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New Instrumentation Technologies for PHM

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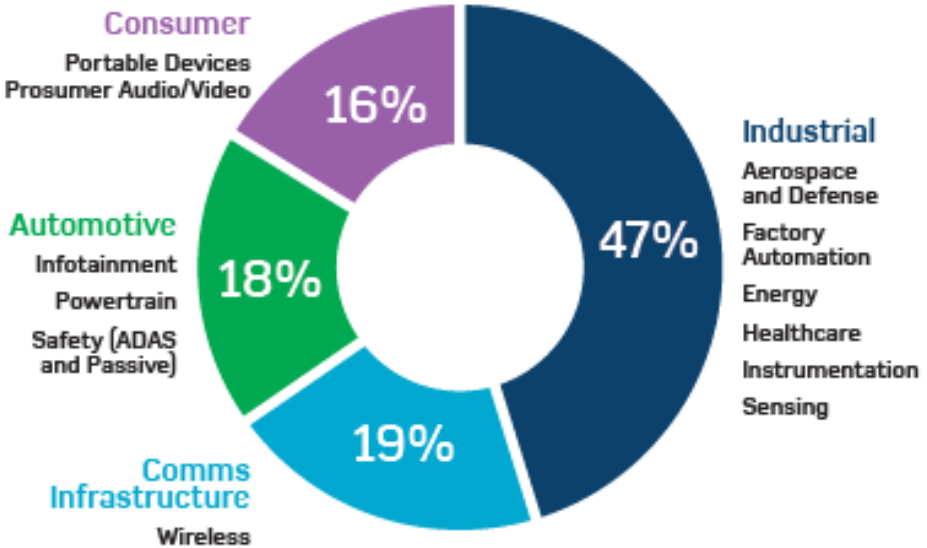
GREENSBORO, NC

Analog Devices
Introduction

Fast Facts

- 15K Employees
- 53 Years in Business
- 4700 Combined worldwide patents granted
- $1B Invested in R&D ~19% of Sales
- 44 Design Centers Worldwide
- 43K Products
- 125K Customers

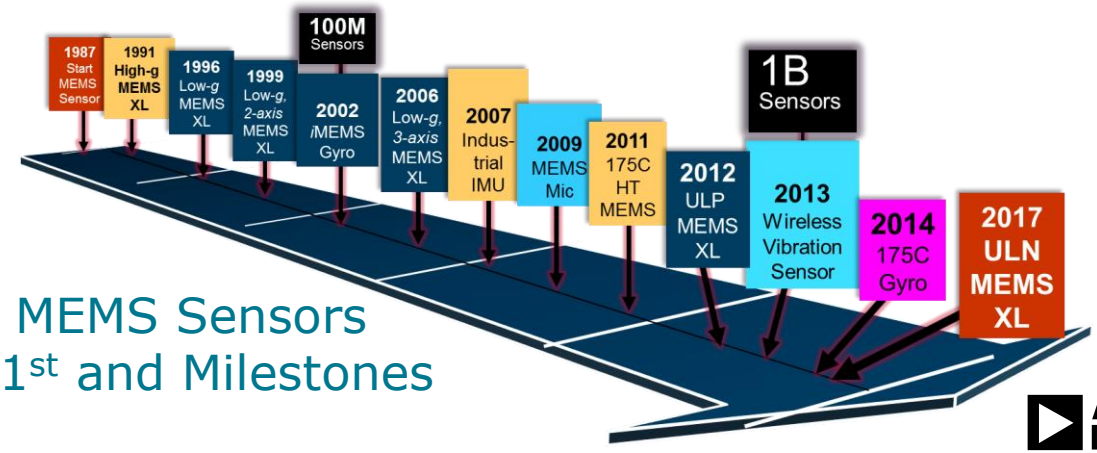
Revenue by End-Market (FY17 Pro Forma Revenue)



