Introducing the MagAlpha MAQ430 & MAQ470: 12-Bit, Automotive-Grade, Magnetic Angle Sensors

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Abstract

Measuring angular movement or rotation in vehicles is becoming increasingly important as vehicles integrate more technologies and systems to aid their drivers. To simplify the number of user interfaces, many vehicle system options have become controllable via a single rotary knob selector. At the same time, many previously manual features, such as seat position, door closure, and tailgate mechanisms, are being motorized, which require control of motor rotation, position, and speed. For both application areas, magnetic angle sensors can provide a highly reliable and contactless way to measure angles, rotation position, or speed. This article discusses how the MagAlpha MAQ470 and MAQ430 automotive-grade angle sensors from Monolithic Power Systems (MPS) can be used in such systems.

As vehicles become ever more sophisticated by providing drivers with electronic control of entertainment, communications, navigation, and engine systems, user interfaces must be simplified to keep the cabin uncluttered and to eliminate driver distractions. Typically, this results in a single, central, rotary control to scroll through and select options via a display panel menu of the various systems within the vehicle. Since that interface is used every time the vehicle is driven, it requires a highly reliable solution to guarantee a long operating lifetime. Mechanical or potentiometer-based rotary switches suffer from mechanical wear and susceptibility to damage from environmental factors, such as moisture or dirt ingress, which can cause early failure. Because magnetic angle sensors are contactless, they provide a highly reliable way of implementing rotary position detection. They can also replace mechanical push buttons by measuring the change in magnetic field strength when a selection knob is pressed down or lifted up.

Some new, advanced user interfaces provide haptic feedback through the knob dependent on the specific feature selected. For example, in a telephone interface mode, selections for the numbers 0-9 are electrically transformed into 10 fixed knob indents. In an audio volume control mode, many small indents are created to give a smooth ratchet impression when turned. Such haptic systems adapt the mechanical threshold between steps using a motor or solenoid coils linked to the selector knob. They require angle sensing and rotation speed measurement in conjunction with the chosen feature to control the number of indents and the haptic effect fed back to the user.

The MAQ470 provides a number of convenient interfaces to read angle position information and detect the speed or direction of rotation (see Figure 1). The absolute rotary angle information is output via an SPI/SSI or PWM interface with 12-bit (3-sigma) accuracy. The PWM signal can be further filtered externally to an analog voltage to mimic a potentiometer-based system. An ABZ quadrature incremental encoder interface with programmable pulse count is also provided. This can be used to provide speed and direction of rotation information, which is useful for scrolling through a menu display or adjusting an audio volume control function. Eight programmable magnetic field thresholds allow detection of changes in the distance between the magnet and the sensor so a contactless push button can be implemented to select the chosen feature (see Figure 2). The MAQ470 can operate over a wide magnetic field range of 30 to 150mT. The eight thresholds are programmable in approximate 15mT steps.

