COLIBRYS
SMART SENSING SOLUTIONS

# APPLICATION NOTE

## MEMS Accelerometers for mid accuracy navigation systems

30N.AERO.B.05.11


The MS9100 product, combines large g range and stability

### Features

- ±1g to ±200g range
- Long term bias stability
- Low rectification error
- Extra small 20 pin LCC ceramic package with hermetic sealing (8.9mm x 8.9mm)
- Harsh environment
- Small size
- RoHS compliant suitable for lead free soldering process and SMD mounting

### Introduction

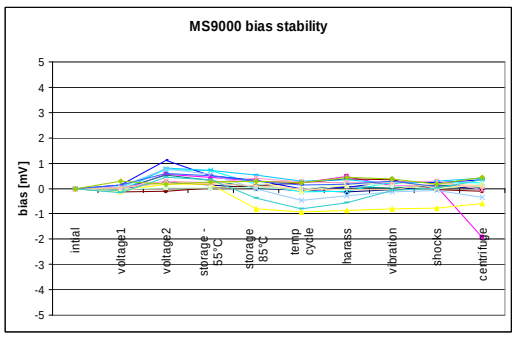
Mid accuracy navigation systems (IMU), AHRS and control systems require gyros and accelerometers to predict the position of a moving object in free space. Accelerometers are used to perform initial leveling and to correct the gyro drift on the move.

In this whitepaper we compare the main parameters of the ±10g Colibrys accelerometers MS9010.D and RS9010.A currently under development, to support the system designers and as a guideline for optimum selection of an accelerometer. Four main parameters are compared including bias repeatability, scale factor, axis misalignment and vibration rectification error. MS9010.D has a long term bias repeatability of better than 5mg while first result on RS9010.A samples is better than 1.5mg. The scale factor repeatability of MS9010.D is 400ppm whilst the value for RS9010.A is 150ppm. In addition, the vibration rectification error of RS9010.A has a potential to be better than 100µg/g².

Considering the various types of requirements, Colibrys offers a large choice of accelerometers for AHRS manufacturers, from the standard MS9010.D and MS9005.D offering the best price-performance ratio to the future RS9010.A representing the best choice for high performance systems. Various g range between ±2g and ±200g are also available

The main product differentiators for the selection of inertial accelerometers are long term bias repeatability, scale factor stability and repeatability of the axis alignment. These parameters are important since any offset of the output signal will be integrated twice over time to determine position. For an object flying several minutes with high accelerations, this could translate into a large position inaccuracy. Furthermore, very often the environment on which the accelerometer is mounted experiences some vibration due to proximity effects to an engine or any other source. The effect of the vibration on the sensor output signal is called vibration rectification error. For many applications, having a product with very low sensitivity to external vibration is of outmost importance.

### MS9010 accelerometers




Colibrys has been supplying MS8010.D and more recently MS9010.D and MS9005.D for a number of years for mid accuracy navigation systems and standard AHRS applications. Their total long term bias stability is better than 7.5mg for ±10g and better than 3.75mg for ±5g as the scale factor repeatability is better than 400ppm. The figure 1 shows the measurement results of the one year bias stability for various ranges of MS9000.D. The analysis includes results from an accelerated aging at 85°C for 10 days, corresponding to 18 months of standard life time, as well as shocks in six directions with amplitude of 1000g, 0.2ms each.

MS9000 has clearly demonstrated excellent shock performance both in term of post shock stability and survivability for many applications where shocks and ease of handling are an issue. Dedicated solutions with shock resistance up to 20'000g have also even been developed (HS8000 and HS9000).

Fig. 1: Bias stability including shocks at 1000g and aging at 85°C for 10 days (corresponding to 18 months of normal life). Combination of products from ±2g to ±100g

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# APPLICATION NOTE

## RS9010 accelerometer

To address new high end requirements, Colibrys is currently developing a new technology platform termed IRIS™. It consists of a novel MEMS sensing element, an open-loop ASIC and a temperature sensor housed in a 20 pin standard LCC package. RS9010.A is a ±10g accelerometer designed and manufactured for high accuracy mid range AHRS application.


Fig. 2: View of MS9010.D (LCC20: interior and sealed) and RS9010.A (LCC20 on evaluation board).

The IRIS™ technology consists of three major improvements: the new MEMS sensor design, the MEMS assembly technology and the improvement of the electronic interface. The new MEMS element is specifically designed for obtaining high bias and scale factor stability. This has been achieved by understanding the physics and mechanics of the sensing element, analyzing the mechanisms contributing to drift and then designing the sensor to be resistant to those mechanisms. IRIS™ uses the latest manufacturing technologies for MEMS such as DRIE and silicon fusion bonding (SFB). This results in uniform and highly predictable manufacturing processes with high yield and very repeatable outcome.

