Standardizing MEMS Testing Equipment:

A path to efficiency and scalability

February 13th, 2025

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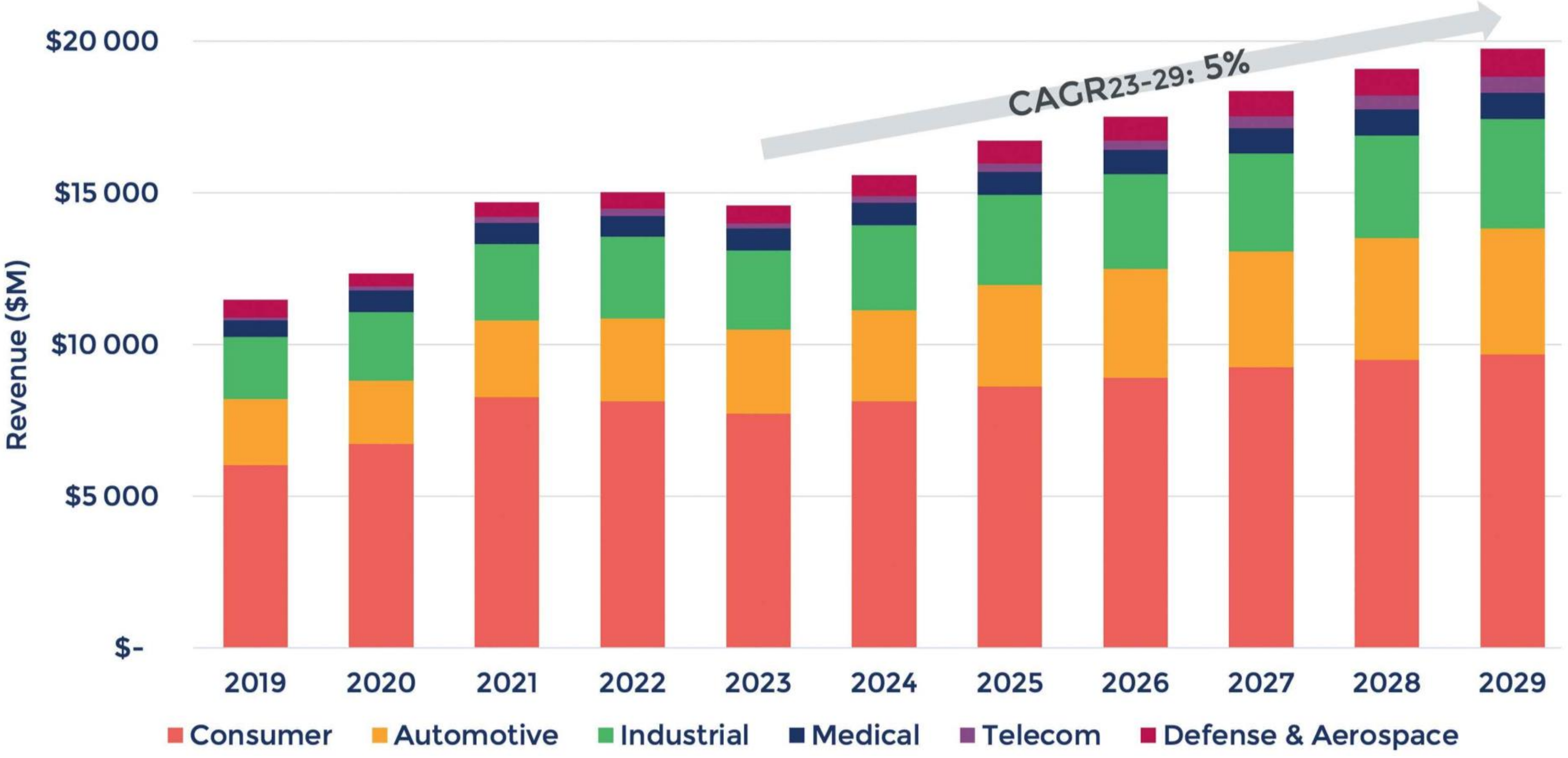
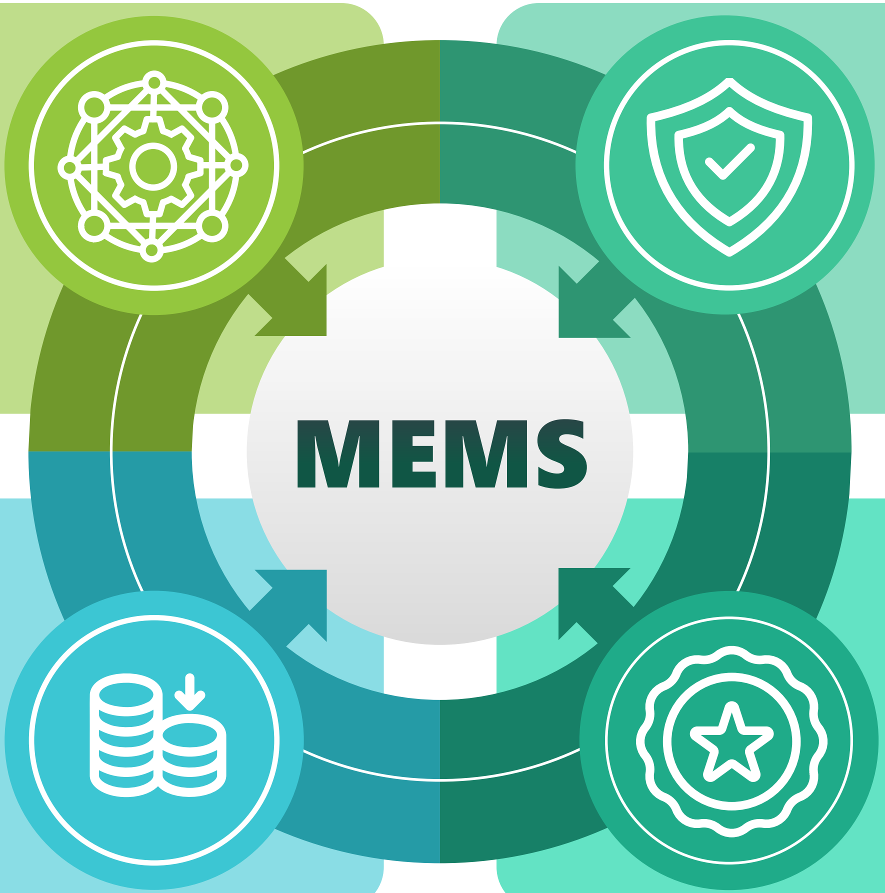
MEMS Market Growth

After a difficult 2023, MEMS market is expected to reach **$20 billion** by 2029, growing at a CAGR of 5%



Source: Status of the MEMS Industry report, Yole Intelligence, 2024

Challenges in the MEMS Industry



MANUFACTURING COMPLEXITIES

Tiny size and intricate structures make MEMS devices prone to yield issues and equipment complexity

RELIABILITY CONCERNS

Need to ensuring device reliability, especially for critical applications such as automotive and healthcare

COST REDUCTION

Reducing the costs to make devices more accessible to a wider range of applications

STANDARDIZATION

Standardization in MEMS design and manufacturing facilitates interoperability and market growth

Test equipment has an impact on all these aspects and can help face these challenges.

