develop, manufacture, and deliver products to our customers with world-class quality and reliability that meet and exceed our customers' expectations.

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Magnetic Angular Position Sensor Solutions

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MagAlpha Sensor Overview

The MPS MagAlpha family of magnetic angle position sensors offers a revolutionary way to measure angles. Leveraging more than a decade of experience, the MagAlpha range offers unique performance advantages compared to rival magnetic sensing technologies.

MagAlpha sensors use the patented SpinAxis™ Hall measurement technique that provides instantaneous angle position in a digital format. SpinAxis™ uses a phase detection approach that eliminates any need for analog to digital conversion or complex angle calculation used by more traditional technologies (see Figure 1).

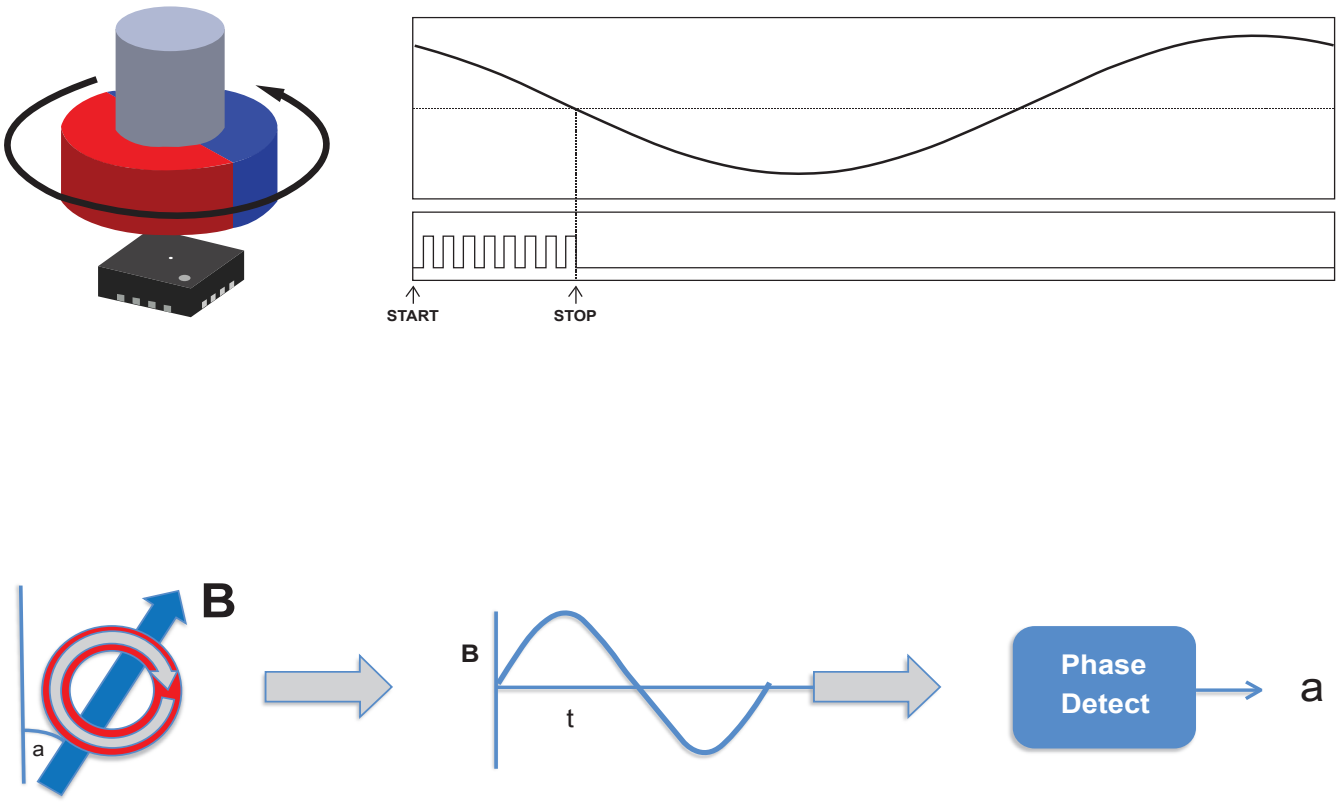


Figure 1: SpinAxis™ Technique

The benefits of the SpinAxis™ technique has allowed MPS to develop different angle sensor ranges spanning all types of end applications, from low cost consumer rotary knobs to high-speed motor commutation and position control.

Advantages of MagAlpha Sensors

Traditional magnetic angle sensors use a set of Hall plates orientated in the X and Y axis that convert the amplitude of the rotating magnetic field into a sine and a cosine waveform. The two waveforms are then digitized with analog to digital convertors (A-to-D), and the angle is computed using an arc tangent calculation. This approach has several disadvantages. Firstly, the amplitude of the magnetic field being measured has to be matched to the A-to-D convertors input range for best results. This limits the minimum and maximum range of the magnetic field that can be accommodated and the magnet's distance from the sensor. The second major disadvantage is that the A-to-D conversion and arc tangent calculation take some time which translates to angle error or position lag at the sensor output. Typical latency can be hundreds of microseconds for this older technique.

MagAlpha sensors in contrast utilize an array of Hall plates that are sampled successively at very high speeds (500kHz or 30 million RPM) in such a way that the signal phase represents the angle to be measured. The "phase-to-digital" SpinAxis™ technique captures the angle instantaneously every 1µs without need for A-to-D conversion or arc tangent calculation. This means the sensor is able to work over a wider magnetic field range (typically 30-150mT) giving greater flexibility and tolerance for magnet positioning.

The fast Hall sampling and subsequent digital conditioning result in very low latency from Hall array sampling to the data availability at the sensor output. Typical latency is only 3µs at a constant rotation speed, allowing MagAlpha sensors to operate in systems with high rotation speed or that require fast position control loops. Rotation speeds from zero to in excess of 100kRPM are possible.

Side Shaft Capability

MagAlpha sensors support both end of shaft and side of shaft topologies. In end of shaft the sensor is placed directly below the magnet connected to the rotating shaft. This topology gives the best performance, but is not always mechanically convenient because the end of a rotating shaft may not be accessible. For example, in a motor it may be hidden by the shaft bearing, or driving into a gear box. Side of shaft topology allows the magnet to be placed to the side of a ring magnet mounted on the rotating shaft. This is advantageous for many designs as the ring can be located anywhere on the shaft which allows the sensor to be embedded more easily within the motor or product casing. MagAlpha sensors contain dedicated bias trimming registers which allow the extra magnetic fields seen in side shaft mode to be normalized in amplitude so that the sensor maintains a linear output response over the full angle measurement range (see Figure 6, page 12).

MagAlpha Angle Sensors offer the following advantages:

- Instantaneous angle sensing: up to 1µs sample rate, only 3µs latency at 100kRPM
- High resolution up to 14 bit
- Support for shaft rotation speeds from zero to over 100kRPM
- Wide magnetic field range support from 15mT to 150mT working range
- End and side shaft sensor topologies
- Low power consumption: 3.3V, 12mA
- Small form factor: 3x3 QFN-16 package

Rotary Human-Machine-Interface Applications

MA8xx Family

Rotary knobs are used in a diversity of human to machine interface applications with examples including the program selector on a washing machine or the infotainment control in a car. These applications typically use a conventional potentiometer or mechanical rotary switch which have limited lifetime due to mechanical wear and tear or environmental degradation. The use of magnetic angle sensors to implement contactless sensing eliminates both issues to provide a long lifetime solution.

The MagAlpha MA8xx family is a new simple-to-use digital magnetic sensor range designed to replace analog potentiometers or rotary switches in such applications. The sensor detects the absolute angular position of a permanent magnet attached to the rotating knob. Typically, a simple diametrically magnetized cylinder with a 3 to 8mm diameter is suitable.

Different options are available, including digital angle output via SPI/SSI bus, incremental ABZ interface, or PWM output.

Programmable threshold magnetic field strength detection is built in to enable implementation of a contactless push or pull button. Detection is performed by reading the device registers or the logic state of the two output signals. In this way, a combined rotary knob with “push or pull to select” functionality can be created.