FY17 Pro Forma Revenue: $5.7 Billion

Market Leader Across Analog Product Categories

Source: Gartner



Inertial MEMS Sensors
30+yrs of 1st and Milestones

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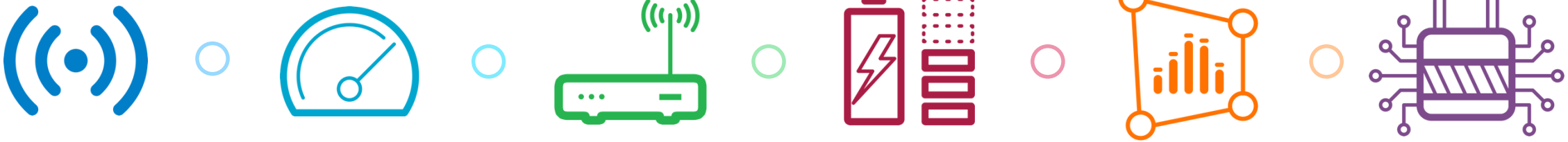
Leader in Capabilities Bridging the Physical and Digital Worlds



Sense

Sensing capabilities that ensure precision, power efficiency, and robustness are at the highest integrity from the start.

Measure

Signal conditioning capabilities turn sensitive signals into useful information for solving challenging measurement problems.

Connect

Next-generation connectivity solutions from RF to mmWave, optical, and cable technologies for a number of wireless protocols and range requirements to enable robust networks.

Power

System-level power management capabilities deliver solutions for every application in every market we serve.

Interpret

Processing capabilities combine hardware and advanced algorithms to deliver intelligence and localized decision making.

Secure

Security capabilities for the point where the data is born for applications in multiple markets.

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Condition Monitoring Is a Challenging Problem (to do correctly)

Condition Monitoring

System Requirements

Sense | Integrated | Edge Intelligence | Connected | Flexible | Robust

Drive New Capabilities

CbM / Machine Health

Control-Loop Integration

To Enable Our Customers to Increase Value

Productivity → Uptime → Quality

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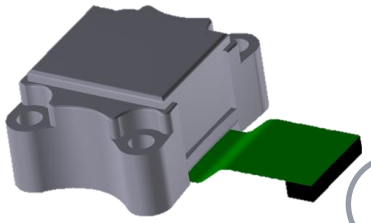
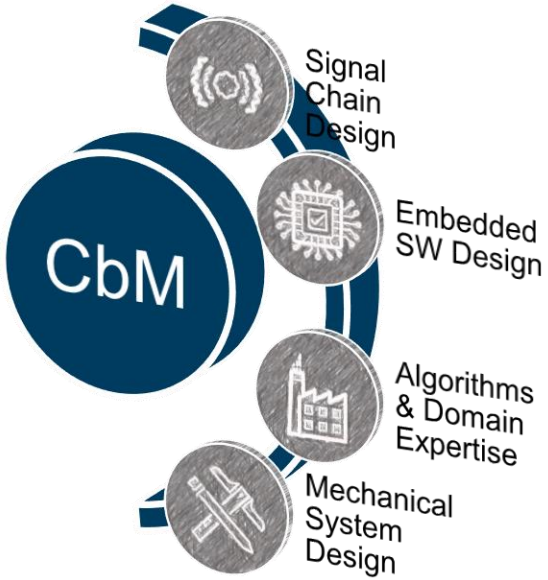
High Performance and Breadth of Skills are Key to Implementing CbM / PHM

Measurement of vibration generally means a survey of the frequency spectrum to determine whether a fault is emerging on the bearings, gears or lubrication.



- Wide Bandwidth
- Wide Measurement Range
- Low Noise
- Stability over Temp & Life
- Multi-axis
- Small Form Factor