MEMS Testing Scenario

Test and calibration represent a major cost contributor for MEMS devices, and problems related to calibration and accuracy remain a major challenge that may hamper the growth of the market

WAYS TO KEEP **PROFITABILITY**

- Drive for **high yields** (>95%)
- Create a **more standard** approach
- Enhance testing **throughput**
- Rely on **cost-effective** solutions

TEST **REQUIREMENTS**

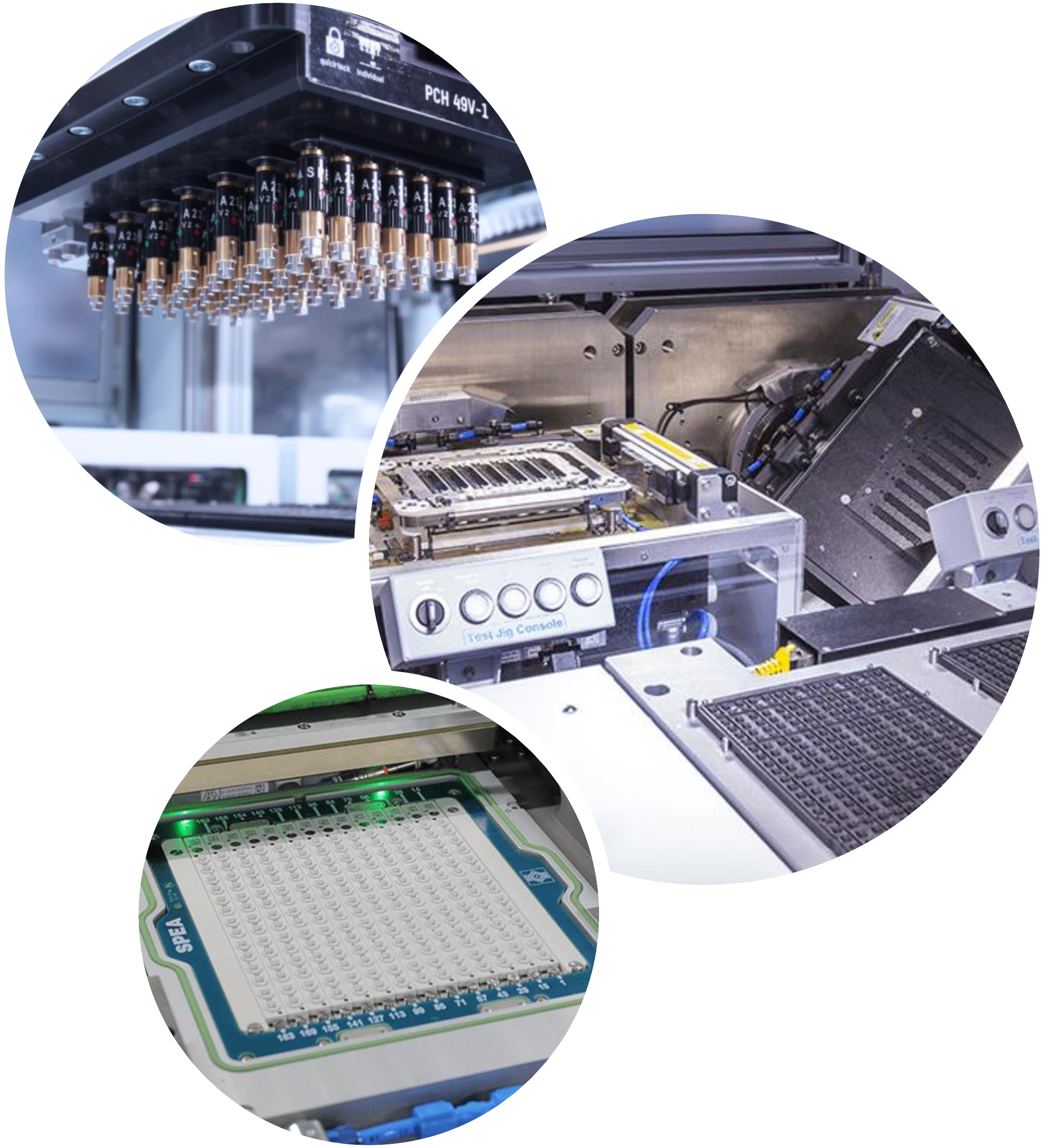
- Test both **electrical and physical** parts
- Test **at wafer and package** level
- Test both **single-chip and multi-chip** devices

MEMS **ATE Standardization**

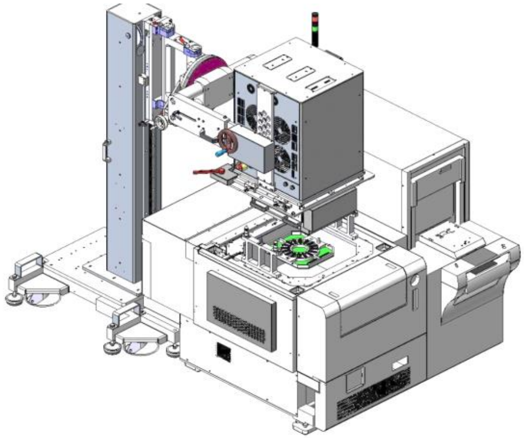
- In the past, test equipment for MEMS has been **strongly application-dependent** and scarcely reusable for different devices

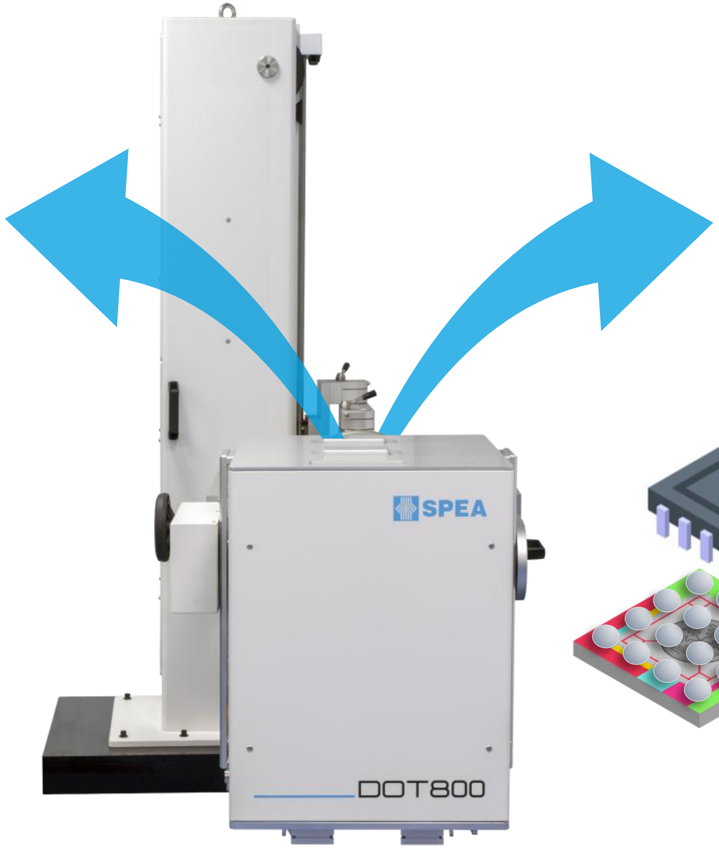
- However, having a completely different machine for each different product is becoming **less and less efficient**, as the number of devices increases exponentially

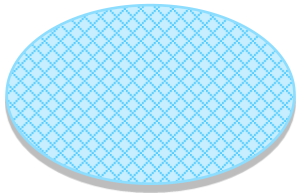
- More and more companies are recognizing the need for a **testing and handling solution that is suitable for the requirements of high-volume production lines, scalable, and convertible** for different application technologies.