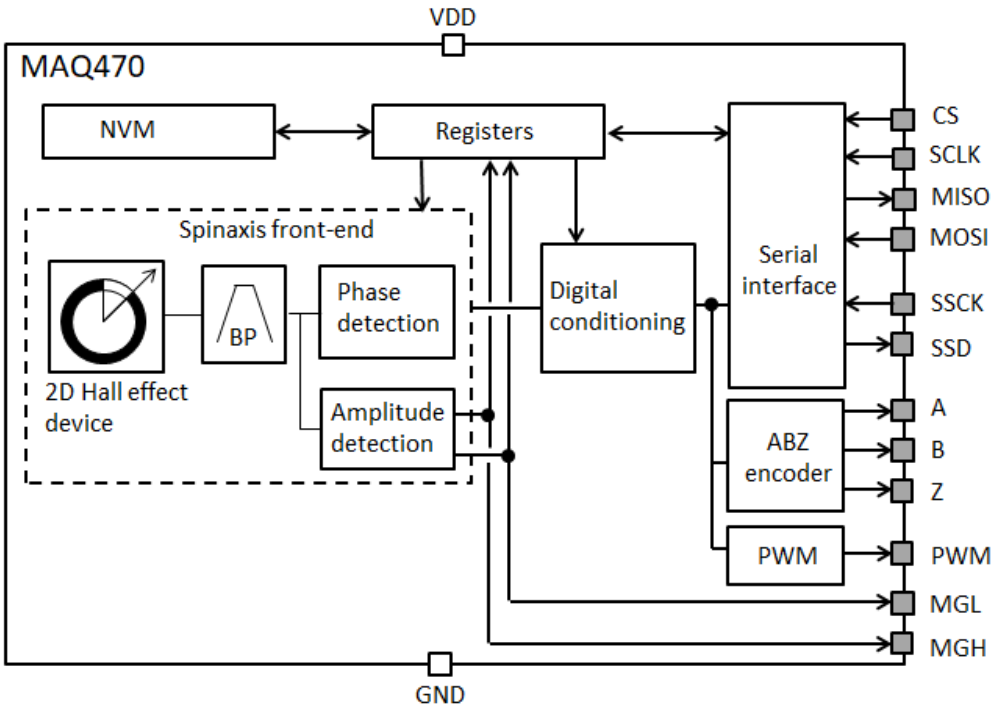

Figure 1: MAQ470 Magnetic Angle Sensor Block Diagram

Figure 2: Rotary Knob with Push Button Example

The use of electric motors is proliferating within vehicles to both increase performance and efficiency in the drive train and to provide increased driver convenience and comfort by automating previously manual features (e.g.: seat position controls, air conditioner mix setting, pop-out door handles, and powered assistance mechanisms for door closure, roof canopies, and tail gates, as shown in Figure 3). With the popularity of larger vehicles, such as SUVs, it is common that doors and tailgates are now motorized due to their size and weight. In addition to sensing when the door or tailgate is fully open or closed, there is also a safety requirement that the system must be able to sense whether an obstruction, such as the driver's hand, is trapped and quickly deactivate or reverse the motor drive to prevent injury. This requires rapid feedback of any change in the motor's rotation speed. Sensors such as the MAQ430 can provide two functions in this respect. Firstly, the absolute angle, speed, direction, or number of rotations can be monitored by either the SPI/SSI bus or the ABZ incremental encoder interface (see Figure 4). Secondly, for brushless motor systems, the MAQ430 sensor can emulate traditional, 3-Hall sensor, UVW commutation signals that inform the motor driver when to energize each phase winding. With the addition of the MAQ430 sensor, the motor becomes a fully brushless servo implementation. Such motors in vehicles are sometimes referred to as compact brushless actuators (CBA).

