Immunity from stray interference just got easier

David Schneider and Marcel Urban look at a new method being used to make magnetic position sensors highly immune to stray magnetic fields

David Schneider

Magnetic position sensing has proved popular in a range of motion- and motor-control applications in the industrial and automotive markets. Various methods for measuring flux density have evolved, leading to the development of the fully integrated position sensor IC or magnetic position sensor (MPS), which incorporates the magnetic sensing element, signal conditioning and signal processing on a single chip. The latest generation of 3D MPS can sense magnetic flux in three dimensions, permitting their use in a wider range of applications than ever before.

Whichever method for magnetic sensing is used, magnetic technology is more robust and reliable than optical sensing or contacting (potentiometer) methods for position sensing, since it is unaffected by the dust, dirt, grease, vibration and humidity commonly found in harsh automotive and industrial applications.

Design engineers who use conventional MPS are increasingly running into a problem, however: interference from stray magnetic fields, which tends to corrupt the MPS's output or reduce the signal-to-noise ratio (SNR) to unacceptable levels. Even the known risk of malfunction due to stray magnetism is damaging to safety-critical designs, which in the automotive field must comply with the stringent risk-management requirements of the ISO26262 functional safety standard.

The increased risk has emerged as electrification in vehicles has been extended. Motors and cables carrying high current are particularly powerful sources of stray magnetism; these can equally be found in many industrial applications.

Counter-measures to protect a vulnerable MPS from stray magnetism are cumbersome and expensive.

Protection from stray fields

A common approach to dealing with magnetic stray fields is to shield the sensor IC. This is a blunt tool to use. The shielding material interacts not only with the magnetic stray field, but also with the field of the magnet with which the MPS is paired. The shielding material may itself become magnetised, and its characteristics will also tend to change as the temperature changes. In addition, shielding materials exhibit hysteretic behaviour, potentially redirecting the paired magnet's flux lines away from the sensor. To prevent these parasitic properties of the shield disrupting the system's operation, it has to be placed at some distance from the magnet.

This limits the system designer's freedom and makes the system larger, heavier, more complicated, more difficult to assemble and more expensive.

A completely different approach, which requires no shielding, is to pair the MPS with a magnet that has very high remanence (Br), and to assemble it in close proximity to the MPS. The effect is to make the signal-to-stray-field ratio much more favourable; it has the same effect on the overall SNR.

Unfortunately, strong magnets, such as the NdFeB or SmCo types, are around ten times more expensive than cheap hard ferrite or plastic-bounded magnets, ruining the economic case for MPS in many cases and many applications cannot accommodate the magnet close to the IC.

Built-in immunity

The best approach is to make the sensor immune to stray magnetism. And in fact, a basic mathematical operation enables the noise from stray magnetic fields to be cancelled – provided the sensor's hardware supports the technique.

In addition, intelligent placement of the paired magnet, as close to the IC as possible, will always help to increase a sensor module's tolerance of stray magnetism, but the MPS has to have this feature built-in.

The crucial hardware feature of an MPS with stray field immunity is a dual-pixel magnetic sensing element. Unlike a conventional absolute 3D magnetic position sensor, a dual-pixel type uses two pixel cells instead of one to determine the position of the magnet. This dual-pixel structure then enables the implementation of differential measurement.

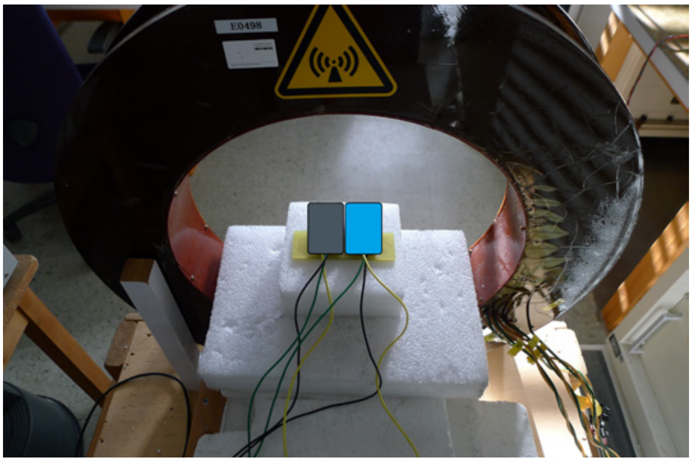

Figure 1

A demonstration

The superior performance of a dual-pixel MPS with differential sensing has been demonstrated in the laboratory. The test described below compared the measurement results from an automotive position sensor module containing a dual-pixel MPS with another automotive module which contains a conventional single-pixel sensor. The modules measured the movement of a magnet in an arc above the sensor IC (Figure 2). The sensor IC's output voltage changes in relation to changes in the position of the magnet (Figure 3). This kind of measurement would typically be required in an application such as measuring the movement of a car's brake, accelerator or clutch pedal.

A Helmholtz coil applied a stray field to the modules (Figure 1). The coil was configured to generate a stray field of known strength in the vectors Bx, By, or Bz and the output voltage of the modules was measured with an oscilloscope.

The captured data showed that the error of the single-pixel sensor IC is more than 30 times greater than the error of the dual-pixel IC when exposed to a stray field in the z direction.