The same test platform should be suitable
for both wafer-level and package test of MEMS and sensors

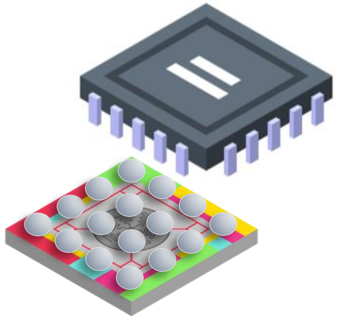






Wafer-Level Test

With Tester + Prober



Package Test

With MEMS Test Cell

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MEMS Testing at Wafer Level

Combination of electrical and non-electrical measurements for early failure detection

Real-working conditions (e.g. acceleration applied to the device) are obtained by electro-static stimulation, making the device mass moving from its reference idle position. The device frequency answer is then measured.

- **High Multisite**
- **fF Capacitance measurements**, with 2.2MHz bandwidth and DC bias -10V to 20V
- **pA Current measurements**
- **µV Voltage measurements**
- **1000kOhm /10pF impedance measurements**
- **mΩ/GΩ Resistance measurements** (4-wire configuration)

MEMS Testing at Package Level | Standard and WLCSP Packages

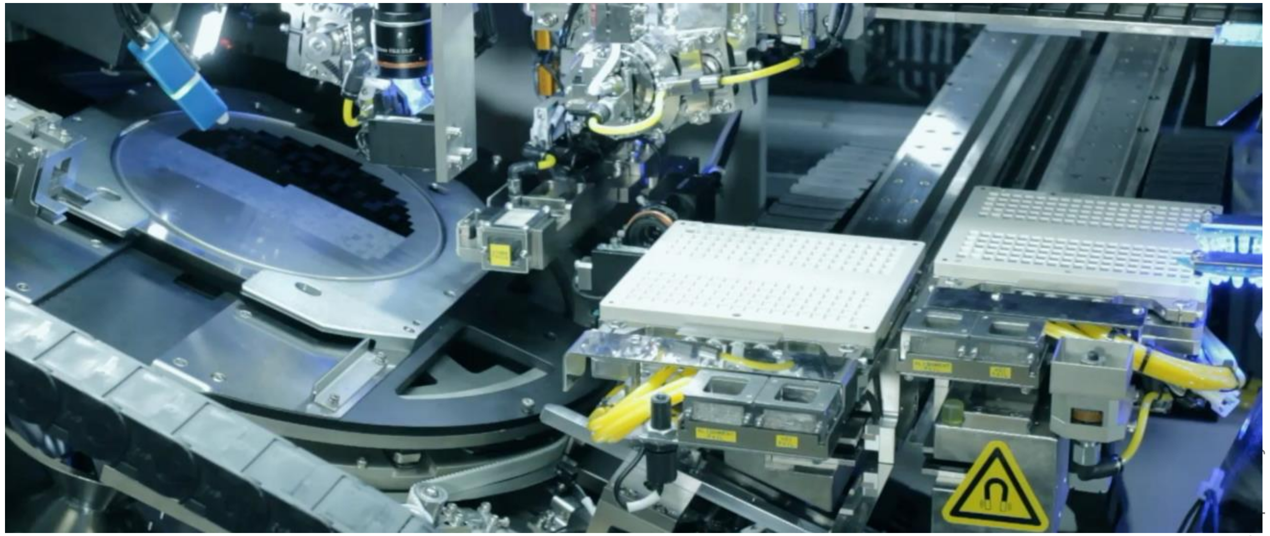
With a field setup adjustment, the same machine can be used for testing both standard packages and wafer-level packages. And it is ready to embrace tomorrow’s technologies.

Standard package test

Example of tray-to-tray handling and testing of three-axial accelerometers

WLCSP package test

Example of wafer-to-reel handling and testing of MEMS pressure sensors



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Standard ATE Architecture for MEMS Package Test

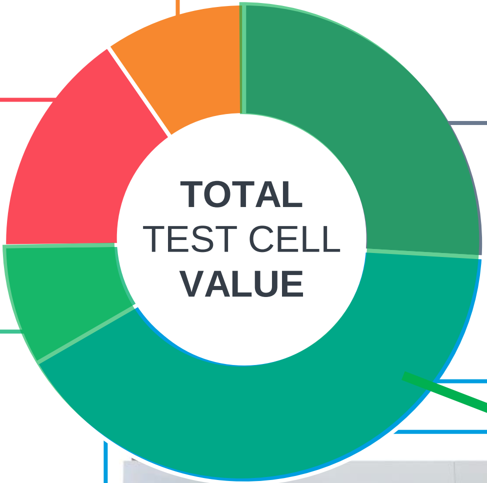
Down time for Test Unit and Product change: **<4hrs typical**

MEMS TEST UNIT

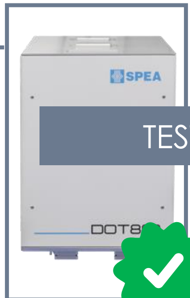
INTERCHANGEABLE FOR DIFFERENT TECHNOLOGY (Usage: according to production batch)

SOCKETS AND APPLICATION

APPLICATION SPECIFIC (Usage: according to production batch)



TESTER



100% STANDARD

HOT/COLD GENERATOR

100% STANDARD

HANDLER

100% STANDARD

Standard equipment, reusable for any kind of different application

(Usage: 100% of the uptime)

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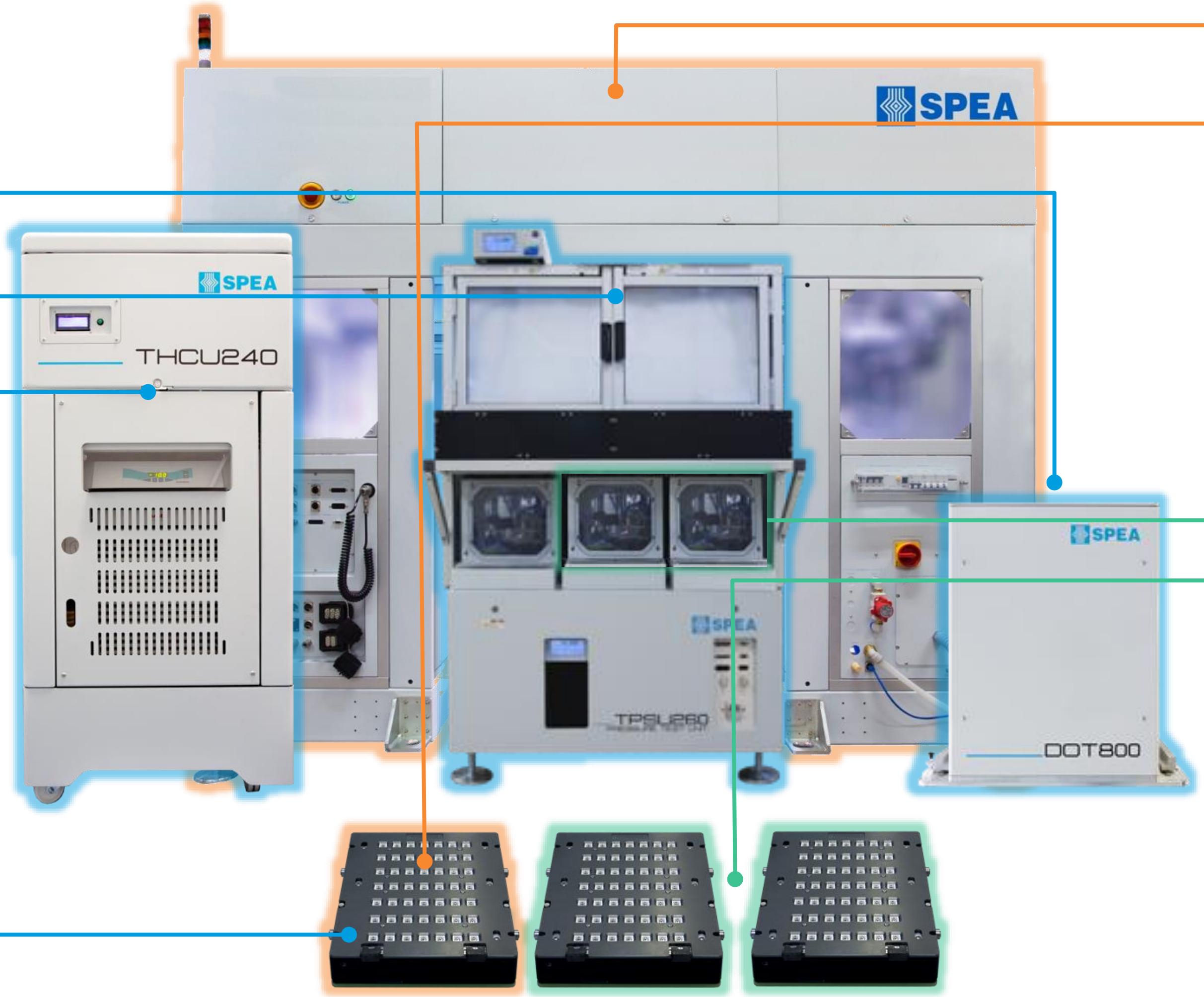
Equipment Scalability