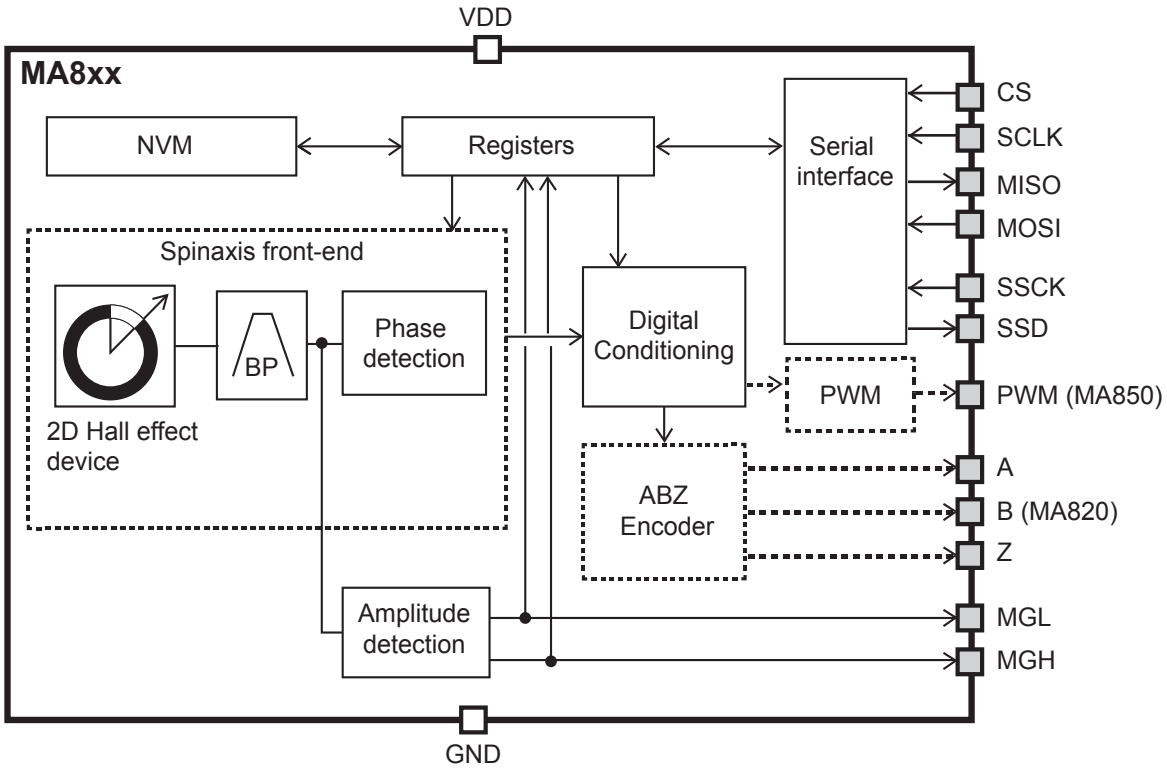


Figure 2: Block Diagram of MA8xx Family Sensor

Push Button Functionality

The MA8xx family provides contactless push or pull button functionality via programmable magnetic field strength thresholds, which can detect the distance of the magnet to the sensor. The graph in Figure 5 shows how this may be implemented with a change in magnet position of approximately 0.9mm crossing the programmed field threshold to cause the MGH signal to change from logic 0 to logic 1.

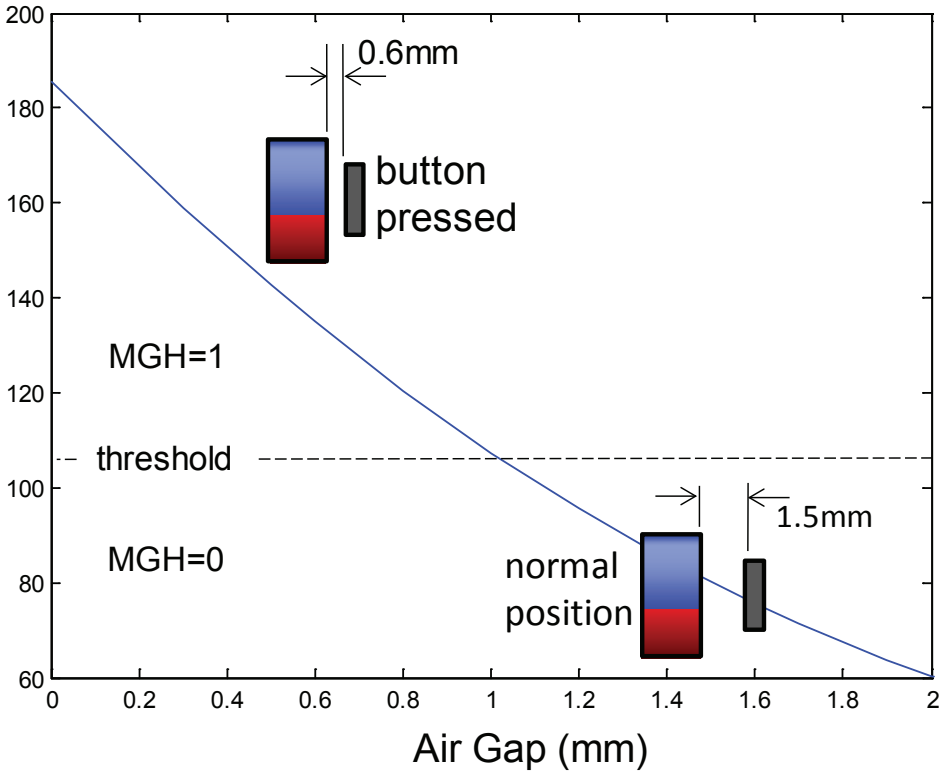


Figure 5: Example of Push Button Detection B(mT) v. Air Gap

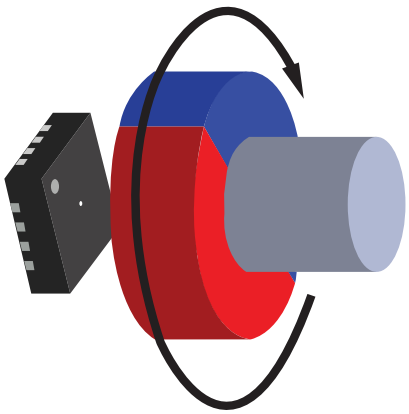
Non-Volatile Memory

Configuration parameters are automatically stored in the MA8xx device's non-volatile memory via the SPI interface. The non-volatile memory provides storage for the reference zero angle position and the magnetic field detection thresholds.

The MA8xx family operates from a 3.3V supply and is packaged in a 3x3mm QFN package. The operating temperature is -40 to +125°C.

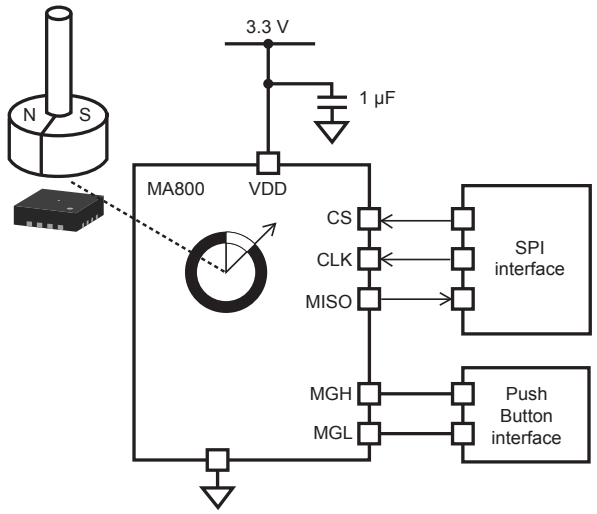
Table 1: MA8xx Family Sensor Range

Features by Part	Unit	Turning Knob Applications		
		MA800	MA820	MA850
		Digital Out	ABZ Incremental Out	PWM Out
Effective angle resolution	bit	8	8	8
Magnetic field range	mT	30 ..150	30 ..150	30 ..150
Zero setting		✓	✓	✓
SPI register configuration		✓	✓	✓
Absolute angle on SPI	bit	8	-	-
Absolute angle on SPI	bit	8	-	-
ABZ incremental			✓	
ABZ resolution	PPR		1 .. 64	
PWM output				✓
PWM resolution	bit			8
Magnetic field detection		✓	✓	✓
Push button functionality		✓	✓	✓



MA800: Digital SPI Output

The MA800 sensor outputs the digital angle reading via an SPI or SSI interface. This allows for an easy interface to all types of microcontrollers. The digital angle is an absolute value with 8 bit resolution between 0 and 360 mechanical degrees. Because it measures the absolute angle, the position information is always true, even after the power is cycled.



MA820: ABZ Output

The MA820 version features a programmable incremental ABZ encoder interface. This provides two channels (A and B) of quadrature encoded signals with a programmable number of pulses per channel for each full 360° turn. The pulses per channel can be set from 1 to a maximum of 64 per revolution. The 90° quadrature spacing of the two channels also provides direction of turn information. An index pulse output (Z) is provided to reference the knob's zero position. The zero reference can be set during system production and programmed into the non-volatile memory of the device.

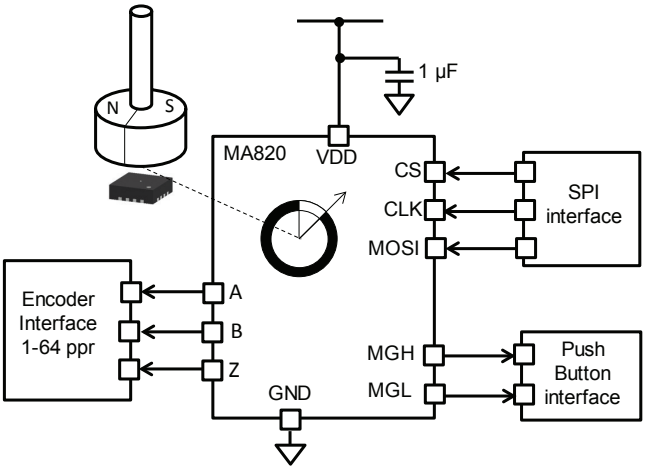
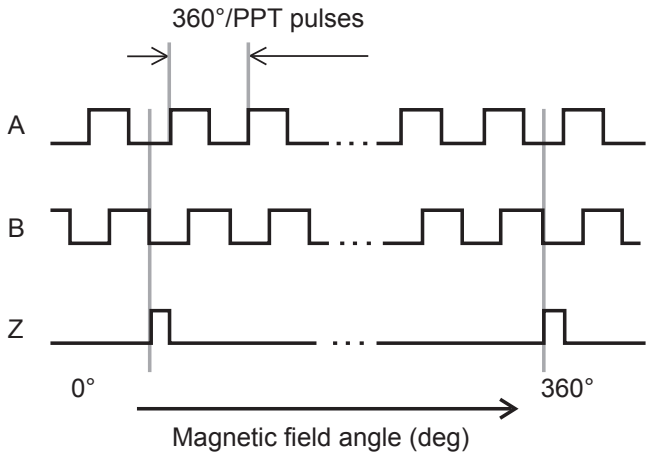


Figure 3: Quadrature ABZ Waveform



MA850: PWM Output

For applications wanting to retrofit to the analogue output of a potentiometer solution, the MA850 version provides a PWM output, which can also be filtered to provide a ratiometric linear voltage that is proportional to the angle. The PWM has an 8 bit resolution and frequency of approximately 3.1kHz. Adding an RC network to the output provides an output voltage over the range from 0 to the device supply voltage of 3.3V. For a 0 to 5V application, the RC network can be buffered by a simple OP-AMP circuit to give a wider output voltage range.