The four following figures show the preliminary performances of the RS9010.A accelerometer. We can see that the total bias shift after shock and long term aging, including hysteresis is better than 1.5mg as the scale factor stability is better than 150ppm. In addition, the vibration rectification error of the RS9010.A compares to electromechanical (Q-Flex) specifications. These combined performances confirm the RS9010.A as one of the future best candidates for high performance AHRS

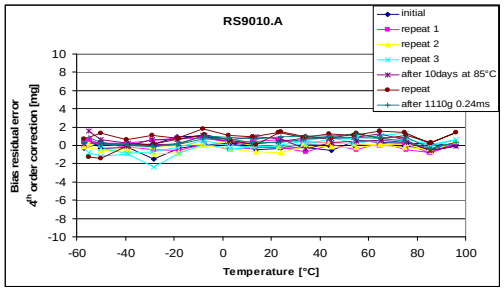


Fig. 3: Residual bias over temperature (after 4th order polynomial correction) including aging at 85°C for 10 days and shocks at 1000g

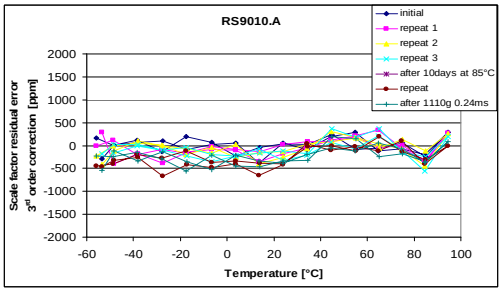


Fig 4: Residual scale factor over temperature (after 2nd order polynomial correction) including temperature hysteresis

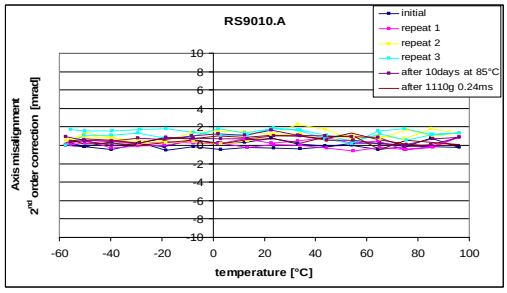


Fig. 5: Axis misalignment stability over full temperature range (after 2nd order polynomial correction), shock and accelerated aging

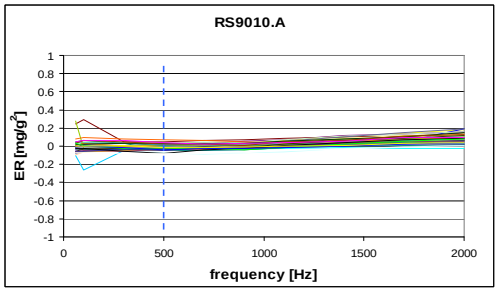


Fig 6: Vibration rectification error of RS9010.A < 100 µg/g2 over the frequency range of 20 to 500Hz and 500 to 2000 Hz. Superposition of 37 different sensors on this graphic

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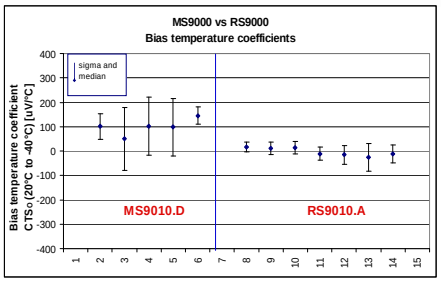
These few graphics clearly demonstrate that the RS9010.A is a real improvement compared to the well performing MS9010.D product. The following graphic further demonstrates the improved performances of the RS9010.A in term temperature coefficient over the full temperature range, suggesting improved performances of the long term stability.




## Conclusion

Colibrys has developed and supplies different accelerometers specifically designed for mid accuracy navigation systems (IMU) and AHRS.

The MS9010.D and MS9005.D with overall long term bias stability of about 5mg present the best price performance ratio for a standard AHRS. They are dedicated for example to general assistance to the navigation of small jets and airplanes, to backup solutions or to unmanned aerial vehicles (UAV). It is also the best solution for applications submitted to harsh environments in term of shocks and vibrations.

Example of UAV

The new RS9010.A, currently under development, with overall objectives of long term bias repeatability of 1.5mg, has already shown excellent vibration rectification characteristics with values lower than 100µg/g² for a 10g. These performances validate the RS9010.A as one of the optimum choices for future high precision AHRS applications such as UAV, large civilian airplanes, helicopters and land or naval navigation or any mid accuracy low g navigation system (IMU).

This new product is scheduled to be released for end of year 2011.