Example: Pressure Sensor Test Cell. The same equipment was expanded with additional modules for engineering, mid-volume and mass-production use.

STEP 1

ENGINEERING

- **Tester**
- **Pressure Test Unit with single Test Chamber**
- **Tri-Temp conditioning unit**
- **Contacting unit for 7 sites**



STEP 2

MID-VOLUME

+ **Pick&Place Handler**
+ Contacting unit for **49x multi-site**

STEP 3

MASS PRODUCTION

+ **2 Test Chambers**
+ **Contacting units for additional 98 sites**

Test Units for the main MEMS technologies

INERTIAL

Low g accelerometers

Gyroscopes

High G sensors

6-DOF sensors

ENVIRON-MENTAL

Barometric sensors

Humidity sensors

Temperature sensors

Gas sensors

PRESSURE

Absolute & Differential pressure sensors

TPMS

Force sensors

Medium & high pressure sensors

LIGHT

Proximity sensors

Time-of-flight sensors

Ranging sensors

UV sensors

IR sensors

Gesture sensors

MAGNETIC

Linear sensors

Angular sensors

Speed sensors

ACOUSTIC

Microphones

Speakers

CASE STUDIES

1. Inertial MEMS

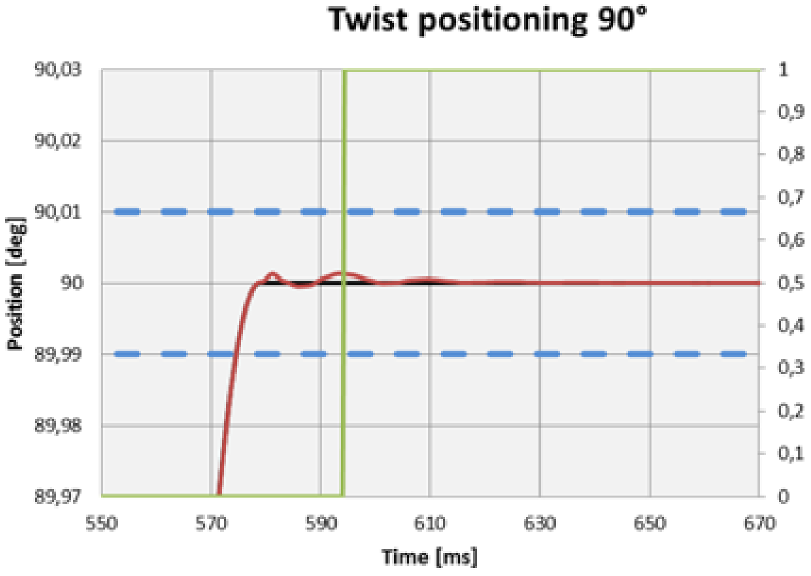
2. Pressure Sensors

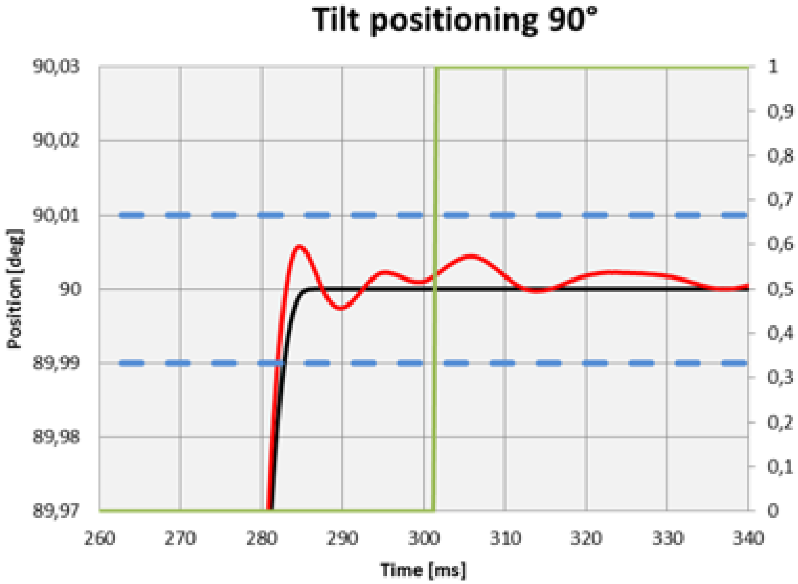
3. Magnetic Sensors

Case Study 1 **Inertial MEMS**

HIGHLIGHTS

- 140 sites tested in parallel
- Double rate table stimulus in a single handler
- Same setup is suitable for accelerometer and gyro test
- High rate accuracy: no drift, excellent stability, high torsion stiffness





ACCELEROMETER TEST

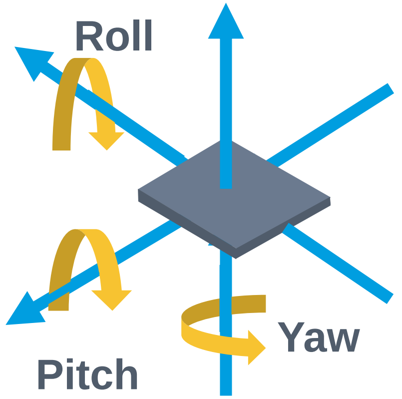
The Rate Table operates with high precision and accuracy in angular movements along the two axes.