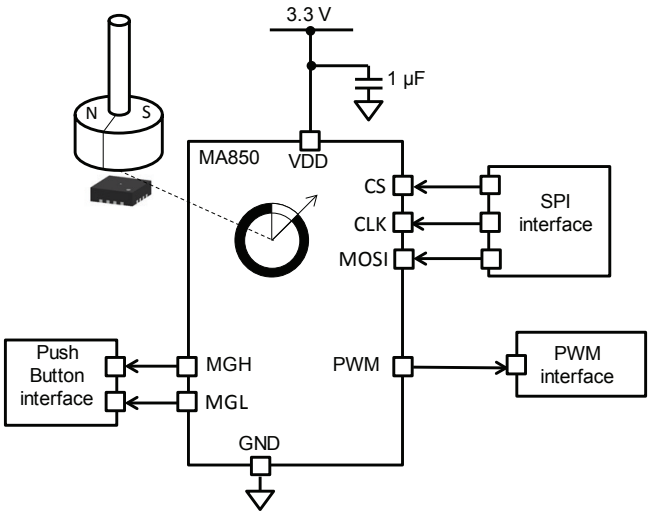
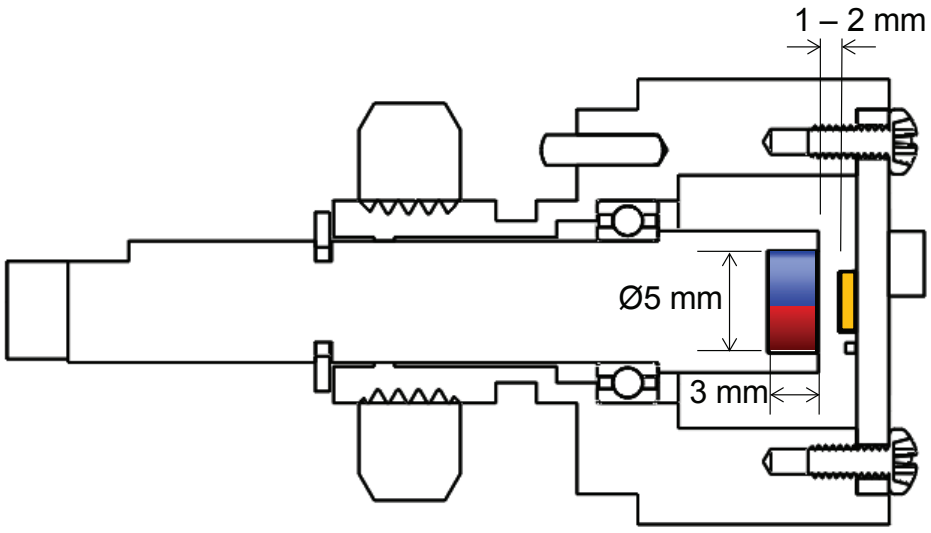


Figure 4: Example of a Potentiometer-Like Assembly Using Contactless Sensing with MA800/820/850



Brushless DC Motor Control Applications

MA1xx and MA3xx Families

Three phase brushless DC (BLDC) motors are increasingly popular in many applications, offering high reliability and long operating life due to the electrical commutation scheme which replaces older carbon brushed motors. MPS offers a range of MagAlpha angle sensors optimized for brushless motor commutation, position, and speed control. The MagAlpha sensor is able to generate both the UVW commutation signals and the position information needed for the motor control system, either in the form of a direct digital angle read over the SPI interface or from an ABZ incremental encoder quadrature output interface.

Table 2: MagAlpha Motor Application Devices

Features by Part		Motor Commutation		Motor Commutation and Position Controlled Drives		
		MA100	MA102	MA300	MA302	MA310
	Unit	High Speed	High Speed	High Speed	High Speed	Side Shaft Opt
Effective angle resolution	bit	11	12	11	12	12
Dynamic response		high	high	high	high	medium
Magnetic field range		30 .. 150	30 .. 150	30 .. 150	30 .. 150	15 .. 150
Zero setting		✓	✓	✓	✓	✓
Side shaft compensation		✓	✓	✓	✓	✓
Adjustable direction			✓		✓	✓
SPI register configuration		✓	✓	✓	✓	✓
Absolute angle on SPI	bit	8	8	11	12	12
ABZ incremental				✓	✓	✓
ABZ resolution	PPR			256	1 .. 256	1 .. 256
Adjustable Z pulse					✓	✓
UVW output		✓	✓	✓	✓	✓
UVW pp per rev.		1	1 .. 8	1	1 .. 8	1 .. 8
Differential UVW			✓			
Magnetic field monitoring			✓		✓	✓

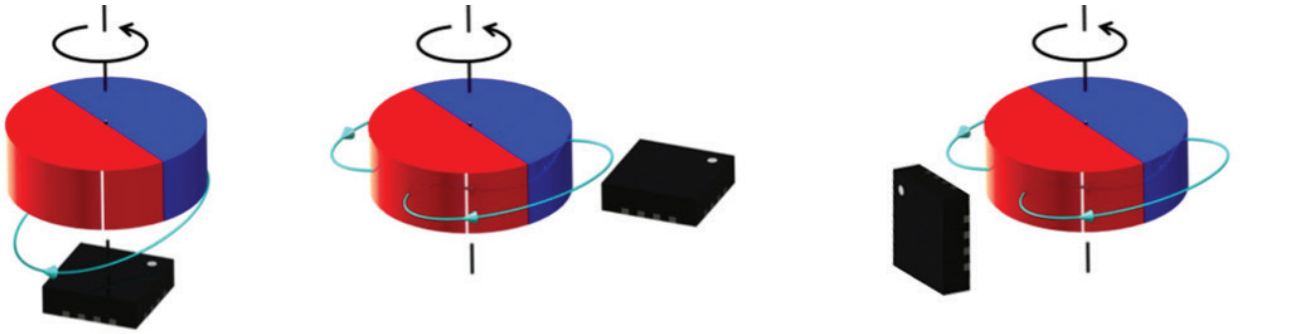
Motor Commutation Sensors

MA100

The MagAlpha MA100 is optimized for motor commutation applications. It can replace the conventional three Hall switch approach with a single sensor and a two pole disc magnet mounted at the end of the rotor shaft or to the side of a ring magnet mounted on the rotor shaft (see Figure 6). The MagAlpha MA100 generates the UVW output signals used to commutate a brushless DC motor with fixed 60° commutation angle step spacing to replicate a traditional three Hall sensor approach when used with a single pole pair rotor.

One-time programmable (OTP) memory is provided to store configuration parameters, including the zero reference angle and side shaft optimization.

Figure 6: Magnet and Sensor Positioning



End of Shaft Mode **Side of Shaft Mode** **Orthogonal Side of Shaft**

MA102

The MA102 represents the latest generation of MagAlpha technology adding higher resolution and additional features for motor commutation applications. The MA102 can replace the conventional three Hall switch approach with a single sensor and disc magnet mounted at the end of the rotor shaft or to the side of a ring magnet mounted on the rotor shaft (see Figure 6).

The MagAlpha MA102 generates the UVW output signals used to commutate a brushless DC motor with programmable commutation angle step spacing to support one to eight magnet pole pairs on the rotor. Complementary UVW signals are provided to support differential signalling for greater cable length in noisy environments.

Reprogrammable non-volatile memory (NVM) is provided to store configuration parameters including the zero reference angle, pole pair step angle, and side shaft optimization (see Figure 7).

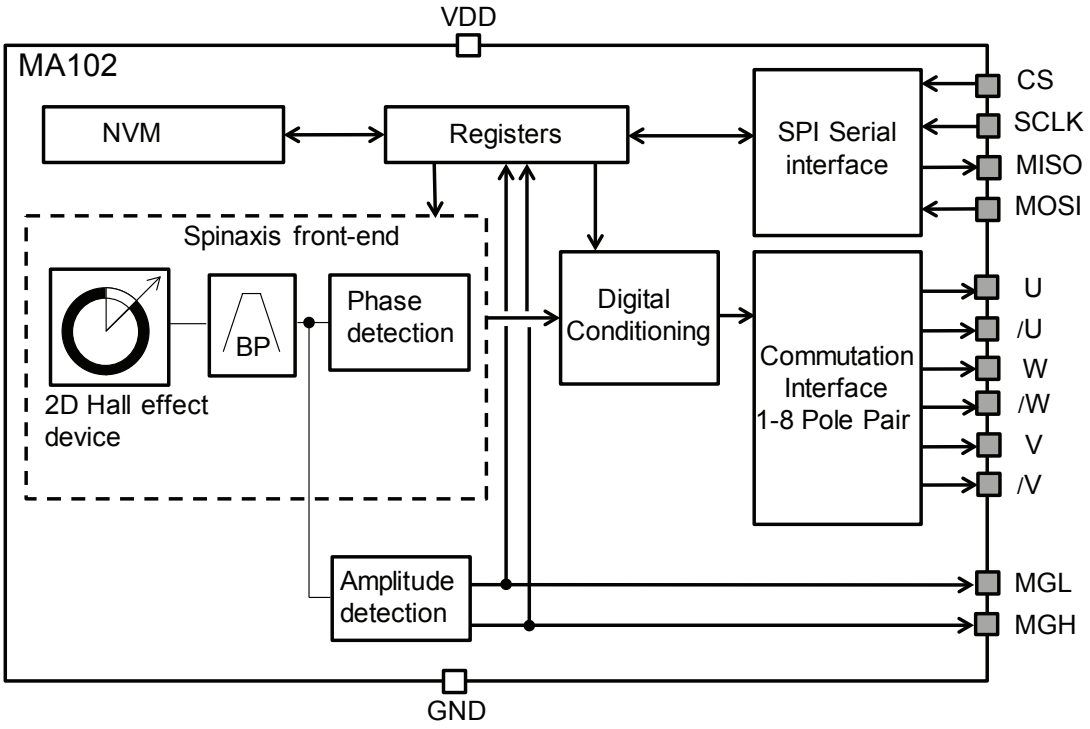


Figure 7: MA102 Latest Generation of Commutation Sensor

Motor Commutation with Position Control (Servo Motor)

MA3xx Family

Brushless DC motors are used in many applications requiring position control. Examples include robotics, process automation, automotive actuators, and power tools. Such motors are usually referred to as servo motors and typically use an encoder mounted on the motor shaft to provide position, direction, or speed feedback to the control system. These external encoders increase the solution cost and size.

