SEISMIC & VIBRATION MEMS SENSORS
BORN FROM TECHNOLOGY AND GROWN TO AN INDUSTRIAL LEADER

Colibrys started in 2001 as a spin-off from a Swiss technological incubator CSEM and matured as a SAFRAN Group company from 2013.
MEMS SENSORS

MEMS capacitive sensors are:

- Small
- Resistant
- Performant
- Cost Effective

One technology, numerous applications:

- Airplane
- Satelite
- Train
- Car
- Wind turbine
- Oil rig
WHY ARE VC SENSORS REPLACING PIEZO SOLUTIONS?

3 technologies available for vibration sensing, VC is the newest

### Piezo Electric (PE) quartz/ceramic
- 3Hz – 30kHz
- 20000g
- -200°C – 700°C
- excellent signal to noise
- no DC signal
- accuracy 10%
- sensitive to temperature variation
- no self-test

### Piezo Resistive (PR) bridge
- DC 0Hz – 6kHz
- 2000g (crash test)
- -55°C – 125°C
- good signal to noise
- bad drift (zero shift)
- accuracy 10%
- sensitive to temperature variation (need external compensation)
- no self-test

### 3D Bulk MEMS Variable Capacitance (VC)
- DC 0Hz – 6kHz
- ±1,2,5,10,30,50,100,200g
- -55°C – 175°C (SOI +300°C)
- excellent signal to noise
- accuracy 0.1%
- high stability over time and temperature (durability testing)
- true internal self-test
NEW STATE OF THE ART 6” SILICIUM FOUNDRY

- 8+ Million MEMS delivered
- 1+ Million MEMS Sensors
- 25+ years of experience
- Extensive designs for multiple applications
- Worldwide support & distribution
- Best in class equipment
- Own unique processes
- 54 patents
Colibrys ACCELERATION
Reference in Accuracy

- Inertial Sensor
- Inclinometer

Colibrys VIBRATION
MEMS For Low To Medium Frequency

- Vibration Sensor
- Seismic Sensor

Colibrys GYRO
Cost Effective Alternative To FOG

- Gyrometer Sensor
- Gyrometer Module

Colibrys CUSTOM
MEMS Experts At Your Service

- Foundry Services
- Custom Solutions
COLIBrys PRODUCT PORTFOLIO

Legacy products
- MS7000
- HS8000
- MS8000
- VS9000
- SF1600+SF2006

Future products
- RS9000
- TS1000T
- VS1000
- SEISMIC – SI1000
- GS1000
- ColibrysACCELERATION
- ColibrysVIBRATION
- ColibrysGYRO

2001 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 … 20
INNOVATIVE BOGIE MONITORING SYSTEM
Colibrys vibration sensors qualified by Siemens to build high-speed trains
AUTOMOTIVE TESTING
Colibrys MEMS world reference
ride quality / durability, vehicle dynamics, ride & NVH, head rest vibration
MONITORING & CONTROL

VIBRATION MONITORING
track in real time frequencies, overload, vibration and shock
SEISMIC STRONG MOTION

SEISMIC Class C 90dB
the VS1000 has an ultra-low noise in band of 7μg/√Hz for the ±2g range
WHAT IS INSIDE THE NEW VS1000?

MEMS SENSOR
- Optimized frequency response
- Improved die attach

NEW ASIC
- Improved bandwidth, non linearity, noise
- Overload detection and recovery after shocks
- Differential output

LCC SUBSTRATE
- Identical mechanical design as VS9000
- New pinout

“The new Colibrys ASIC represents a multi-million dollars project, with approximately 10 full-time top-notch engineers during 4 years (2012-2015)”
HOW DOES THE VS1000 WORK?

→ Functional Block Diagram

ISO 9001, ISO 14001, OHSAS 18001
<table>
<thead>
<tr>
<th>Parameter, typical values</th>
<th>VS1002</th>
<th>VS1005</th>
<th>VS1010</th>
<th>VS1030</th>
<th>VS1050</th>
<th>VS1100</th>
<th>VS1200</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-scale acceleration</td>
<td>±2</td>
<td>±5</td>
<td>±10</td>
<td>±30</td>
<td>±50</td>
<td>±100</td>
<td>±200</td>
<td>g</td>
</tr>
<tr>
<td>Frequency range (±5 %)</td>
<td>0-700</td>
<td>0-1'150</td>
<td>0-2'000</td>
<td>0-2300</td>
<td>0-2700</td>
<td>0-2'900</td>
<td>0-2'500</td>
<td>Hz</td>
</tr>
<tr>
<td>Frequency range (±3dB)</td>
<td>0-1’150</td>
<td>0-1’900</td>
<td>0-3’200</td>
<td>0-4’000</td>
<td>0-4’500</td>
<td>0-5’000</td>
<td>0-7’000</td>
<td>Hz</td>
</tr>
<tr>
<td>Non-linearity (full scale)</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>%</td>
</tr>
<tr>
<td>Noise (in band)</td>
<td>7</td>
<td>17</td>
<td>34</td>
<td>102</td>
<td>170</td>
<td>339</td>
<td>678</td>
<td>µg/√Hz</td>
</tr>
<tr>
<td>Scale factor (nominal)</td>
<td>1’350</td>
<td>540</td>
<td>270</td>
<td>90</td>
<td>54</td>
<td>27</td>
<td>13.5</td>
<td>mV/g</td>
</tr>
<tr>
<td>Scale factor temperature coefficient</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>ppm/°C</td>
</tr>
<tr>
<td>Bias temperature coefficient</td>
<td>±0.2</td>
<td>±0.5</td>
<td>±1</td>
<td>±3</td>
<td>±5</td>
<td>±10</td>
<td>±20</td>
<td>mg/°C</td>
</tr>
<tr>
<td>Shock Survivability</td>
<td>6’000</td>
<td>6’000</td>
<td>6’000</td>
<td>6’000</td>
<td>6’000</td>
<td>6’000</td>
<td>6’000</td>
<td>g</td>
</tr>
</tbody>
</table>
NEW ASIC 200’000 HZ CLOCK OFFERS OUTSTANDING FLAT FREQUENCY RESPONSE