Performances are guaranteed along angular stroke with excellent rate stability and position accuracy

- **Precision ≤0.01 deg**
- **Accuracy ≤0.01 deg**

Theoretical position [deg]
Real position [deg]
In-window trigger

Gyroscope Testing Details



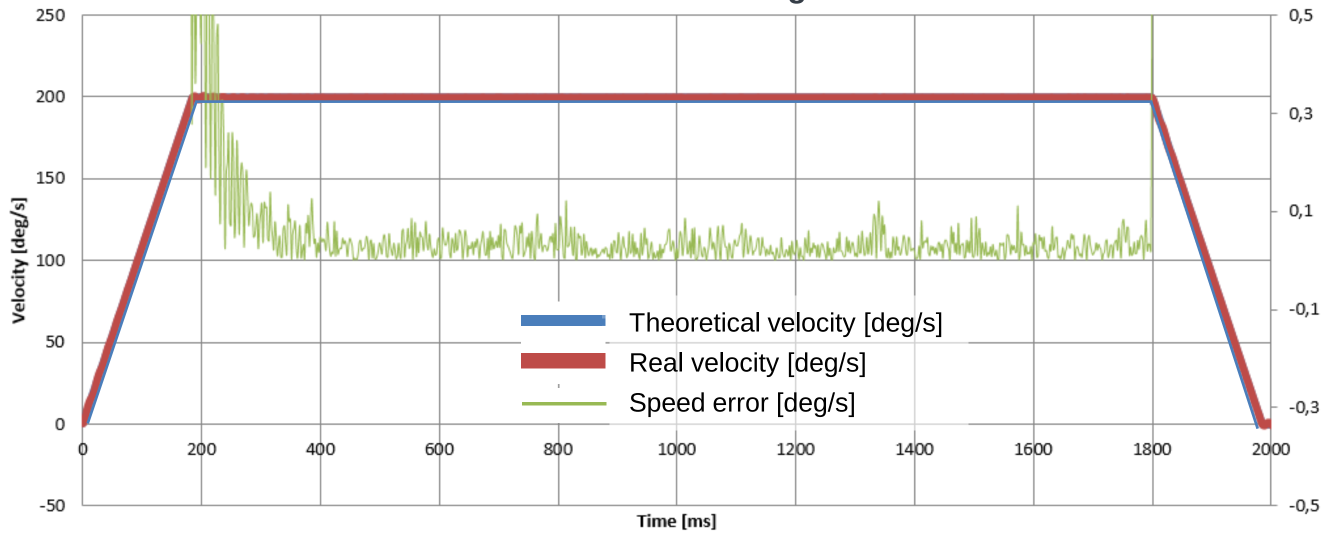
The Rate Table operates with constant angular speed during gyroscope test, with a very limited speed error.

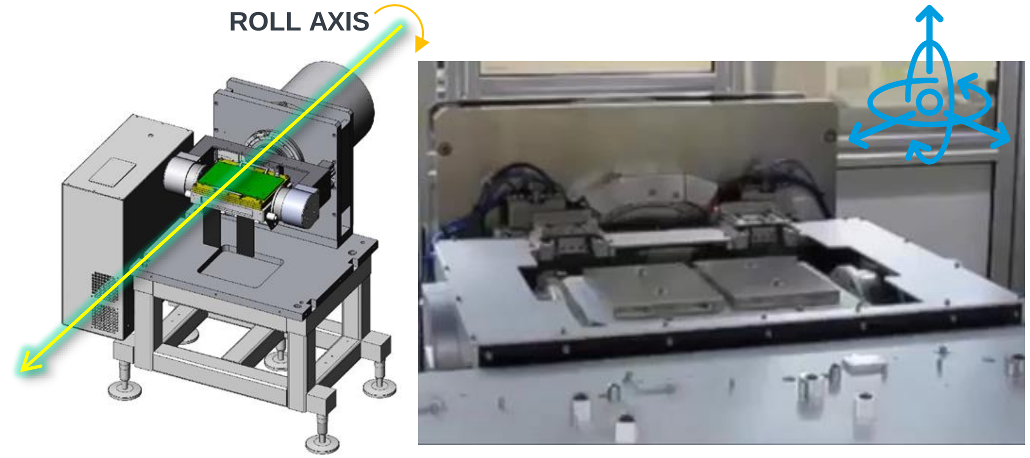
Speed test, start and stop position are easily configurable.

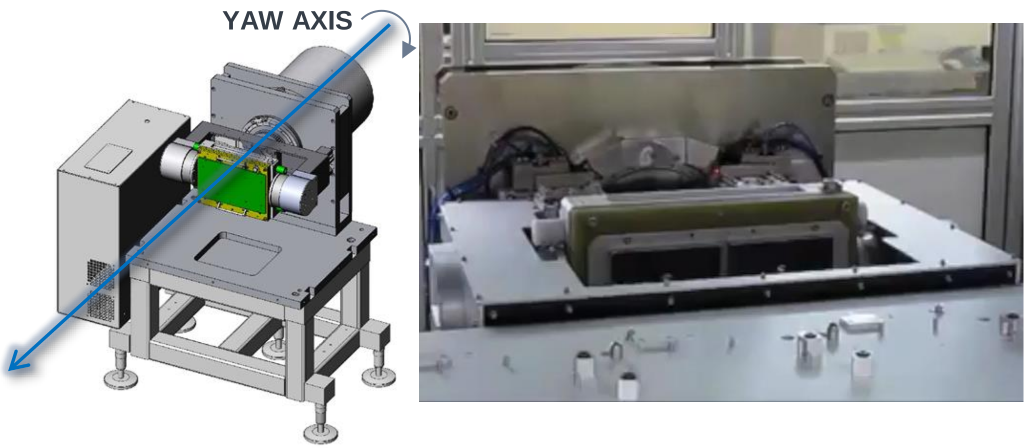
Triggers are available for synchronization.

