MA800 Family Contactless Angle Sensing Increases Reliability in Rotary Switch Applications

The mechanical potentiometers and switches used in most rotary user interfaces suffer from limited operating life and low reliability due to mechanical wear and susceptibility to environmental damage. This article discusses how magnetic contactless sensing can eliminate these issues and simultaneously provide additional benefits and features.

Rotary knobs are used in a diversity of human-to-machine interface applications, from the program selector on a washing machine, to the infotainment and navigation control system in a car, to the temperature control knob of an oven. These applications typically use a conventional potentiometer or, in some cases, a mechanical rotary switch. The drawback of such approaches is the operating lifetime. The resistive tracks on a potentiometer or the contacts on a switch wear out over repeated turns, and such solutions are often limited to around one hundred thousand cycles. They are also prone to failure due to environmental factors such as dirt or moisture ingress into the rotary shaft mechanism.

The use of magnetic angle sensors to implement contactless sensing has distinct advantages for rotary interfaces. The obvious advantage is a much longer life span since there are no contacting parts to wear out. Additionally, the fact that the sensor is physically separate from the magnet means that complete hermetic isolation of the sensor is possible, removing the possibility of dirt or moisture ingress.

The MagAlpha MA800 family is a new, simple-to-use, digital, magnetic sensor range designed to replace analog potentiometers or rotary switches in the above applications. The sensor detects the absolute angular position of a permanent magnet attached to the rotating knob. Typically, a simple diametrically magnetized cylinder of 3mm to 8mm diameter is sufficient.

A wide field strength range of 30mT to 150mT is supported, which allows for flexibility in the mechanical arrangement of the rotary knob and sensor. A typical arrangement is shown in Figure 1.

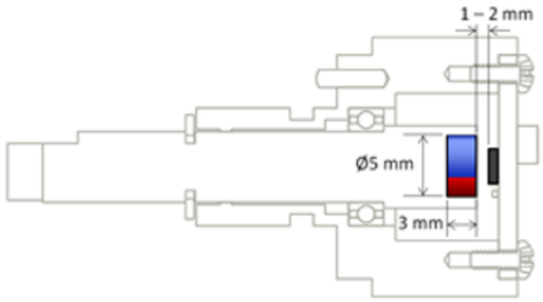

Figure 1: Example of a Potentiometer-Like Assembly Using Contactless Sensing with the MA800

At the heart of the MA800 family is the proprietary angular Hall sensing technology called the SpinAxisTM, which converts the mechanical angle information into a digital format without the need of complex analog-to-digital conversion and mathematical computation. A block diagram of the sensor architecture is shown in Figure 2.

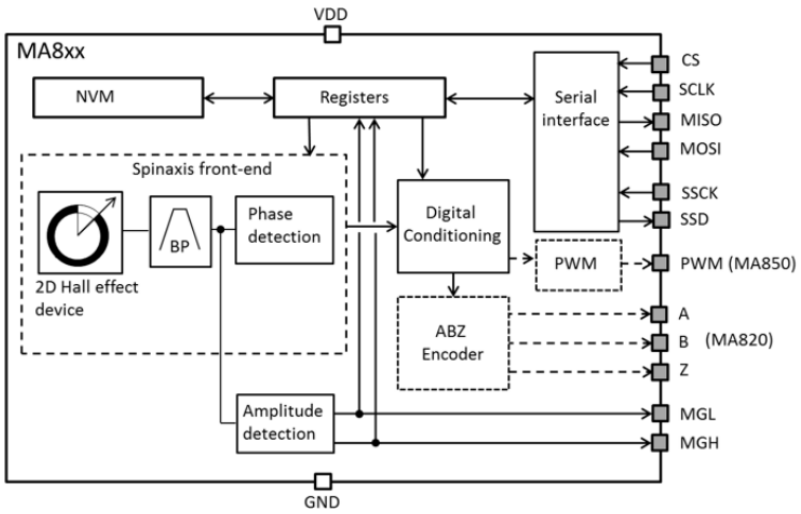

Figure 2: Block Diagram of the Sensor

This unique approach provides high performance and cost effectiveness due to its simplicity, making the MA800 family competitive against existing potentiometer or mechanical switch solutions, even in price-sensitive consumer applications.

There are three members in the MA800 family: the MA800, MA820, and MA850.

The MA800 sensor outputs the digital angle reading via an SPI or SSI interface. This allows for 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 is absolute, the position information is always true, even after the power is cycled.

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 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. Example uses could include a volume or temperature control or a menu select scroll wheel on a graphical interface.

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 (see Figure 3).

