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Sensors for IoT

FOR ANT SYMPOSIUM 2018

PAUL PERRAULT

SENIOR STAFF FIELD APPLICATIONS ENGINEER

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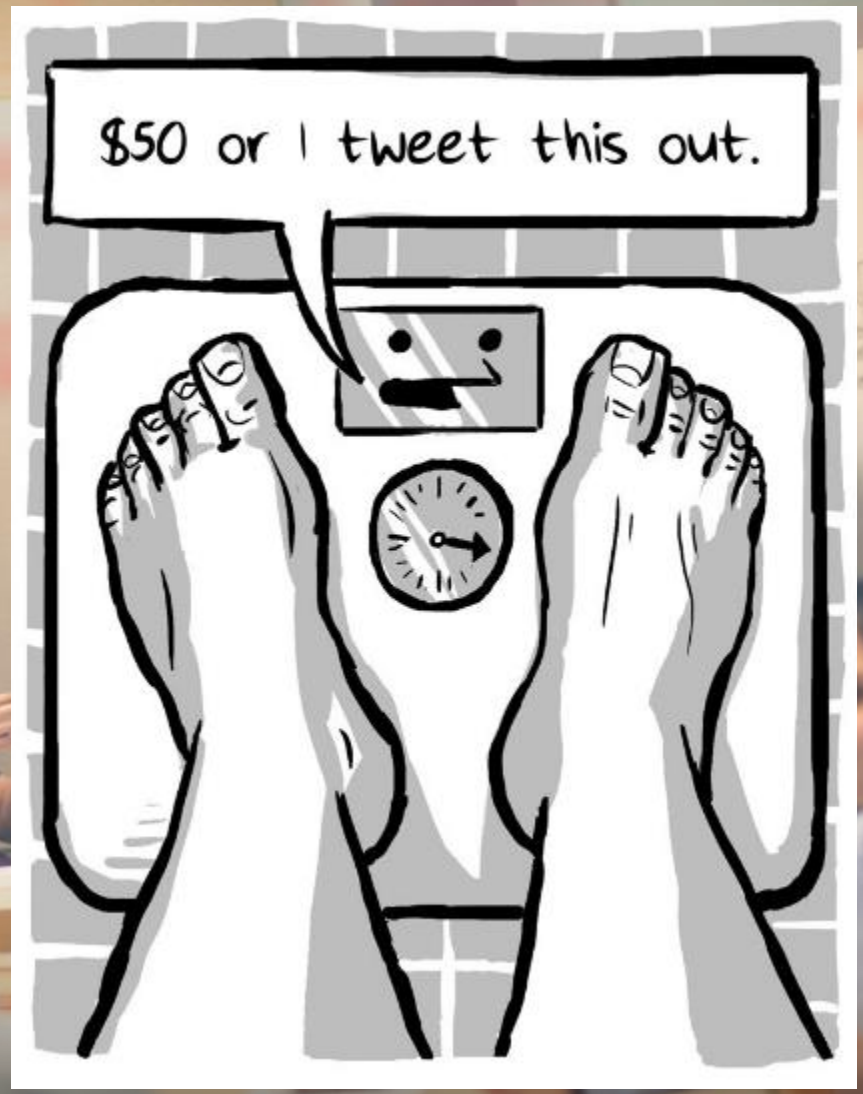
COCHRANE, AB, CANADA

OCT 2018



50 ADI 1965 2015

Internet of Things

Insights that Deliver Intelligent IoT Solutions

Cultivate a complete and impactful customer solution with

- Precise measurement
  - Better data equals more insight
- At the node processing
  - Intuitive and efficient
- Superior technology across the IoT signal chain

Smart City | Smart Building | Smart Infrastructure | Smart Industrial Plant

Smart Health | Smart Agriculture | Smart Machine | Smart Energy

- Solving challenges that couldn't be solved before through advanced sensing and precision measurement
- Secured, scalable wireless mesh network connectivity solution
- Improving outcomes with analytics at the edge and the most reliable connection to the cloud