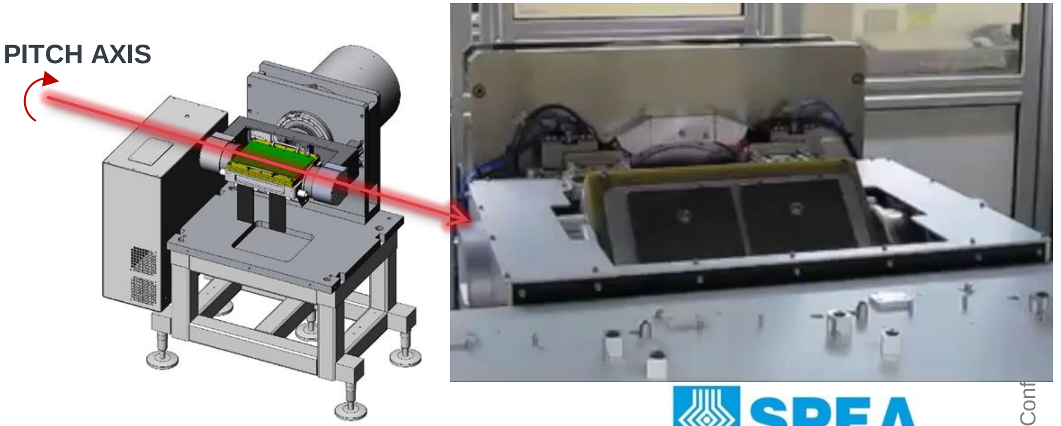
- **Speed error ≤0.1 deg/s**

Twist constant profile @ 200 deg/s
Stroke 0 ÷ 360 deg









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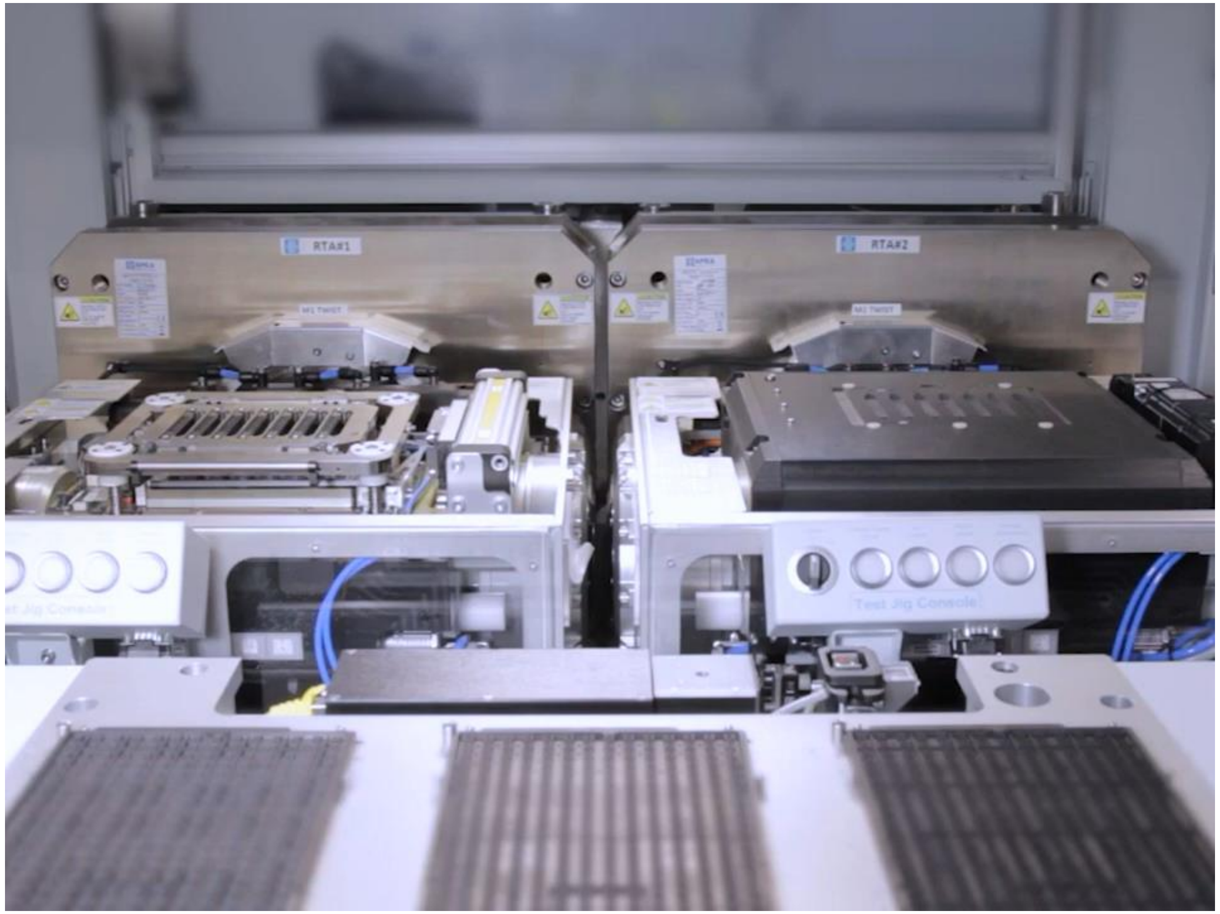
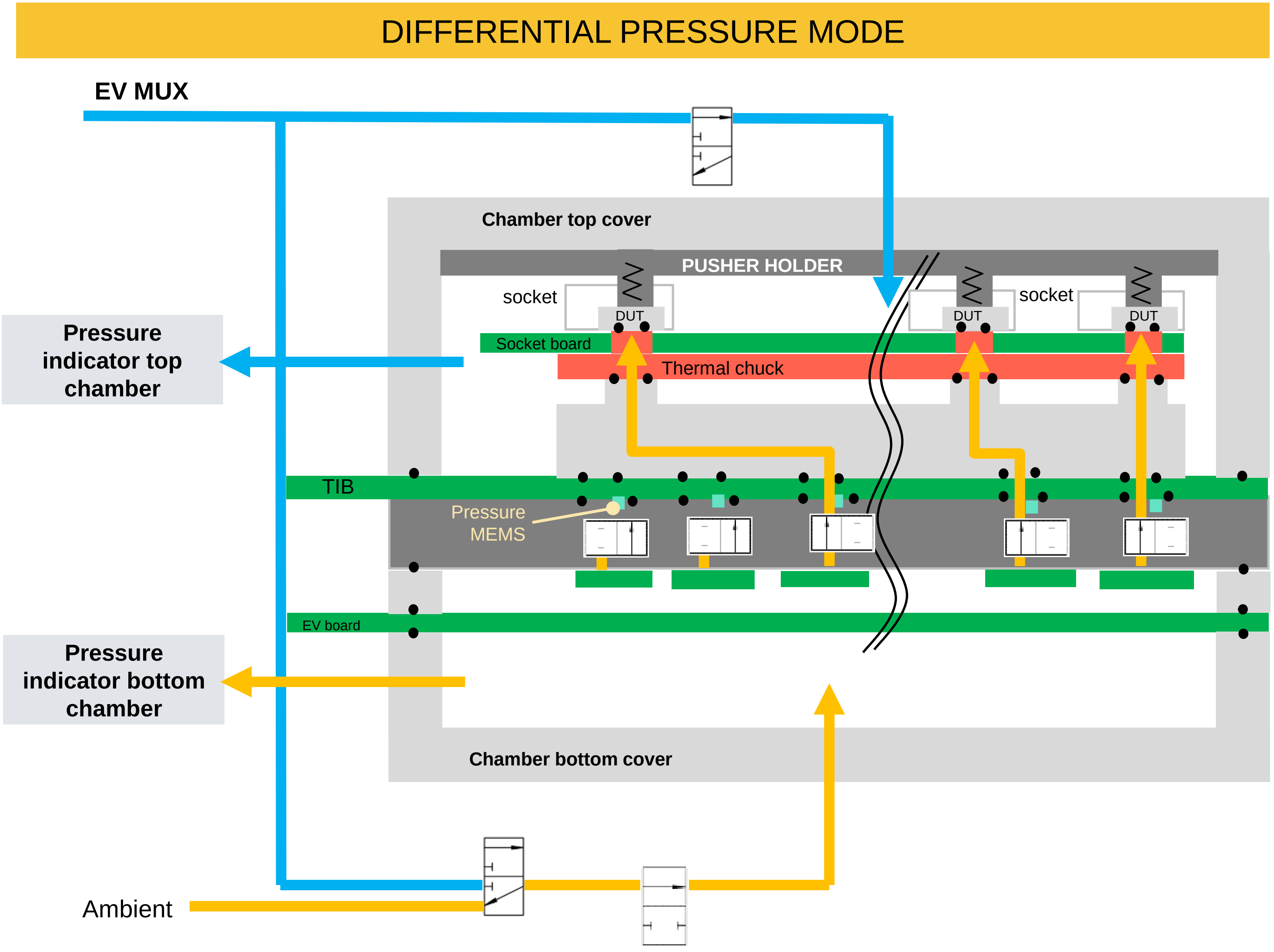
Inertial MEMS Testing Operation



Case Study 2 **Pressure sensors**

HIGHLIGHTS

- 392 sites tested in parallel
- Absolute and differential pressure stimulus
- Up to 3 independent test chambers
- Multiplexed tanks to speed up set point change and settling time
- Absolute pressure ranges from 0.03 to 7.05 MPa (0.3 to 70.5 barA)
- Differential pressure range: -0.07 to 0.4 MPa (-0.7 to 4 bar)