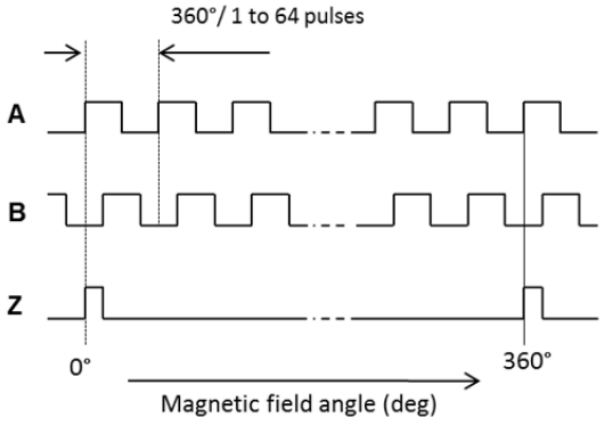

Figure 3: Quadrature ABZ Waveform

The MA850 features a PWM output which can be filtered to provide a linear voltage proportional to the angle. In this way the MA850 is suitable for applications needing to retrofit to the analog output voltage of a traditional potentiometer solution. The PWM has an 8-bit resolution and frequency of approximately 3kHz. Adding an R-C network to the output provides an output voltage over the duty cycle range of 10-90% of the 3.3V supply (see Figure 4).

For a 0 to 5V applications, the R-C network can be buffered by a simple OP-AMP circuit to provide a wider output voltage range.

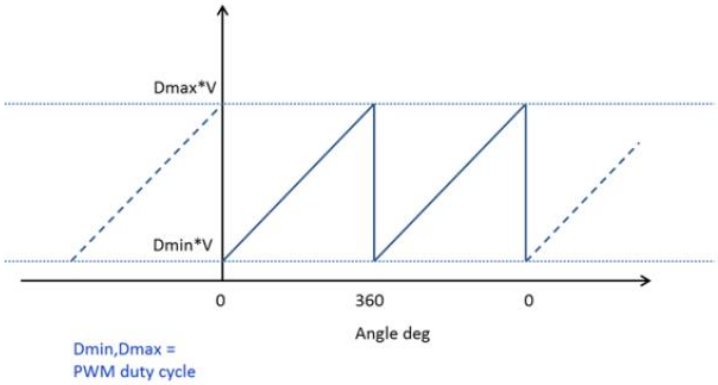

Figure 4: Filtered PWM Waveform

Some rotary interfaces also require push button functionality to implement program selection. For example, to scroll through radio stations and select the one you wish to listen to has previously only been possible by adding further mechanical complexity to the knob in the form of a contacting switch. The MA800 family provides the capability to implement a push or pull button function by having programmable magnetic field strength thresholds which detect the distance of the magnet to the sensor and provide dedicated signals to indicate when those thresholds are triggered. A non-contacting push button function is therefore easy to implement with a simple spring action on the rotary knob to move the magnet closer or further from the sensor. The threshold settings are shown in Table 1.

Table 1: Magnetic Thresholds

MAGLOW / MAGHIGH	Field threshold in mT	
	From low to high magnetic field	From high to low magnetic field
000	20	15
001	36	31
010	51	46
011	67	62
100	83	78
101	99	94
110	114	109
111	130	125

Two detection directions are implemented with programmable MAGHIGH and MAGLOW thresholds, allowing either a push or a pull to be detected.

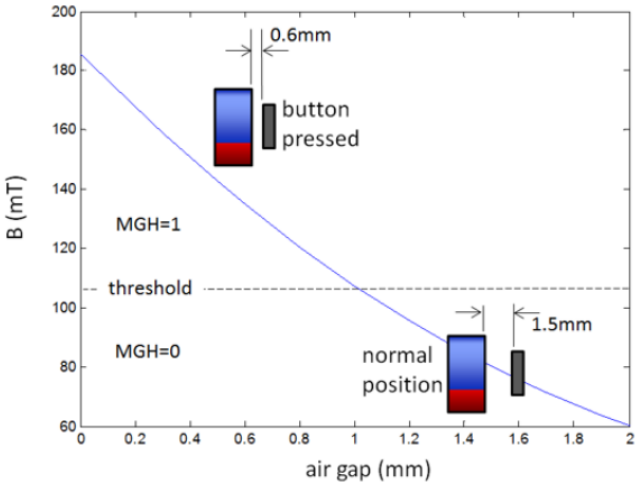

Figure 5: Push Button Detection B (mT) vs. Air Gap

Configuration parameters are automatically stored in the MA800 family devices' non-volatile memory whenever a register is written via the SPI interface. The non-volatile memory provides storage for parameters such as the reference zero angle position, the ABZ pulse per turn setting, and the magnetic field detection thresholds.

The MA800 family operates from a 3.3V supply and is packaged in a QFN (3mmx3mm) package. The operating temperature is -40°C to +125°C.

Conclusion

The unique flexibility of the MA8xx family provides designers with an innovative way to improve reliability in rotary interface applications while simultaneously adding increased functionality to the end user's experience. Its small size and cost effectiveness make it suitable for a wide variety of consumer and industrial and automotive applications.