Reliable System-Level Solutions Through Ecosystem Partnerships

LifeQ | scio

SYPRIS SOLUTIONS

dust networks®

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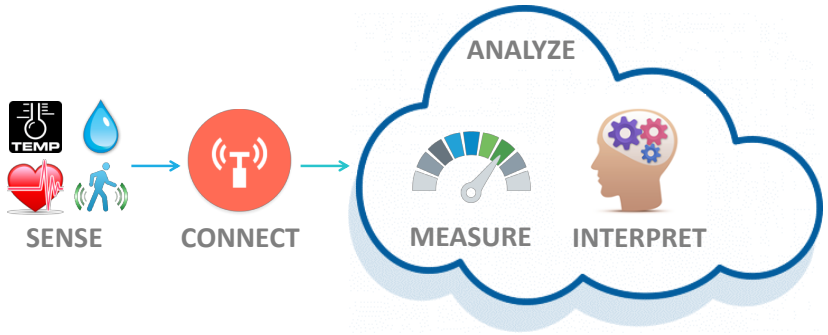
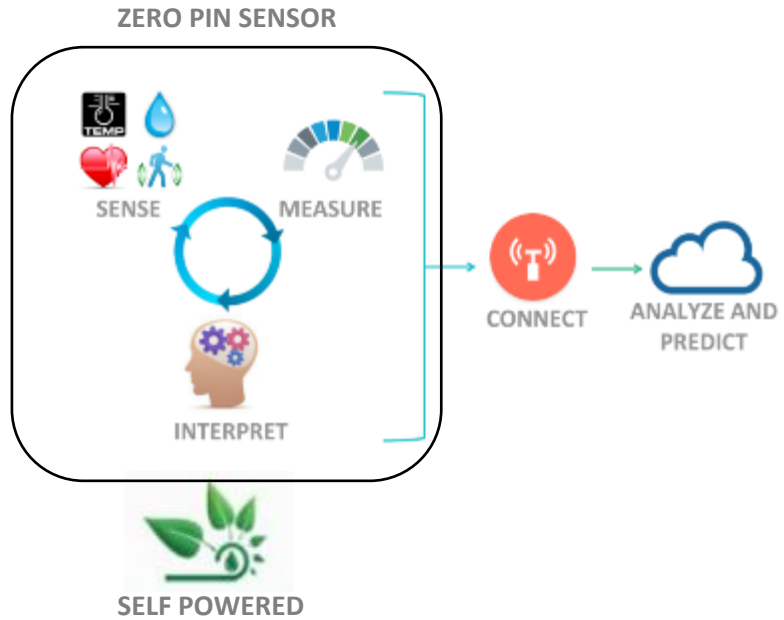
IoT Evolving to More Intelligence at the Node



- Data stays data: does not generate wisdom and knowledge at the node
  - Power hungry and bandwidth intensive to convert and send all data

Today

Tomorrow



- Intelligent “Smart” Sensing: node turns data into information
  - Can balance analytics at the edge, bandwidth and power consumption depending on the use case.
  - **Focus on applications to support self-powering or 10+ year battery lives**

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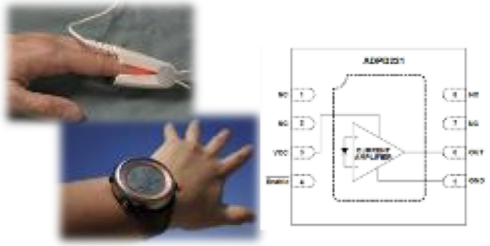
ADI Sensor Technology

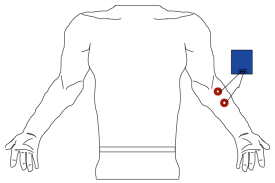
Optical

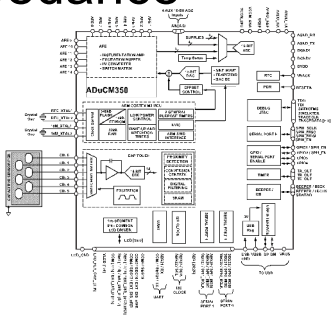


ADPD221
Ultralow power photodetector and amplifier
ADPD103: Optical AFE ambient light rejection