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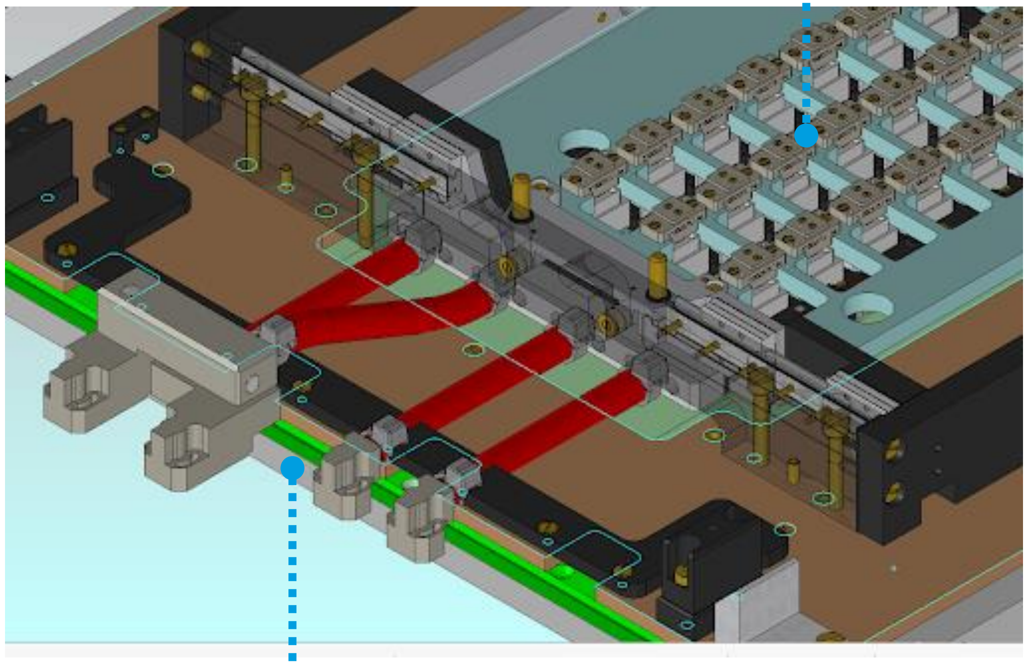
Case Study 3 **Magnetic Sensors**

HIGHLIGHTS

- The test unit can generate **unidirectional, bidirectional or fully tridimensional** magnetic fluxes, according to the test needs
- A **magneto board** can generate the magnetic fields needed to perform the test in correspondence of every DUT, through an electrical coil system and current generators
- The magnetic flux can be static or evolving, according to the **fully programmable AWG** of the current power source
- Chuck, pushers, pogo pins, ceramic pockets and all the hardware around the test area are manufactured in **non-magnetic material to avoid any magnetic field distortion**.



Magneto board is located right under the sockets holding the components under test

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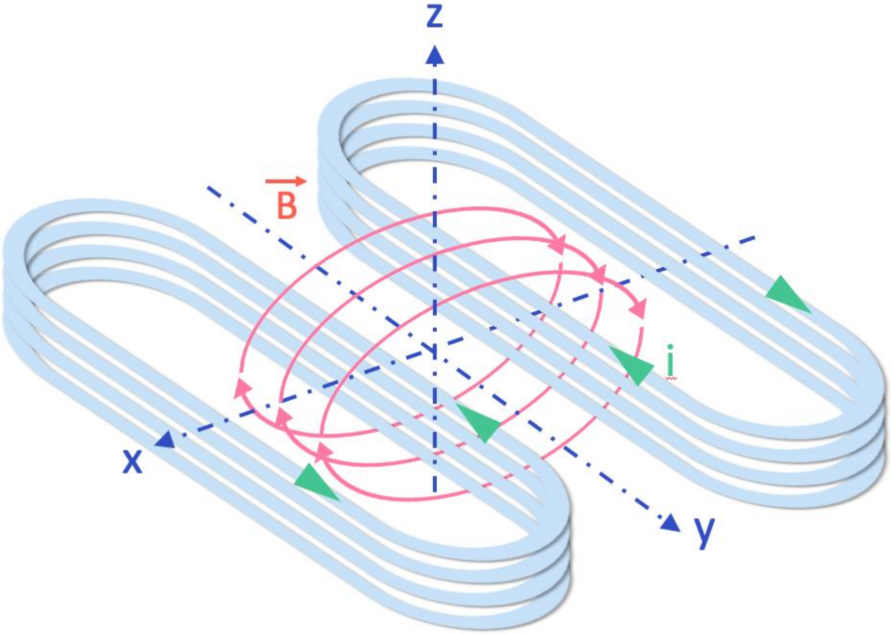
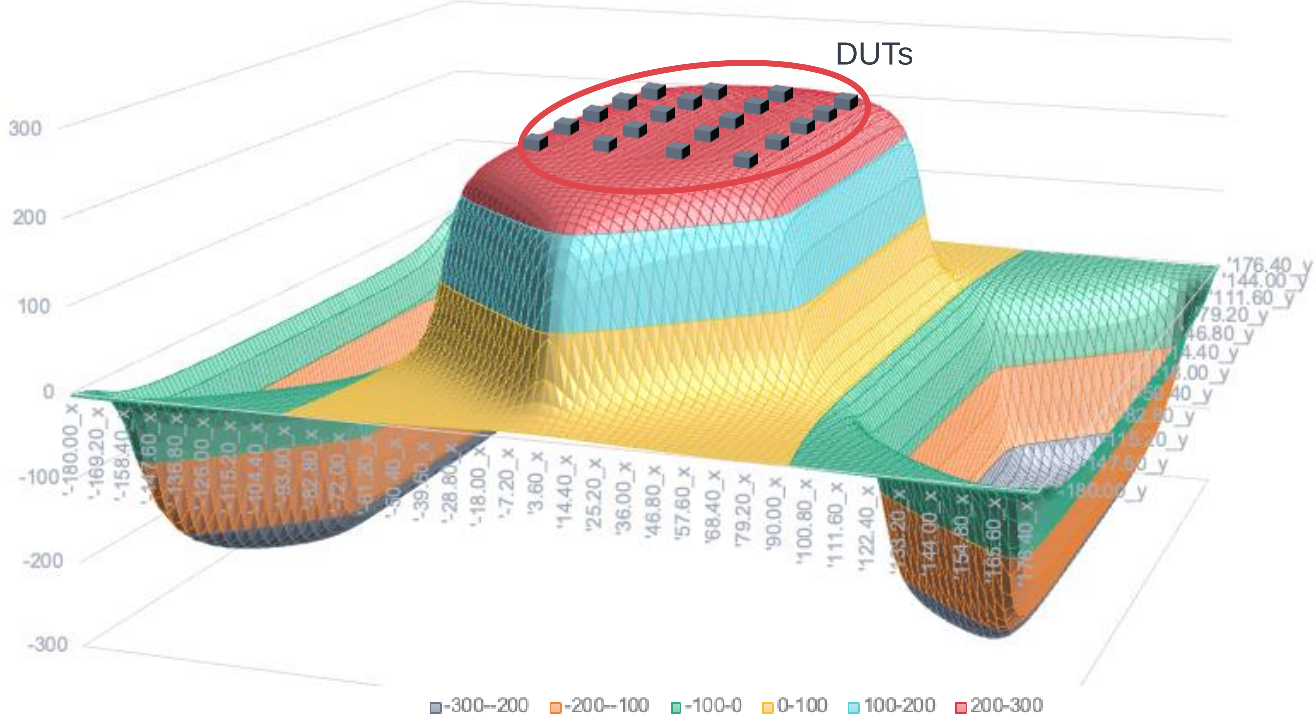
Magnetic sensor **XY Axes Stimulation**

A pair of coreless dipole coils generates a magnetic field, whose lines are almost XY parallel in the region around the axes intersection.
The test area is subjected to a uniform magnetic field, stimulating the devices in X and Y.