The MagAlpha MA3xx range provides the ability to commutate the brushless motor and provide an incremental ABZ style encoder interface in the same sensor device for speed and position control. As such, it saves cost and allows for a very compact servo solution size (see Figure 10).

The MagAlpha MA3xx range features include:

- SPI interface for direct digital angle reading and chip configuration
- ABZ encoder interface with up to 256 pulses per channel per turn
- UVW commutation interface with pole pair emulation from a simple two-pole magnet
- Magnetic field strength monitoring for diagnostics on latest generation parts
- One-time programmable or reprogrammable non-volatile memory for storage of zero position and other programmable chip configuration parameters

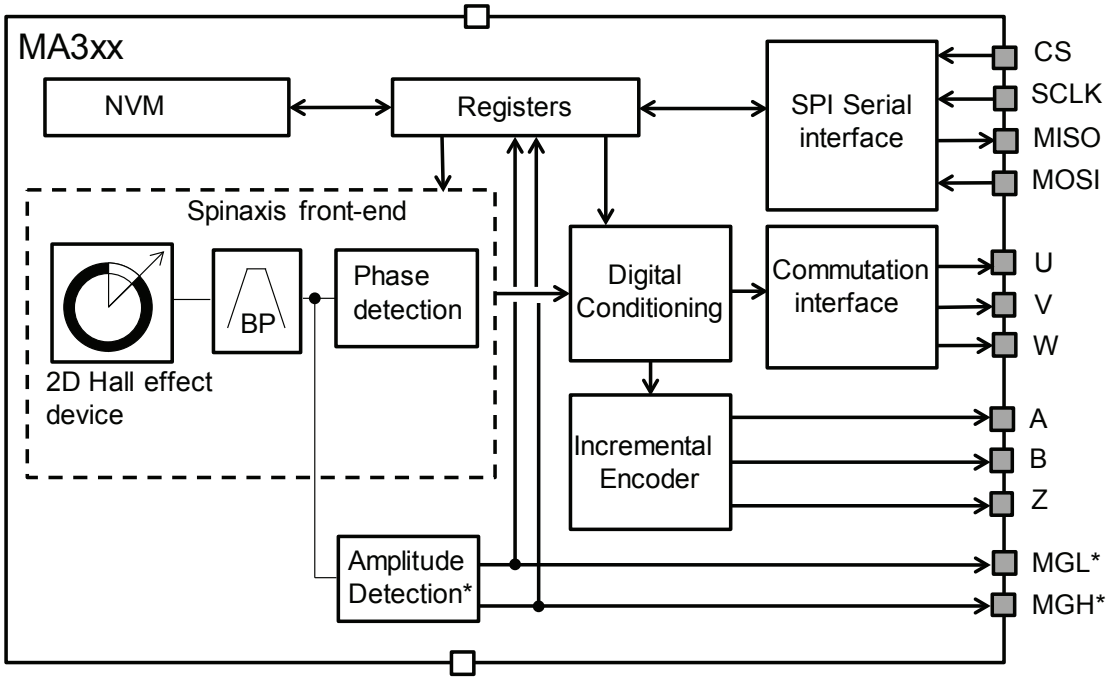
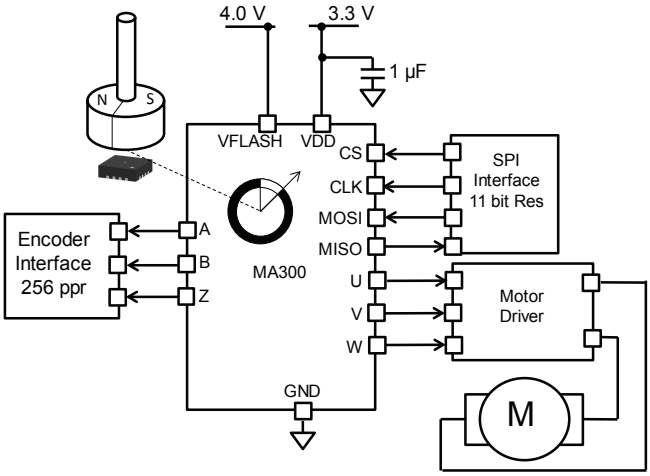


Figure 10: MagAlpha MA3xx Block Diagram (*only on MA302/310)

MA300: 11 bit Servo Motor Sensor

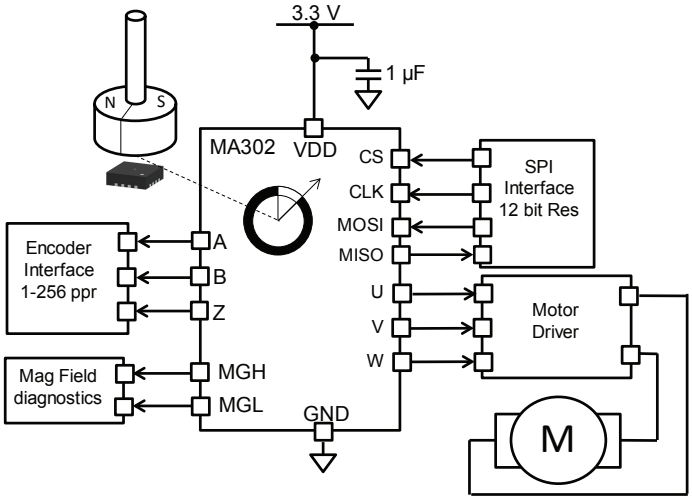
The MagAlpha MA300 was the first MagAlpha sensor to support motor servo applications. The MA300 provides 11 bit absolute digital angle resolution via the SPI interface, an incremental ABZ encoder interface with fixed 256 pulses per channel per rotation, and a UVW interface with fixed 60° step spacing. The MA300 supports end of shaft and side shaft topologies. Speeds over 100kRPM are supported on the SPI and UVW interfaces.



MA302: 12 bit Fast Response Servo Motor Sensor

The MagAlpha MA302 represents the latest generation of MagAlpha technology adding higher resolution and additional features. It is optimized for high dynamic response and is suited to applications that experience rapid speed change and the need to support high rotation speeds. Examples include high-speed brushless or synchronous reluctance motors in servo applications.

The digital conditioning block is optimized to maintain the highest resolution over different operating conditions. Speeds of over 100kRPM are supported on the SPI, ABZ, and UVW interfaces. End and side shaft topologies are supported.



MA310: 12 bit Side Shaft Optimized Servo Motor Sensor

The MA310 is optimized for side shaft topologies where magnetic field strength is typically lower due to magnet position and the need to equalise the magnitude of the multiple magnetic fields sensed to obtain a linear output response. The MA310 is able to work with magnetic fields as low as 15mT and still achieve 12 bit digital angle resolution on its SPI interface.

MA3xx Applications Servo Motor Example

An example of a complete miniature servo drive implementation using the MA302 is shown in Figure 11.