- Applications:
  - SpO2; heart rate; noninvasive blood pressure

Impedance

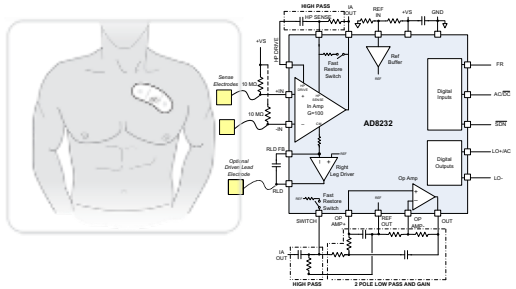




ADuCM350 AFE and Cortex®-M3
High accuracy configurable analog front end with peripheral rich microcontroller subsystem

- Applications:
- Impedance Measurement
- SpO2/HRM/NIBP subsystem

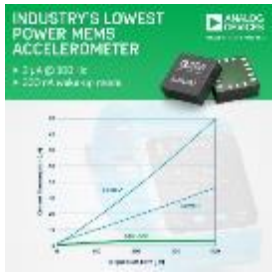
Biopotential



ADAS1000
Diagnostic quality ECG AFE
AD8232/3 HRM AFE
Low cost/low power heart monitor AFE

- Applications:
  - HRM, ECG Monitor

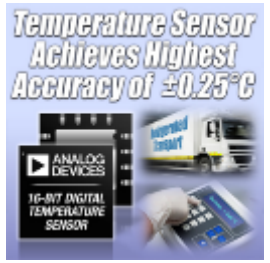
Motion



ADXL362 Micropower 3-axis accelerometer industry's lowest power accelerometer

- Applications:
  - Motion activated power management
  - Vital signs monitoring …

Temperature



ADT7320 ±0.25°C accurate digital temp sensors ±0.2°C Accuracy from –10°C to +85°C @ 3 V

- Applications:
- Body temperature sensing

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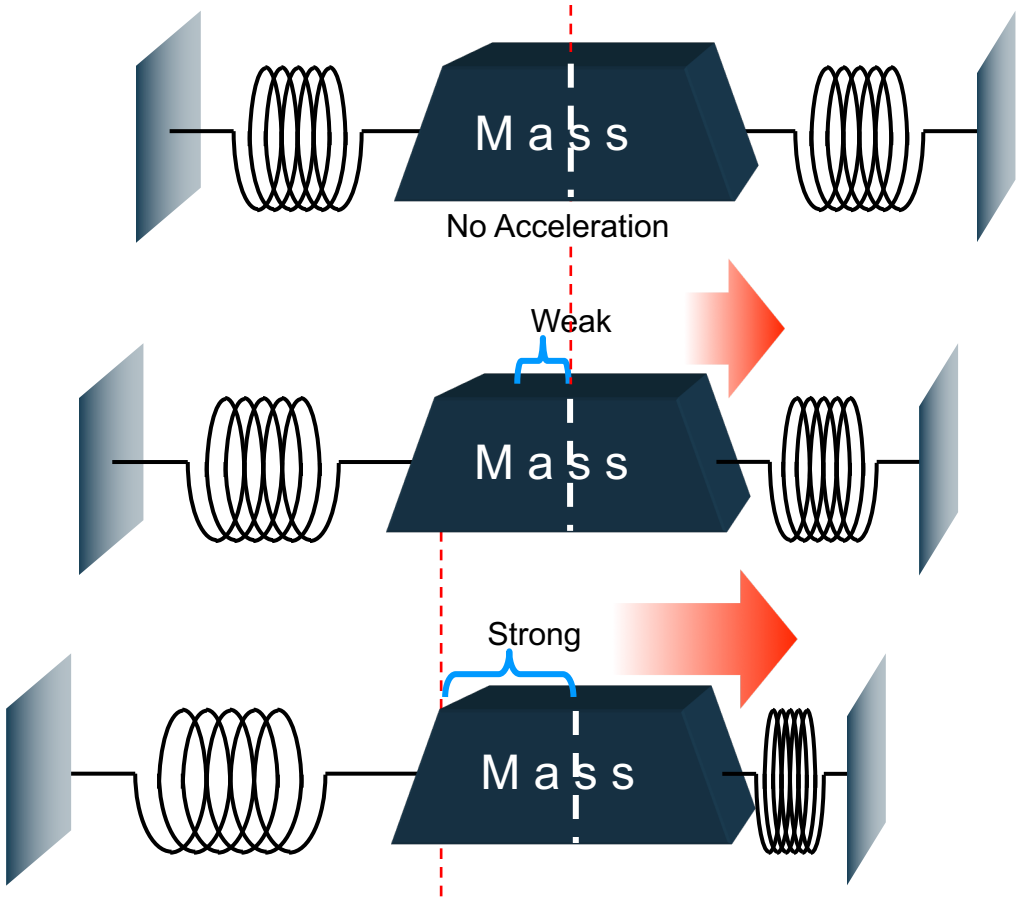
Accelerometers use Inertia to Measure Acceleration



