General description

SensoNor has a long history in developing and supplying inertia sensors for a number of application areas. In recent years SensoNor has established a completely new technology platform for micro electro mechanical systems (MEMS) using single crystal silicon. This includes advanced silicon and glass processing as well as automated assembly, test and packaging. SAR10 with its double mass "butterfly" shaped structure takes the full benefit from this new platform using simple single sided electrostatic excitation and capacitive detection. In addition to reduced size, reduced cost and reduced power consumption the use of single crystal silicon, which perform close to ideally elastic, will secure excellent long term behaviour. The micromachined "gyro element" is assembled together with an advanced mixed mode full custom ASIC chip into an epoxy transfer moulded miniature package.

The functional principle is based on the excitation of a reference motion (excitation vibration) that enables conservation of momentum. An angular rotation (angular rate input) of the device containing the reference motion will generate Coriolis forces (inertial forces due to the law of conservation of momentum), whose frequency equals that of the reference motion.

By using SensoNor's unique patented sealed cavity technology, the vibrating masses are protected from contaminations as well as contained within a low-pressure hermetic environment needed for creating low dynamic damping and high Q factors. The structure is built up by using a glass chip with metallized patterns defining excitation and detection electrodes as well as bonding pads, a middle micromachined silicon chip with the masses which also represent the opposite electrode and a top cover glass chip. The three chips are bonded together using anodic bonding and the low parasitic electrical crossings into the cavity are established by using a buried conductor technique.

The double masses are suspended using a beam with an asymmetric cross section so that transversal (normal to the chip) electrostatic forces bend the beams both transversal and lateral (in the plane of the chip) creating a rotational excitation oscillation. The vibrating masses are shaped so that the velocity vectors are essentially lateral which generates Coriolis forces and therefore transversal detection oscillations, which are capacitively detected. In this way the simplicity and maturity of bulk micromachining is combined by the benefit of a high "gyroscopic" sensitivity.

By the symmetric mechanical design and by connecting the electrodes cross-wise symmetric, the "butterfly" masses are operated in a balanced anti-phase movement. The balanced anti-phase vibration of both the excitation mode and the detection mode makes SAR10 insensitive to environmental vibrations, limits effects causing offset as well as improves the Q-factors.

A fine-tuning of the detection vibration mode is done during final test for each sensor by applying and programming a DC-bias utilising the nonlinearity of the electrostatic force to reduce the mechanical stiffness.

In addition to the DC-bias function the ASIC contain several control loops. The excitation loop is responsible for setting up a constant amplitude movement for the excitation mode. Critical issues controlled are start-up time, noise and mode selectivity. The detection loop is responsible for recovering the rate signal proportional to the Coriolis force. This is achieved using a closed loop operation. Critical issues controlled are noise, bandwidth and sensitivity. A time multiplexed, switched interface is used between the "gyro element" and the ASIC. This makes it possible to improve the symmetry using the same electrodes for drive interface and sense interface. A switched demodulator is used to demodulate the AM signal.

The demodulated signal is AD converted. Fixed algorithms using calibration coefficients determined during final test for each sensor and stored in OTPROM polyfuse cells and readings from the internal temperature sensor are used for accurate angular rate definition as well as for temperature compensation. Both digital HP as well as LP filters are also included.

SAR10 is designed to be located in the vicinity of a microcontroller and the communication between the MCU and the SAR10 is provided through an SPI-interface. The angular rate data is in the form of a 10-bit word. The 8 MSB's are read using the command RARH (read angular rate high byte) and the 2 LSB's by the command RARL (read angular rate low byte). The 3 MSB's of the response from the RARL command is a fixed bit pattern included to detect "stuck at" errors for the communication between the MISO (master in slave out) and the MCU. The response to either command will be a STATUS error byte if data is not valid. This self-diagnosis function is linked to a number of internal error conditions.
Applications

The inherent performance of the "gyro element" and the modular architecture of the ASIC make even improved versions in respect to noise, resolution and filter characteristics easily available. Also versions with analogue output are planned for the future. SAR10 or improved versions based on the identical “gyro element” can meet requirements within a number of applications:

- Rollover airbag systems
- Adaptive cruise control systems
- Dynamic stability control systems
- Active suspension systems
- Navigation systems
- Intelligent ammunition
- Platform stabilisation
- Gamepads
- Data mouse and joystick controls
- Vision stabilisation systems
- Remote controls
- Robotic controls
- Angular vibration measurements
- Body movement
- Virtual reality

Shipment and mounting

SAR10 is shipped in standard blister tape, ready for automatic assembly machines. The very compact small outline package is perfect for standard reflow soldering processes.