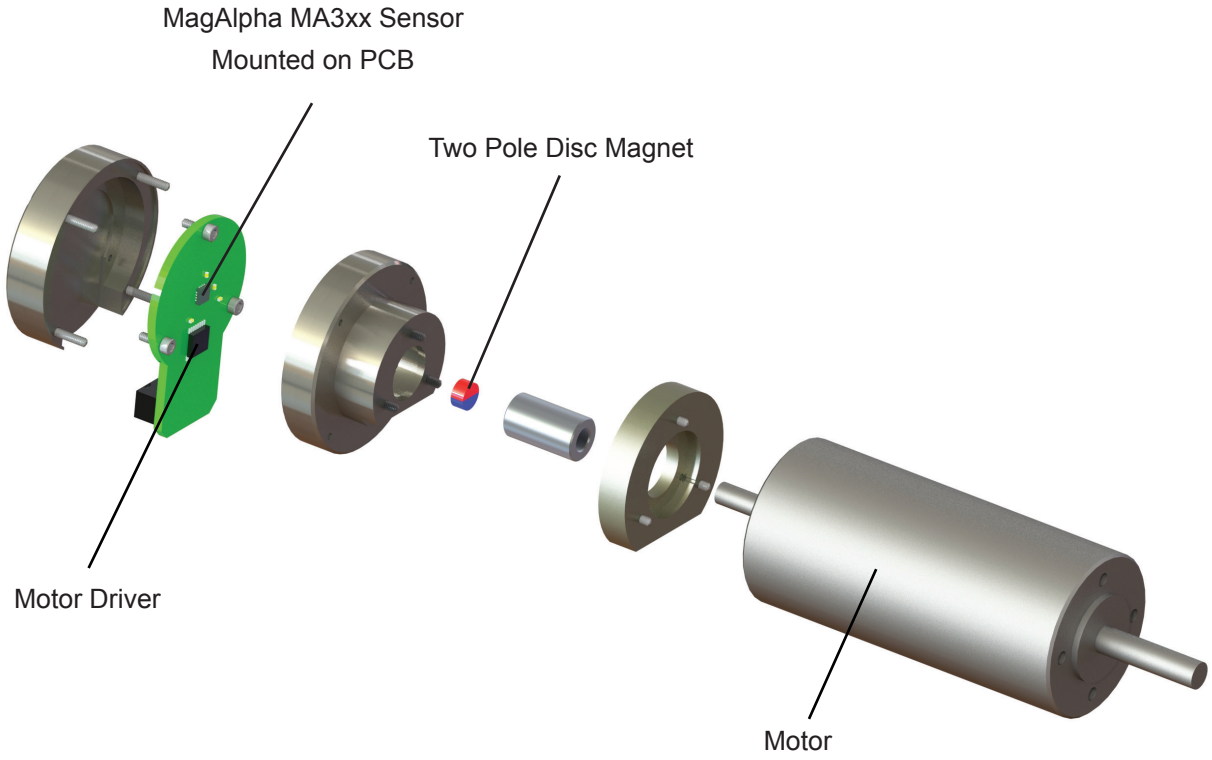


Figure 11: Servo Motor Example using the MA3xx Sensor

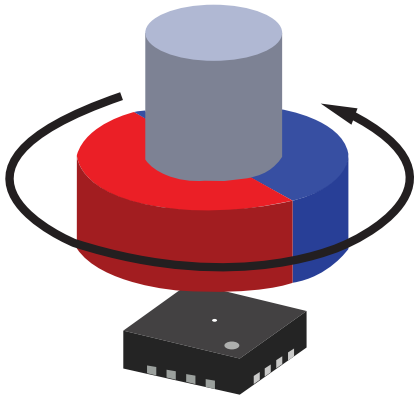
Motor Commutation Application Overview

Brushless DC (BLDC) or electronically commutated (EC) motors require feedback to the controlling electronics to indicate the position or angle of the rotor so that power can be applied to each of the stator windings at the correct time to maintain smooth rotation with low torque ripple. Traditionally, this has been done using three Hall sensors to sense the field of the magnets mounted on the rotor. This approach has the disadvantage that the Hall sensors need accurate mechanical alignment to the magnets mounted on the rotor such that the poles align correctly to the stator phases. This can be a complex manual procedure during motor manufacturing. For very small motor sizes, it can also be physically difficult to accommodate the three conventional Hall sensors inside the motor body.

The MagAlpha range simplifies commutation by internally converting the measured digital angle into the required UVW signals.

The MagAlpha range sensors can be mounted either at the end of the rotor opposite a simple to two-pole diametrically polarised disc magnet or mounted to the side of a two-pole ring magnet mounted on the rotor shaft. This allows for an extremely compact mechanical arrangement. Figure 8 shows the 60° UVW commutation signals for a two-pole rotor (one pole pair) configuration.

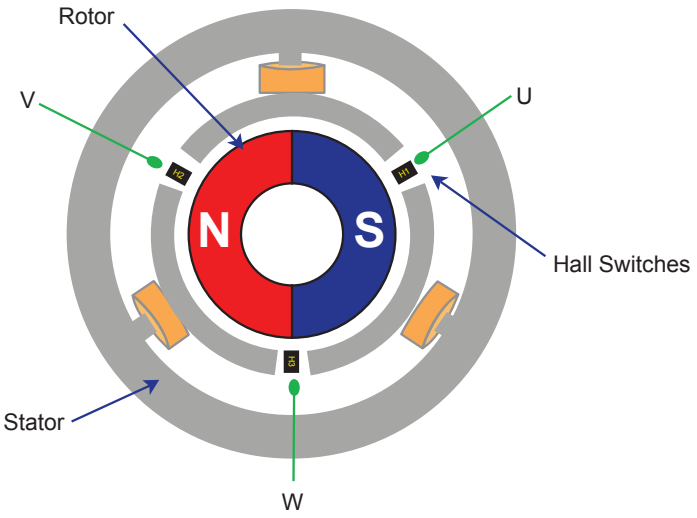
Motor manufacturing is further simplified by the ability to perform rotor magnet to stator phase alignment by programming the MA1xx zero angle offset position into one-time programmable (MA100) or reprogrammable non-volatile memory (MA102). This can be done as an automated software procedure at the end of line test during motor manufacturing.

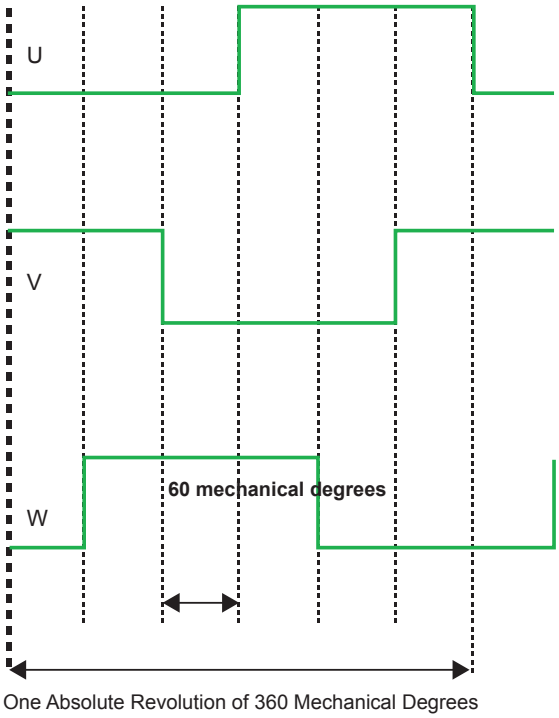


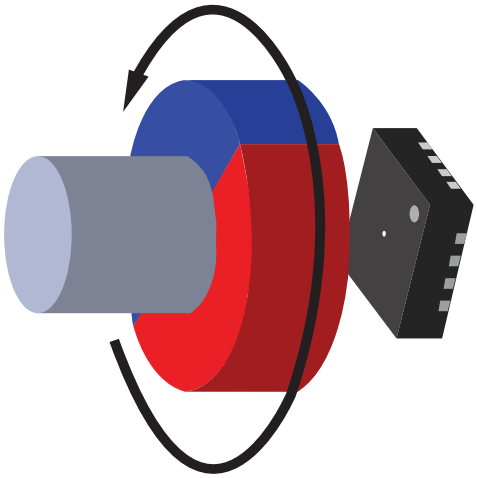
Motor Commutation

Simple Single Pole Pair Brushless DC Motor

Conventional Two-Pole Rotor (One Pole Pair)
BLDC Motor with 3 Hall Switches







MagAlpha Two-Pole Disc Magnet at End of Rotor
6x60° States per 360°
Emulating Two-Pole Rotor with Three Hall Switches

Figure 8: Replacing Three Hall Sensor Approach with the MagAlpha Sensor

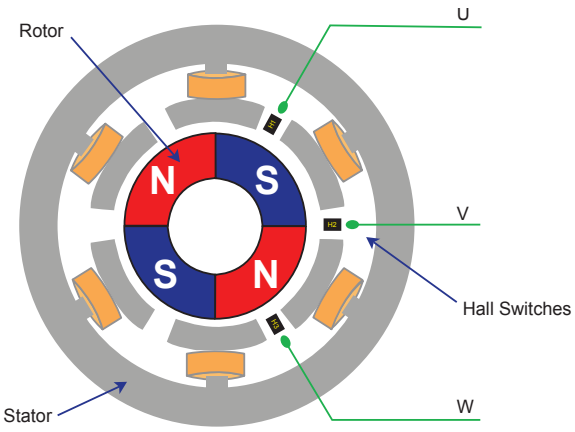
Commutation of Multi Pole Pair Brushless DC Motors

To provide smoother operation with low ripple, most three phase brushless DC motors use more than one pole pair on the rotor. As the number of poles increases, the number of angular states for one 360° revolution increases. This has the effect to reduce torque ripple. However, this means that the control algorithm has to process more UVW commutation steps for each revolution. This can limit the maximum motor speed due to system processing limits, and eventually a trade-off is reached between motor performance and cost.

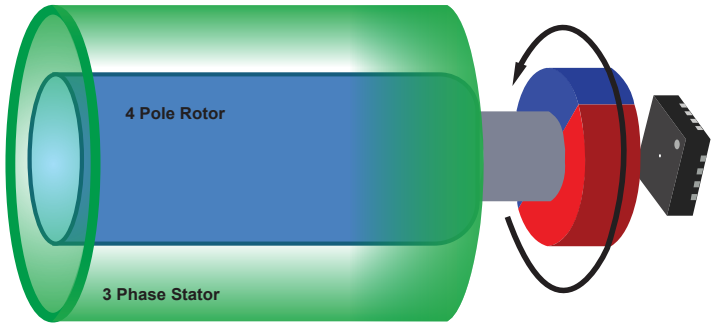
The MA102 sensor has the capability to produce UVW signalling for 1 to 8 pole pair rotors, using just a simple two-pole diametrically polarized magnet at the end or side shaft (see Figure 9).

The low latency angle acquisition of the SpinAxis™ sensing technique means that rotor speeds over 100kRPM can be supported, even for high pole pair counts.