$$F = m * a$$

$$F = -k * x$$

$$a = -\frac{k}{m} * x$$

Acceleration =
***Displacement* × (*Spring Constant* ÷ *Mass*)**

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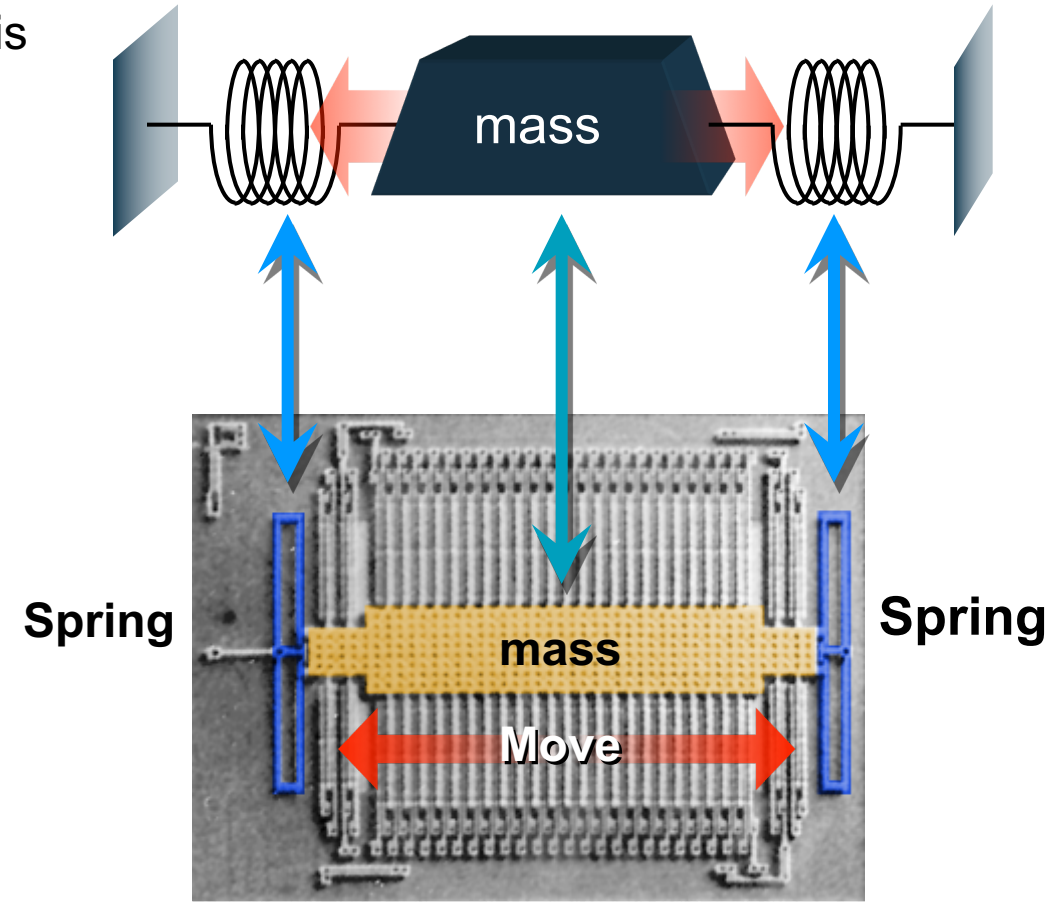
How Do MEMS Accelerometers Work?