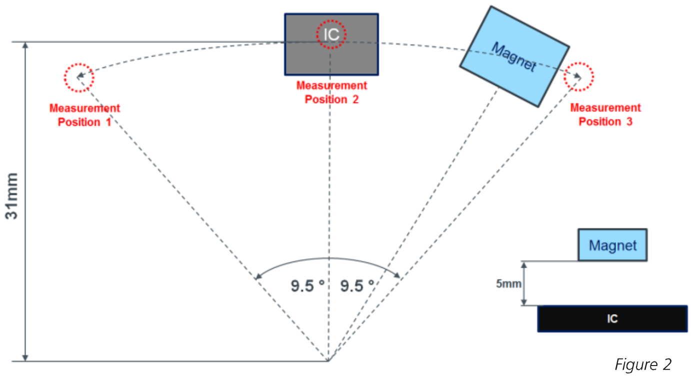

Figure 2

Conditions of test:
Magnet position: 4V
Stray field direction: z
Stray field frequency: 50Hz
Stray field strength: 2500A/m

DC stray fields appear as an offset superposed on the desired signal. AC stray fields appear as noise; the frequency of the stray field is superposed on the desired signal.

Figure 4 also shows a clear difference between the two sensor types. The ±1% error limit is a typical requirement in

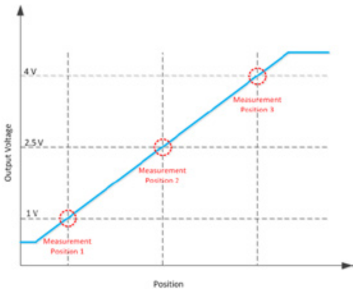

Figure 3

automotive motion-sensing applications. The test measured all noise sources, including the stray magnetic field. Integral non-linearity and temperature drift are application-dependent, and so their values are not included in this diagram.

Dual-pixel products

The dual-pixel method of differential sensing is implemented in all the AS54xx series of automotive-qualified MPS from ams. They can be used in a temperature range of -40°C to 150°C, with no temperature compensation. Designed to be extremely sensitive, they can operate in a large input range from 5mT to 100mT. When combined with high tolerance of magnetic stray fields, this allows the use of small and cheap magnets.

Reliable operation in the presence of stray magnetism helps automotive system designers to comply with ISO26262. Other functional-safety features in the AS54xx devices include integrated self-monitoring functions. The safety layer provides protection in the event of a failed ground connection or power supply, as well as under- and over-voltage protection. Advanced safety functions include an EEPROM self-check which detects bit flips.

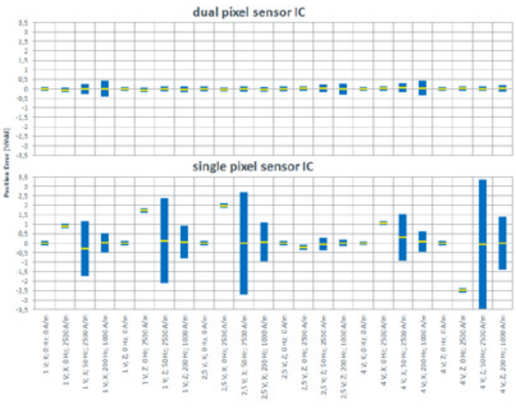

Figure 4

The dual-pixel differential principle of operation does not only provide for stray field immunity, however: it also eliminates the need to offset for drift over temperature and time. Featuring 14-bit resolution, these MPS offer both accuracy and precision, making them suitable in a wide variety of applications.

In the automotive arena, stray field immunity is going to become an increasingly important attribute of MPS as the drivetrain of vehicles becomes partially or wholly electrified. New standards such as ISO11452-8 add to the challenge.In this electromagnetically and mechanically harsh environment, 3D dual-pixel sensor ICs provide a means for designers to achieve robust performance and to provide for compliance with the most exacting functional safety standards, without the need for complicated and expensive magnetic shielding.

Summary

Magnetic position sensors (MPS) have proved popular in a range of motion- and motor-control applications in the industrial and automotive markets. The latest generation of 3D MPS from ams can sense magnetic flux in three dimensions, permitting their use in a wider range of applications than ever before.

Magnetic technology is more robust and reliable than optical sensing or contacting (potentiometer) methods for position sensing, since it is unaffected by the dust, dirt, grease, vibration and humidity commonly found in harsh automotive and industrial applications.

Design engineers who use conventional MPS are increasingly running into a problem, however: interference from stray magnetic fields, which tends to corrupt the MPS's output or reduce the signal-to-noise ratio to unacceptable levels. The increased risk has emerged as electrification in vehicles has been extended. Motors and cables carrying high current are particularly powerful sources of stray magnetism; these can equally be found in many industrial applications.

Counter-measures to protect a vulnerable MPS from stray magnetism are cumbersome and expensive. As this article shows, a better method is to make the MPS immune to stray magnetic fields. It has described the operation of differential sensing, a technique made possible by the use of MPS with dual-pixel sensing elements. It then shows the results of tests of a dual-pixel and a conventional single-pixel MPS, revealing the superior rejection of stray magnetism by the dual-pixel version.

ams I www.ams.com

David Schneider and Marcel Urban are Marketing Application Engineers at ams AG