Figure 9: Multi-Pole Pair Emulation with the MagAlpha Sensor



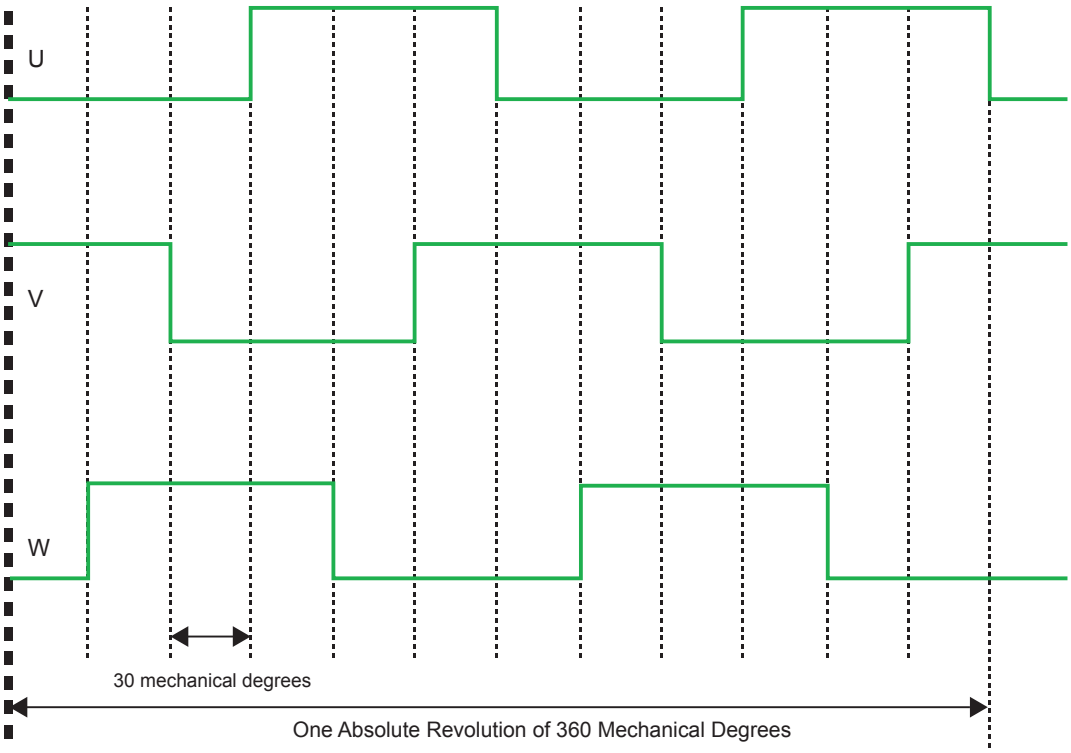
Traditional Four-Pole Rotor (Two Pole Pair) BLDC Motor with Three Hall Sensors



New Four-Pole Rotor (Two Pole Pair) BLDC Motor with MagAlpha Solution

Commutation of Multi Pole Pair Brushless DC Motors

Pole Pairs	States per Revolution	State Width in Degrees
1	6	60
2	12	30
3	18	20
4	24	15
5	30	12
6	36	10
7	42	8.6
8	48	7.5



The MA102 programmed for 12 x 30° stats per 360° replaces three conventional Hall switches and uses a simple two-pole disc magnet to commutate a four pole rotor BLDC motor

General Angle Sensor Applications

MA7xx Family

Many applications require position or angle feedback for system control. Examples include:

- Robot consumer appliances
- Joysticks / gaming devices
- Camera gimbal stabilization
- Industrial process automation: rotary position encoders & actuators
- Automotive systems: pumps, fans, e-turbo, headlight adjusters, windshield wipers

The MagAlpha MA7xx range provides accurate sensing of the angular position with the direct output of the digital angle value on an SPI or SSI interface, incremental encoder information on the ABZ interface (MA700, MA702, MA704, MA710, MA730), and PWM output (not present on the MA700).

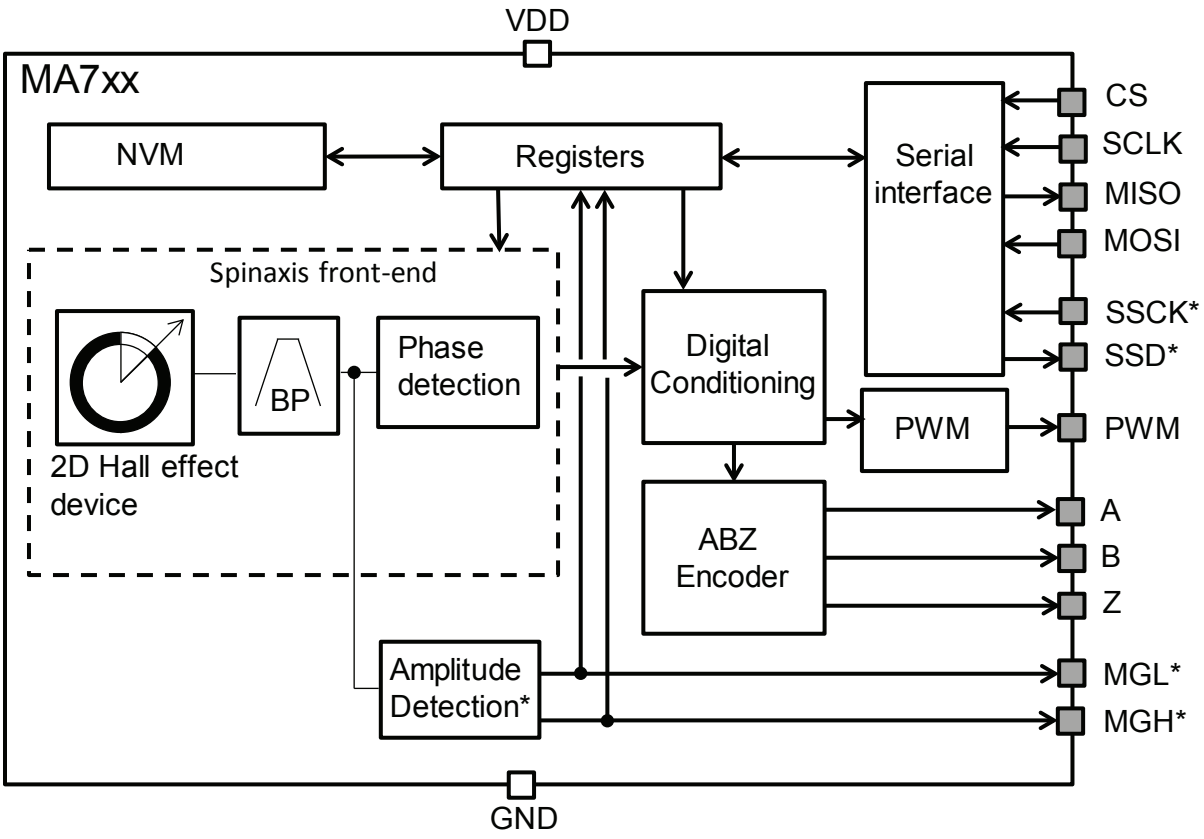


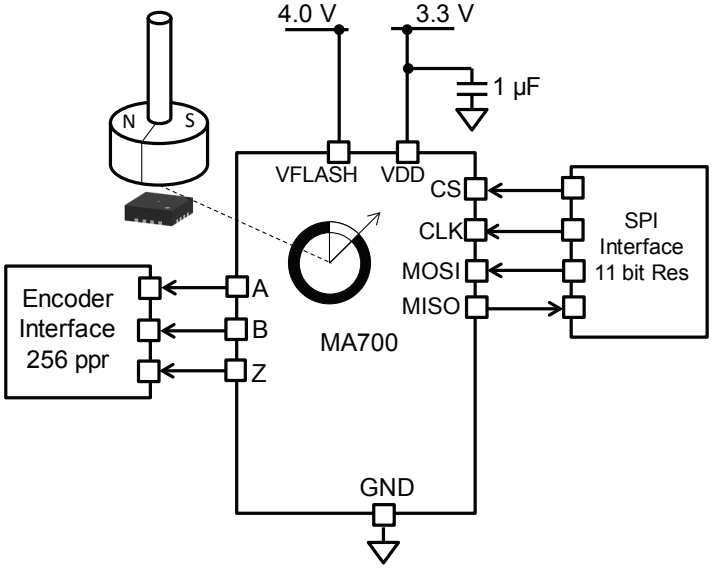
Table 3: MagAlpha Rotary Angle Sensors

Features by Part		Rotary Angle Sensors					
	Unit	MA700 Digital & ABZ	MA702 Digital & ABZ	MA704 Digital & ABZ	MA710 Side Shaft Optimized Digital & ABZ	MA730 High-resolution Digital & ABZ	MA750 PWM
Effective angle resolution	bit	11	12	10	12	14	8
Dynamic response		High	High	Ultra-high	Medium	Medium	Slow
Magnetic field range	mT	30 .. 150	30 .. 150	30 .. 150	15 .. 150	40 .. 150	30 .. 150
Zero setting		✓	✓	✓	✓	✓	✓
Side shaft compensation		✓	✓	✓	✓	✓	✓
Adjustable direction			✓	✓	✓	✓	
SPI register configuration		✓	✓	✓	✓	✓	✓
Absolute angle on SPI	bit	11	12	10	12	14	8
Absolute angle on SSI	bit		12	10	12	14	
ABZ incremental		✓	✓	✓	✓	✓	
ABZ resolution	PPR	256	1 .. 256	1 .. 64	1 .. 256	1 .. 1024	
Adjustable Z pulse			✓	✓	✓	✓	
PWM output			✓	✓	✓	✓	✓
PWM resolution	bit		12	10	12	14	12
Magnetic field detection			✓	✓	✓	✓	

MA700: 11 bit Angle Sensor

The MA700 is a general purpose angle encoder providing 11 bit resolution absolute digital angle output via an SPI interface at rotation speeds from zero to over 100kRPM.

The MA700 has an ABZ quadrature encoder interface with fixed 256 pulses per A or B channel per 360° rotation. As such, the ABZ interface can provide 1024 unique edges per rotation (equivalent to 10 bit). End and side shaft mounting topologies are supported. One-time programmable (OTP) memory is provided on-chip for storage of configuration settings including zero position and side shaft linearization parameters.