- Similar structure adopted in a MEMS accelerometer
  - One Axis



(ca. 1992-1995)

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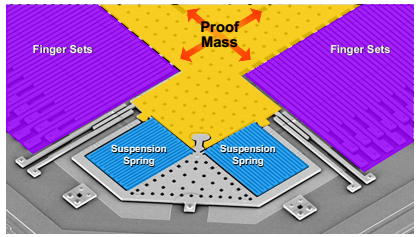
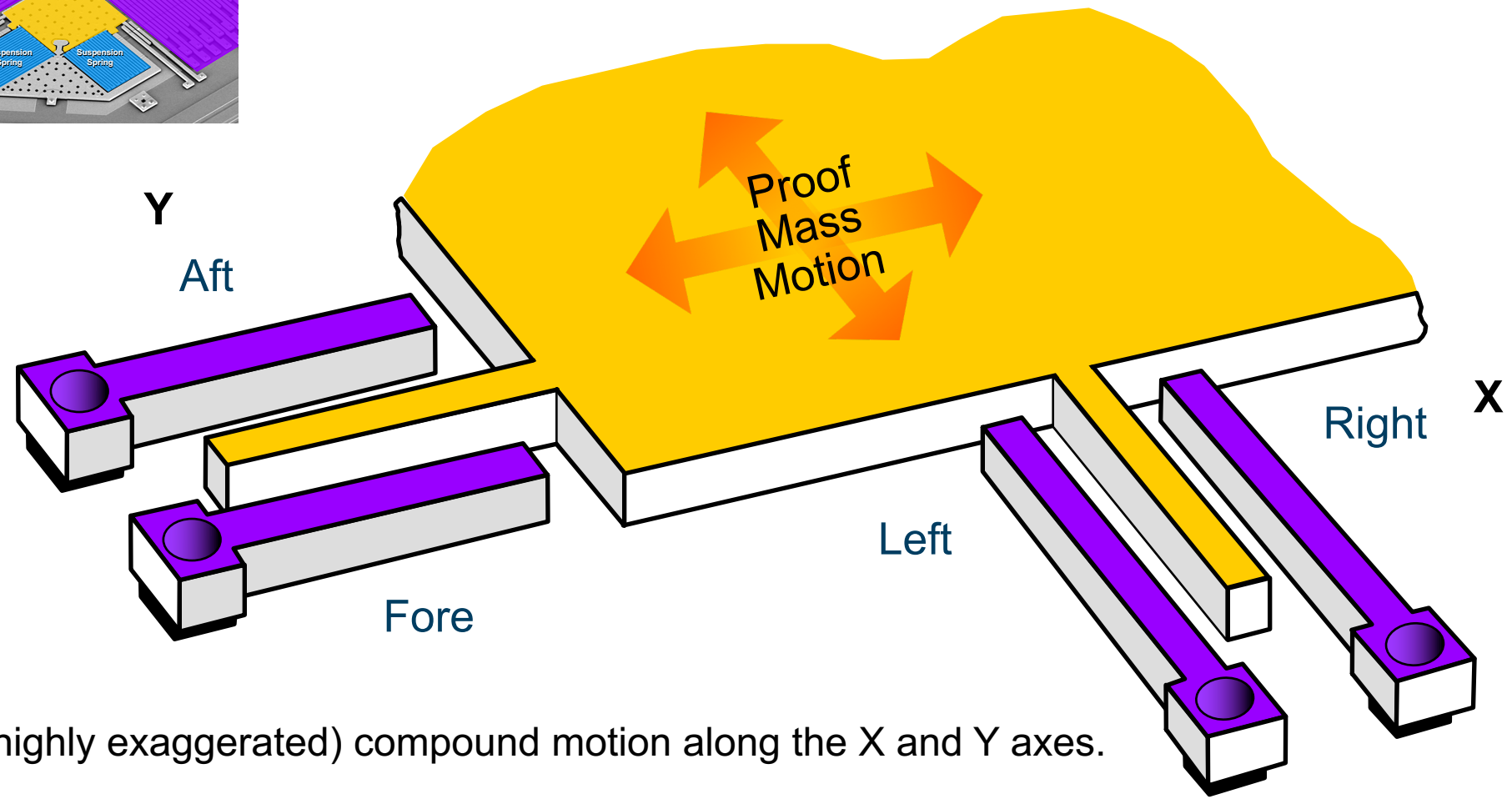
How Do MEMS Accelerometers Work?