» Frequency range from DC 0Hz up to 2500Hz (typ) @ ±5%, 7000Hz @ ±3dB
INCOMPARABLE TEMPERATURE STABILITY
EXCELLENT LINEARITY FOR EASY COMPENSATION

- Scale factor temperature coefficient: \((S_z) = 120\text{ppm/}^\circ\text{C (typ)}\)
- Bias temperature coefficient: \((S_o) = \pm 0.2\text{mg/}^\circ\text{C (min/max)}\) for VS1002

Graphs showing sensitivity and output at 0g vs. temperature for VS9000 and VS1000.
NON-LINEARITY BECOMES ALMOST NONEXISTENT

- Non-linearity < 0.1% (typ) of full scale, under vibrations

![Graph showing non-linearity vs acceleration](image)

- VS9030
- VS1030
LOWER NOISE FOR BETTER MEASUREMENTS

Noise in band (typ)

VS1002 : 7μg/√Hz
VS1005 : 17μg/√Hz
VS1010 : 34μg/√Hz
VS1000 & VS9000 PERFORMANCE IMPROVEMENTS

- Frequency Response
  - 1500 vs. 1000 [Hz] @ ±5% (min)

- Power consumption
  - 10 vs. 2 [mW] (max)

- Noise in band
  - 7 vs. 25 [µg/√Hz] @ 2g (typ)

- Shock resistance
  - 6000+overload vs. 6000 [g] (max)

- Non linearity
  - 0.3 vs. 1 [%] of FS (max)

- Bias Temperature stability
  - ±0.2 vs. ±0.4 [mg/°C] (max)
VS1000: THE NEW REFERENCE IN PERFORMANCE

- Frequency Response
  - 1500 vs. 1000 vs. 625 [Hz] @ ±5% (min)

- Power consumption
  - 10 vs. 32 vs. 8 [mW] (max)

- Shock resistance
  - 6000 vs. 2000 vs. 500 [g] (max)

- Noise in band
  - 7 vs. 7 vs. 44 [µg/√Hz] @ 2g (typ)

- Non linearity
  - 0.3 vs. 0.6 vs. 2 [%] of FS (max)

- Bias Temperature stability
  - 0.2 vs. 0.4 vs. 1 [mg/°C] (max)
COMPARISON NOISE VS1000 VS COMPETITOR S

![Graph comparing noise levels of VS1000 and Competitor S](image-url)
SELF-TEST FUNCTION

- Self-test signal (internally generated) on the differential acceleration output (frequency: 24Hz / amplitude 1g)
RECOMMENDED CIRCUIT + PCB LAYOUT (GERBER FILE)

Power Supply → Accelerometer Sensor → Output signal conditioning
EACH PRODUCT IS FULLY TESTED AND QUALIFIED TO THE STRONGEST COLIBRYS STANDARDS.

- Frequency response
- Non linearity
- Bias calibration
- Bias temperature coefficient
- Scale factor calibration
- Scale factor temperature coefficient
- Self-test function
- Temperature sensor
- Reset function
- POR (Power-On-Reset) function
- Operating current consumption
Datasheet ±2,5,10,30,50,100,200g
- Recommended circuit

Application notes
- Automotive testing
- Bogie monitoring
- Machine health monitoring (MHM)
- Seismic prevention
- Structural health monitoring (SHM)
- Wind turbine

Technical notes
- Design an evaluation board
- Gerber file to manufacture the PCB board of the evaluation board
- Convert a differential output into a single output
- Handling, mounting & soldering recommendations

All on colibrys.com
MEMS IS THE FUTURE

- Colibrys is currently developing the next generation of seismic **MEMS sensors Class B**

- Our current target is an ultra-low noise in band of \(0.6 \mu g/\sqrt{Hz}\) (typ) for a ±3g acceleration range and \(1.0 \mu g/\sqrt{Hz}\) (typ) for a ±5g; a frequency range from \(<0.1Hz\) to \(1000Hz\); a power consumption of \(40mW\); a hermetic ceramic package of \(0.8cm^3\).

- Please contact us for further information concerning the datasheet and the availability of samples.