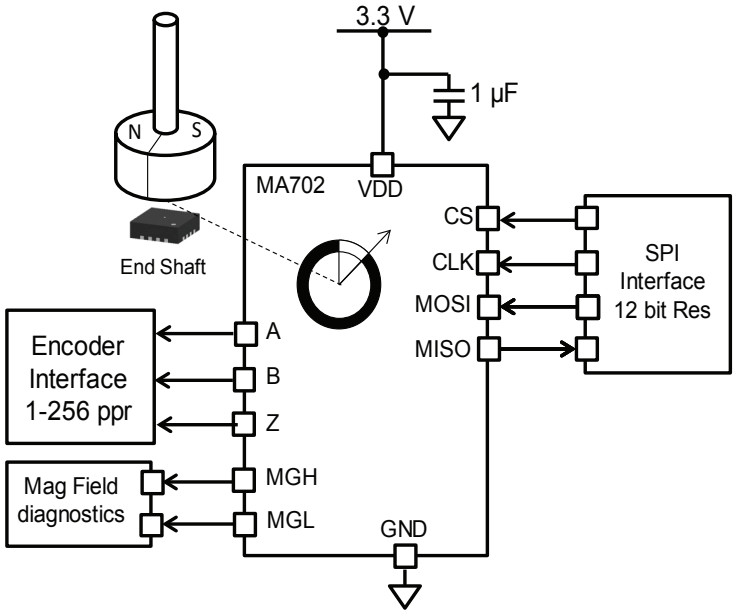


MA702: 12 bit Fast Response Angle Sensor

The MA702 represents the latest generation of MagAlpha technology and is optimized for encoder applications needing high accuracy over rapidly changing rates of change of rotation.

Example applications include external position encoders on servo motor drives and industrial actuators. The internal signal conditioning is optimized to provide 12 bit position resolution whilst maintaining low latency under rapid speed change. Speed ranges from zero to over 100kRPM are supported.

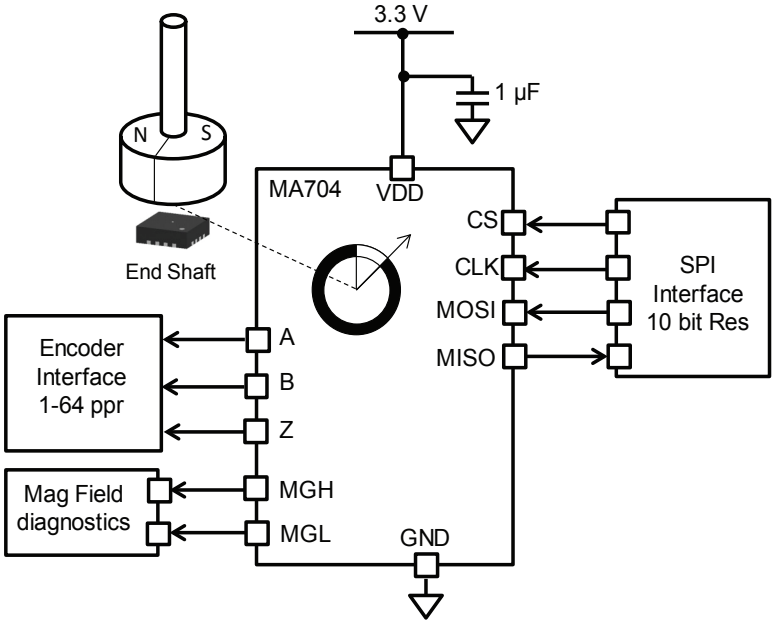
12 bit absolute digital angle resolution is available via the SPI bus. A programmable ABZ quadrature encoder interface provides 1 to 256 pulses per 360° rotation. End and side shaft magnet topologies are supported.



MA704: 10 bit Ultra-Fast Response Angle Sensor

The MA704 represents the latest generation of MagAlpha technology and is optimized for position control loops needing very high dynamic response times. Compared to the MA702, the MA704 resolution is restricted to 10 bits, and the internal signal conditioning is further optimized to give the shortest response times to speed change.

Rotation speeds from zero to over 100kRPM are supported. 10 bit absolute digital angle resolution is available via the SPI bus. A programmable ABZ quadrature encoder interface provides 1 to 64 pulses per 360° rotation. End and side shaft magnet topologies are supported.

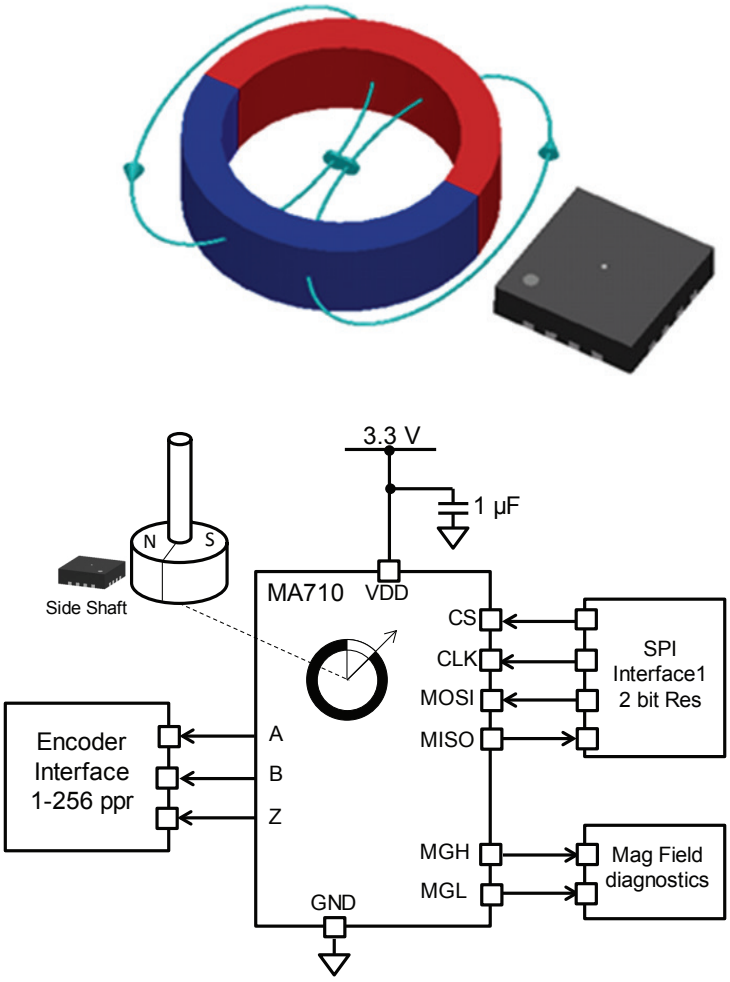


MA710: 12 bit Side Shaft Optimized Sensor

The MA710 represents the latest generation of MagAlpha technology and is optimized for applications that work with side shaft magnet positioning.

In side shaft orientation, the sensor sees magnetic field strengths of different amplitudes and has to equalize these to linearize the sensor's response. MagAlpha sensors supporting side shaft position enable this feature by use of bias current trimming (BCT) registers to normalize field strengths in the relevant axis.

Figure 13: Side Shaft Mode



One consequence of side shaft positioning is that the resultant field strengths are lower than in end of shaft magnet positioning. The MA710 is optimised to compensate for these lower field strengths whilst maximising angle resolution.

12 bit absolute digital angle resolution is available via the SPI bus. A programmable ABZ quadrature encoder interface provides 1 to 256 pulses per 360° rotation.

MA730: 14 bit High Resolution Angle Sensor

The MA730 represents the latest generation of MagAlpha technology and is optimized for encoder applications needing the highest resolution. The absolute digital angle is provided on the SPI interface with 14 bit resolution. A programmable 12 bit resolution ABZ incremental encoder interface is provided with up to 1024 pulses per revolution per channel, or 4096 combined edges.

Signal conditioning time is increased to maximize the output resolution. Rotation speeds of over 50kRPM are supported. Typical applications include replacement of optical encoders for higher system reliability and lower system cost.

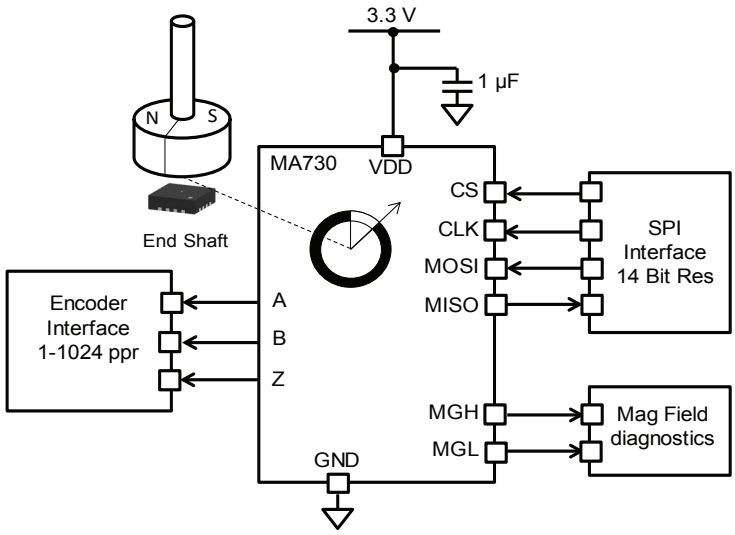
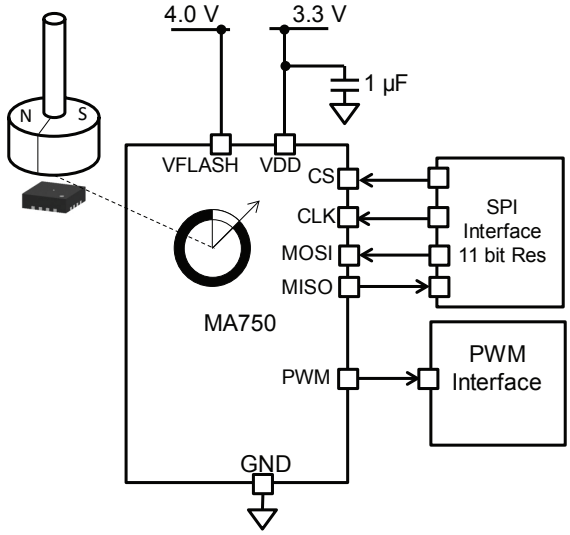


Figure 14: A Conventional Optical Encoder

MA750: 11 bit PWM Angle Encoder

The MA750 provides a high resolution 11-bit pulse width modulated output at 15KHz. The PWM output can interface directly to a microcontroller or can be analog filtered to provide a linear output voltage proportional to the angle being measured.