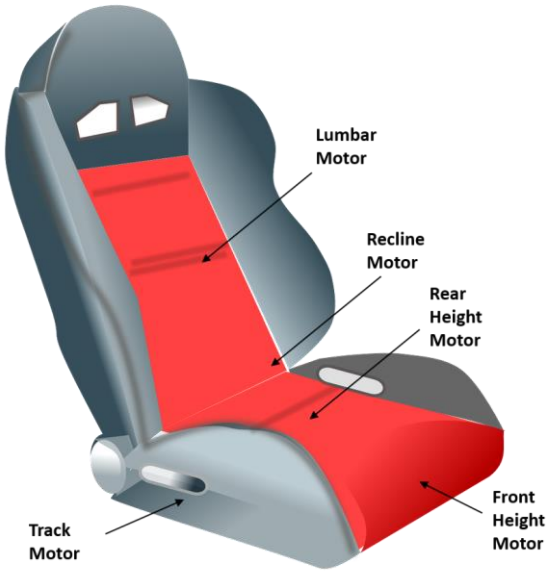

Figure 3: Motorized and Automated Controls

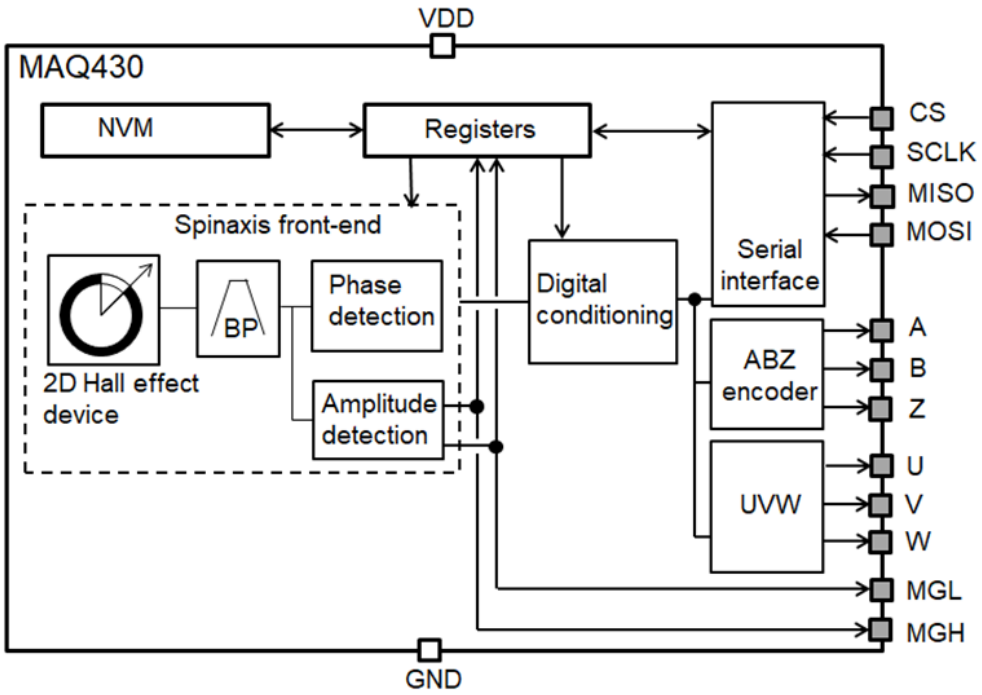

Figure 4: MAQ430 Magnetic Angle Sensor Block Diagram

Size is often a critical factor in the design of such actuators to minimize vehicle weight and fit within the tight mechanical constraints of the mechanism. The MAQ470 or MAQ430 are available in small QFN (3mmx3mm) packages, and the typical disc magnet size is only 3mm diameter by 2mm height for an end-of-shaft topology, making these solutions compact and cost-effective.

A useful feature of these sensors is the ability to operate with several topologies of magnet and sensor position. In addition to the usual end-of-shaft magnet position, the MAQ470 and MAQ430 also support two types of side-shaft configuration (see Figure 5).

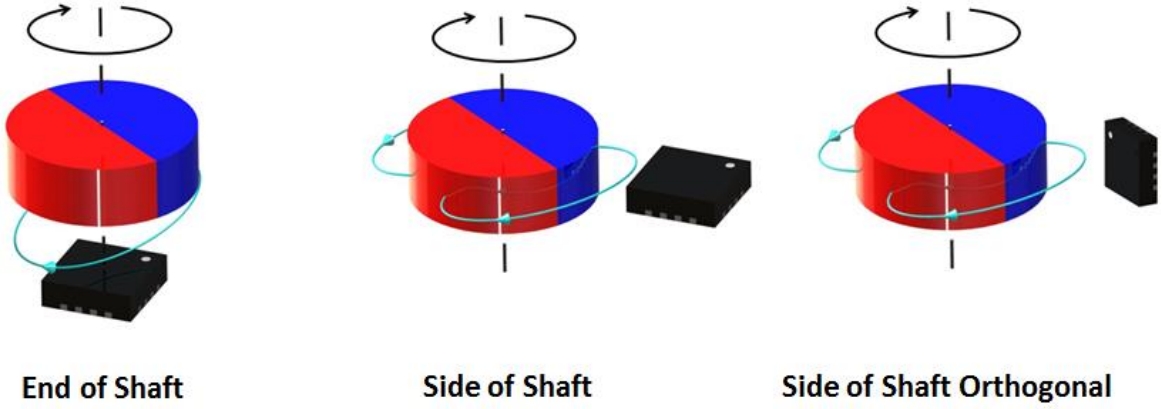

Figure 5: MAQ430/470 Magnetic Angle Sensor Magnet-Sensing Topologies

Side-shaft configurations increase the choice of mechanical options, permitting designs that are more compact. For systems requiring redundancy for safety, side-shaft mode also permits the positioning of two sensors at 90° or 180° positions relative to each other around the magnet shaft axis.

For applications where the absolute position is not required, a multi-pole ring magnet can be used to increase the sensor's effective resolution. The sensor detects 360° of magnetic revolution for each magnet pole pair on the ring. For example, in a motor commutation application, the number of poles on the ring can be matched to the rotor pole count. The sensor

can store a programmable offset so the sensor magnet poles can be aligned to the rotor poles during motor production.

Both the MAQ470 and MAQ430 magnetic angle sensors are qualified to AECQ grade 1 and support operation from -40 to +125°C, satisfying the requirements for the typical in-cabin and vehicle body systems described above. The devices are packaged in a small, 3mmx3mm, 16-pin, plastic, QFN with wettable flanks to aid production solder joint inspection.

The MagAlpha MAQ470 and MAQ430 sensors provide a highly reliable and contactless method to measure angles, position, and speed in automotive systems. Their compact size, multiple angle output formats, and flexible magnet position topologies ease the implementation of cost-effective angle sensors and actuators.

For further details, please contact MPS at www.monolithicpower.com.