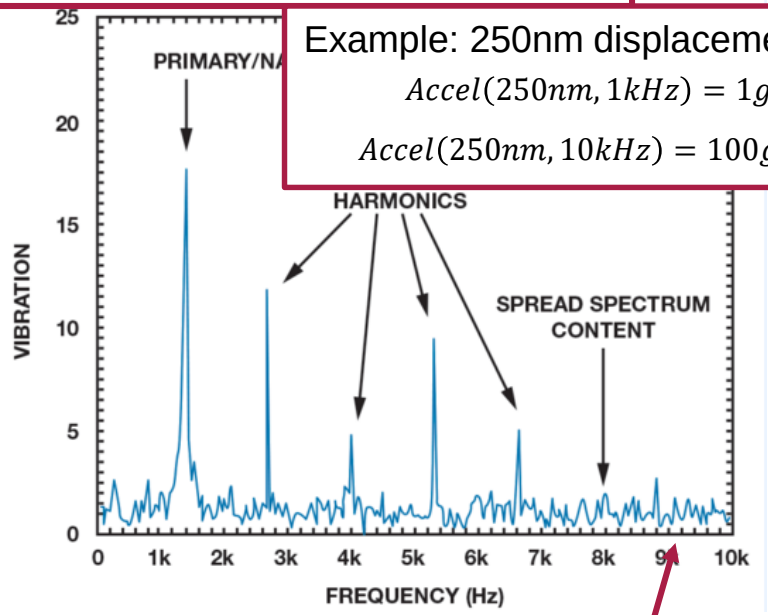
Higher frequency signals create larger accelerations, requiring wider measurement ranges

$$Accel(d, f) = 4 \cdot \pi^2 \cdot f^2 \cdot d$$

Example: 250nm displacement

$$Accel(250nm, 1kHz) = 1g$$

$$Accel(250nm, 10kHz) = 100g$$



Wider bandwidths and lower noise enables earlier detection of initial signs of wear

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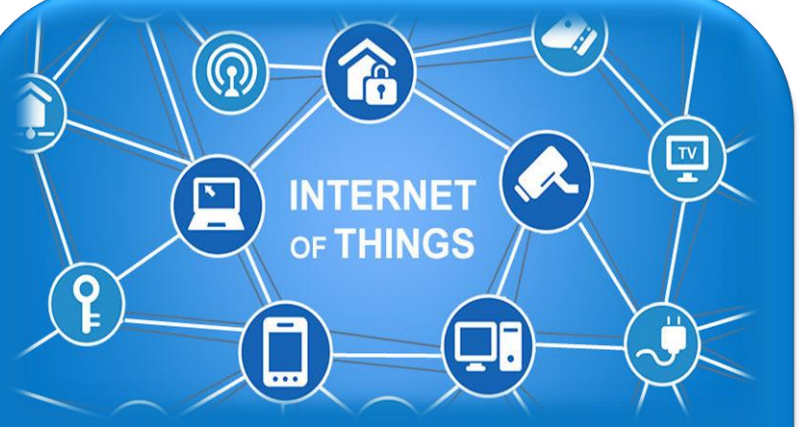
Enabling Industrial Efficiency and Autonomy:
Performance Monitoring – Machine Health Assessment – Condition Based Maintenance

INDUSTRY 4.0

- Development of Cyber Physical Systems
- Enabled Smart Factory, Manufacturing, and Automation



- Readily available, robust, low power, secure, and cost effective wired and wireless communication solutions
- Sophisticated “Edge” Processing
- “Big data” Analytics and Tools

MEMS-SENSOR CAPABILITIES

- High reliability and low costs
- High performance with low drift, low noise, low power, small size, low mass, wide bandwidth, wide operating temperature range
- Dense integration

Problem Complexity and Technical Drivers

Machine Learning / AI
- S/W installed on the plant server or cloud
- Resolution improves with # of measurands
- Differentiated sensors fusion (Acc, T, I, V…)

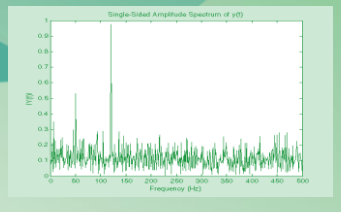
Sufficient sensor data, Historian (EAM), Maintenance records

Plant Server / Historian

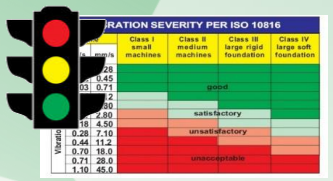
PROGNOSTIC
- Sophisticated processes, algorithms & know-how
- Can be implemented using vibration sensors
- Requires development of machine models

High quality XL data
Applied Domain Expertise

DIAGNOSTIC
- Data analysis, model development
- Can be done now with handheld instruments
- Pin point fault detail, limited RUL prediction



CONDITION MONITORING
- Thresholds set by ISO-10816



RPM, Anomaly Detection

Processing Complexity

Sensor(s) Performance

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