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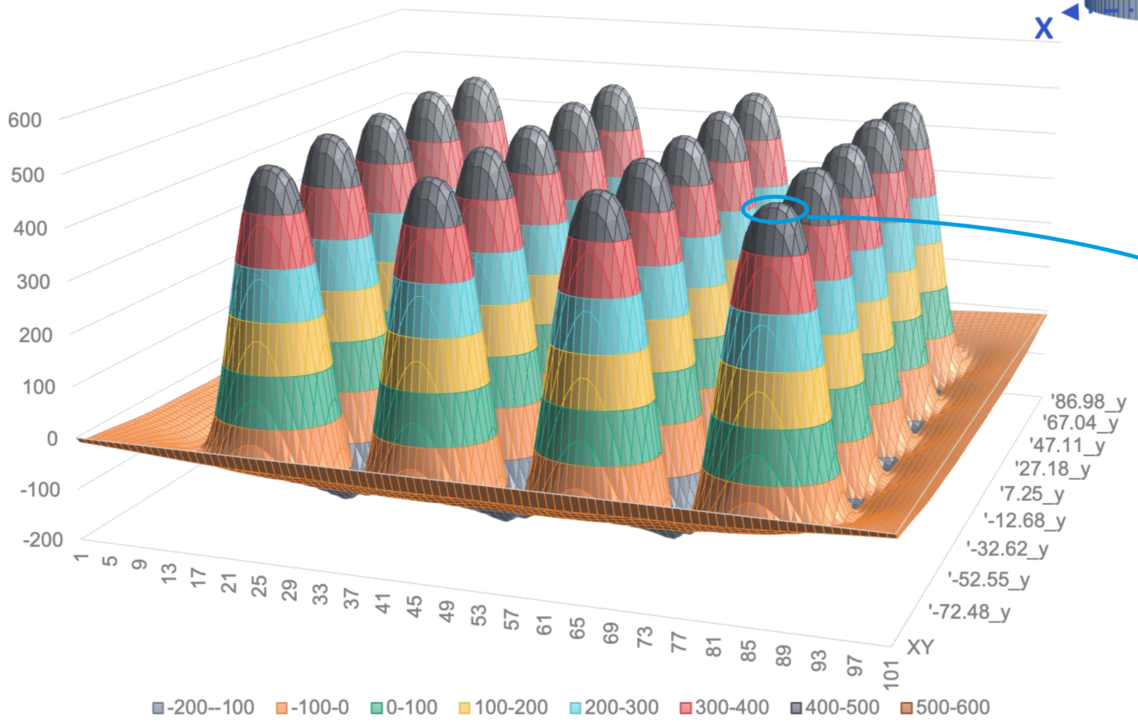
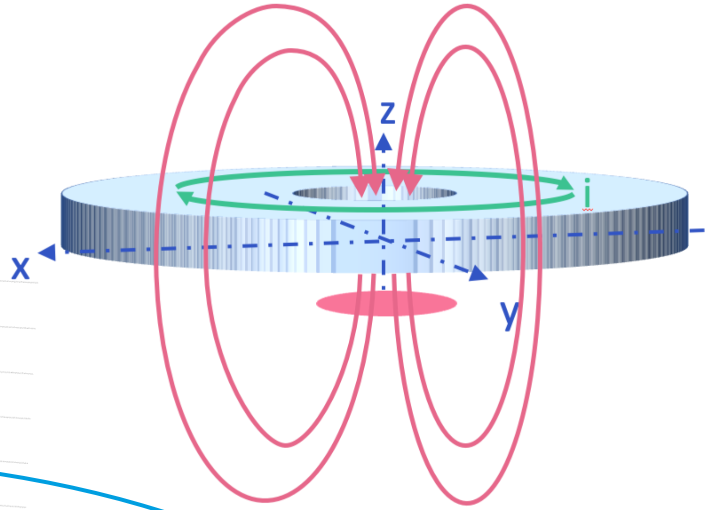
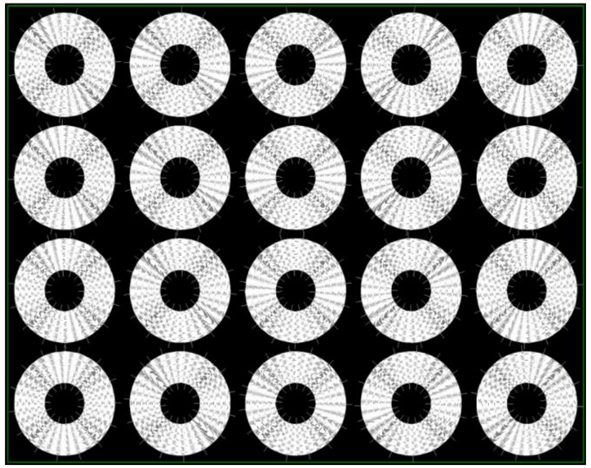
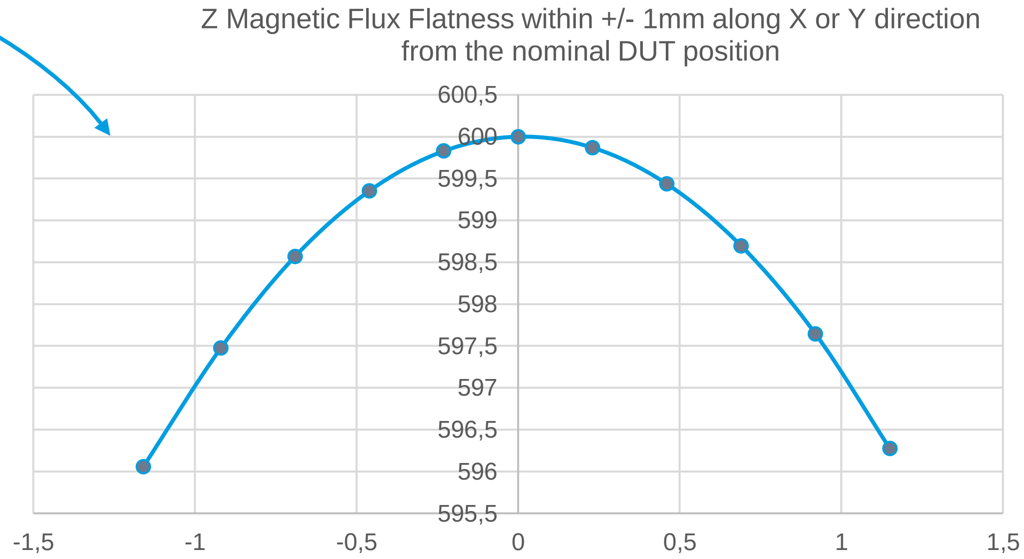
Magnetic sensor **Z Axis Stimulation**

A coreless coil per each site generates a magnetic field whose lines are almost Z parallel in the region close to the axes intersection.









The magnetic field variation is within ±1% in the Die area

Conclusions

Standardizing MEMS testing equipment is crucial for:

- **Addressing manufacturing complexity** ➔ Simplifies production processes, and reduces redundancies
- **Ensuring reliability** ➔ Especially critical for applications like automotive, healthcare, industrial
- **Reducing costs** ➔ Scalable and flexible setups optimize ROI

By embracing standardization and innovation, it is possible to create a MEMS testing ecosystem that is faster, more reliable, and ready to face the challenges of the future.

THANK YOU!

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