In this way, the MA750 can replace potentiometer based angle sensors for higher reliability. Many industrial systems rely on older rotary track potentiometers for position feedback. Potentiometers suffer from a short operating lifetime due to mechanical wear and environmental susceptibility to dirt and moisture. Use of a contactless magnetic angle sensor eliminates both of these issues.



Filtering the PWM Output

For parts with a PWM output (MA702, MA704, MA710, MA730, MA750), the PWM can be filtered to provide a ratiometric linear analog voltage replicating the output of a conventional potentiometer.

For an analog output in the same range as the MagAlpha supply of 0 to 3.3V, a simple RC can be used, or for a wider output voltage range (for example, 0.5V to 4.5V as found in many potentiometer-based systems), an OP-AMP filter can be used.

See Figure 15 and Figure 16 below.

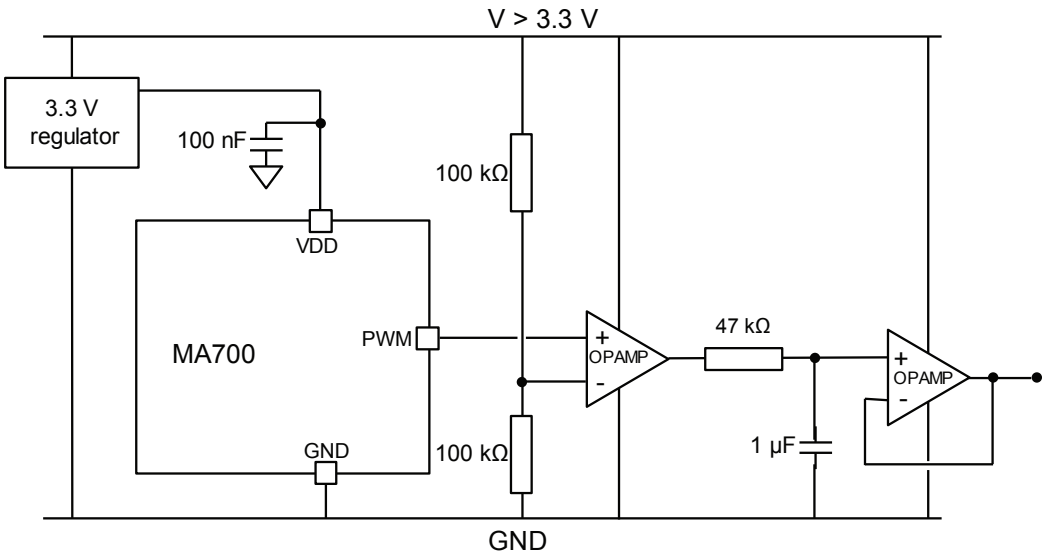
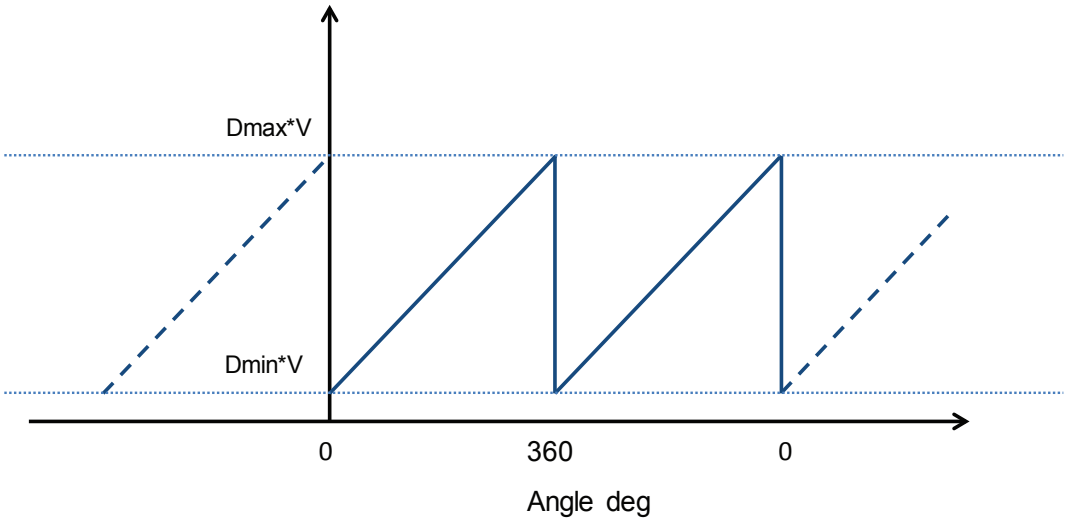


Figure 15: Example of Circuit for MA700 Filtering the PWM Output with an OP-AMP



Dmin, Dmax = PWM duty cycle

Figure 16: Filtered PWM Output

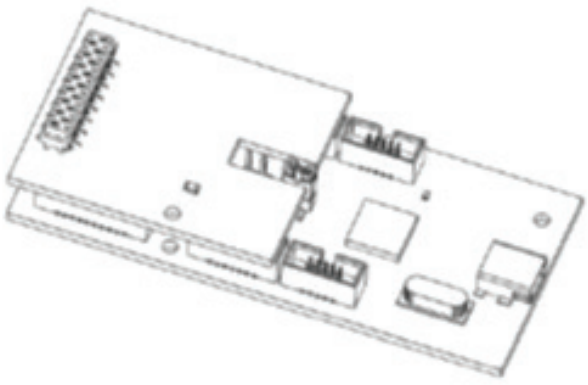
MagAlpha Sensor Evaluation Kits

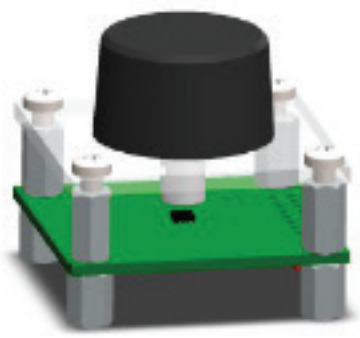
MPS provides a variety of evaluation tools and software to aid development with the MagAlpha family of angle sensors. The MagAlpha Communication kit (MACOM) interfaces via a standard PC USB port to a Windows-based software GUI that displays the sensors output angle value. It also allows configuration of various MagAlpha parameters including zero position offset, side shaft linearization, and magnetic field strength thresholds. Cables are included to interface either to the MagAlpha TMBA test boards or to the rotary EVMA turning knob evaluation kits.

A summary of the kits is shown in the table below. For a complete list of available kits, please refer to the MPS website **www.monolithicpower.com/Products/Position-Sensors/Products-Overview**

Name	Part Number	Kit Contents	Description
MagAlpha Communication Kit	EVKT-MACOM	LPC Link2 board TBMA-CONN board EVMA-CONN board 1x16 pin ribbon cable w/connectors 2x8 pin female micromatch connectors MACOM app for Windows	Universal PC USB interface kit for all MagAlpha sensor products
Test-Board MA Long	TBMAxxx-LT	Long shape test board for MagAlpha xxx = specific MAxxx part	Used with MACOM interface kit or customer's own SPI interface
Test-Board MA Round	TBMAxxx-RD	Round shape test board for MagAlpha xxx = specific MAxxx part	Used with MACOM interface kit or customer's own SPI interface
Rotary Knob Kit	EVKTxxx-KNOB	Sensor assembly with end of shaft mounted magnet and rotary knob xxx = specific MAxxx part	Used to evaluate MagAlpha in rotary interface applications

Communication Interface





About Monolithic Power Systems

Who we are:

We are creative thinkers. We break boundaries. We take technology to new levels. As a leading international semiconductor company, Monolithic Power Systems (MPS) creates cutting-edge solutions to improve the quality of life with green, easy-to-use products.

What we do:

We make power design fun! With our innovative proprietary technology processes, we thrive on re-imagining and re-defining the possibilities of high-performance power solutions in industrial applications, telecom infrastructures, cloud computing, automotive, and consumer applications.

Where we come from:

It started with a vision. Michael Hsing, pioneering engineer and CEO, founded Monolithic Power Systems, Inc. in 1997 with the belief that an entire power system could be integrated onto a single chip. Under his leadership, MPS has succeeded not only in developing a monolithic power module that truly integrates an entire power system in a single package, but also it continues to defy industry expectations with its patented groundbreaking technologies.

Our values:

We cultivate creativity
As a company we believe in creating an environment that encourages and challenges our employees to collaborate and think outside the box to excel beyond their preconceived capabilities.

We do not accept the status quo
We do not believe in limitations. It is not about what is, but what can be. Possibilities are endless at MPS.

We are passionate about sustainability
It's about the future. From materials to finances, we are committed to conservation. We will not tolerate waste in an effort to improve and preserve the quality of life.

We are committed to providing innovative products to our customers.
Let us do the heavy lifting. We relentlessly strive to make system design versatile and effortless to meet our customers' specific needs. We'll do the work, so our customers can have the fun.

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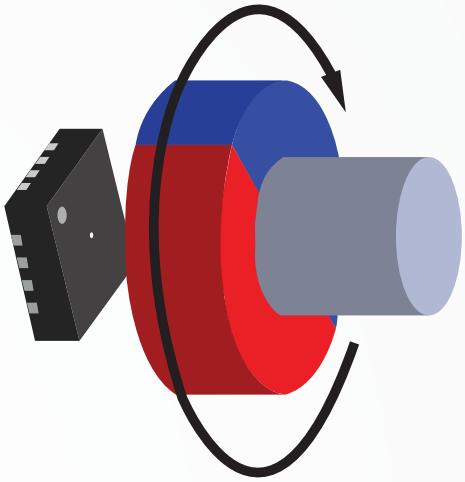
Magnetic Angular Position Sensors

Product & Applications Brochure



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