Here is (highly exaggerated) compound motion along the X and Y axes.

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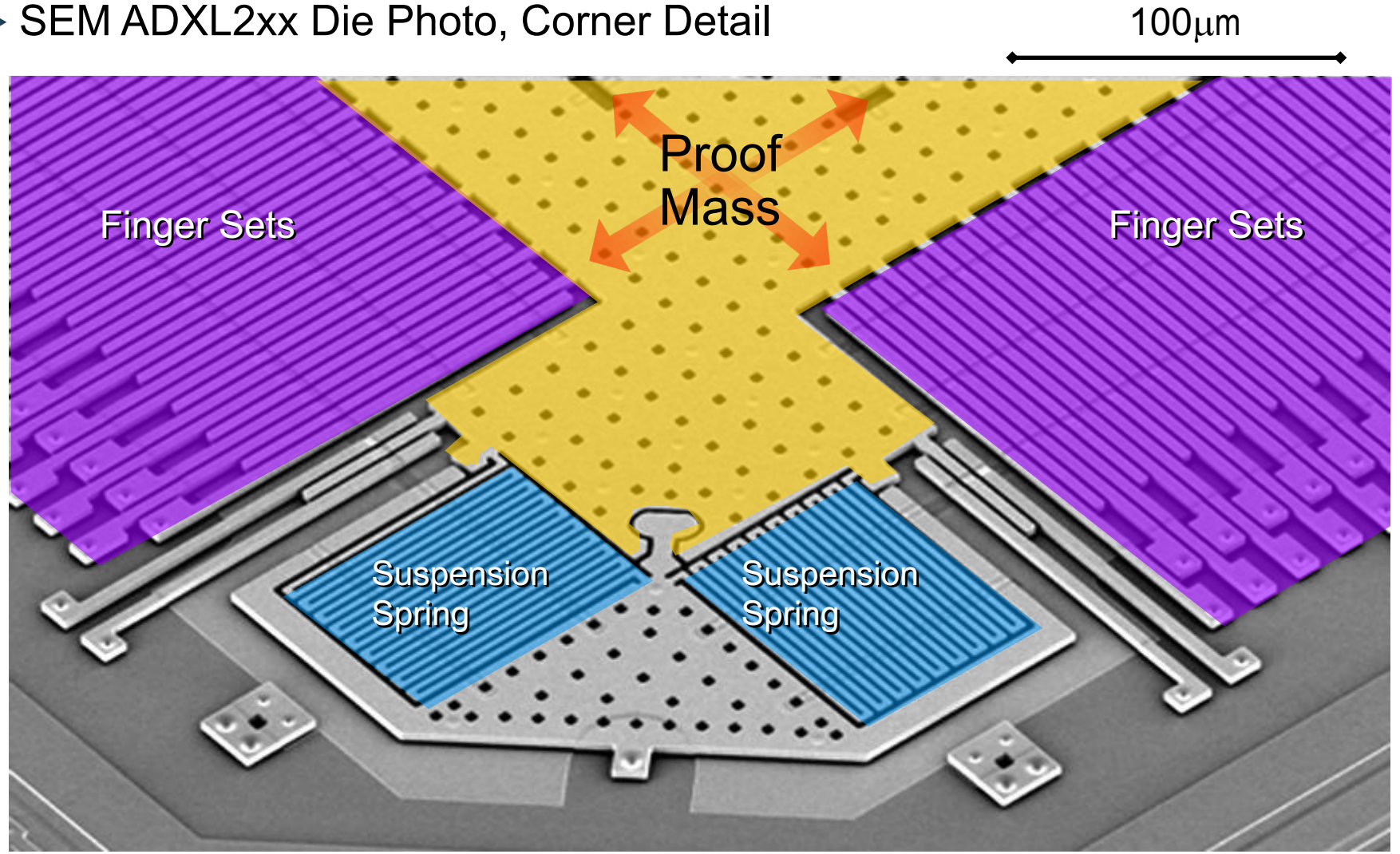
ADXL202 Accelerometer Structure

- SEM ADXL2xx Die Photo, Corner Detail



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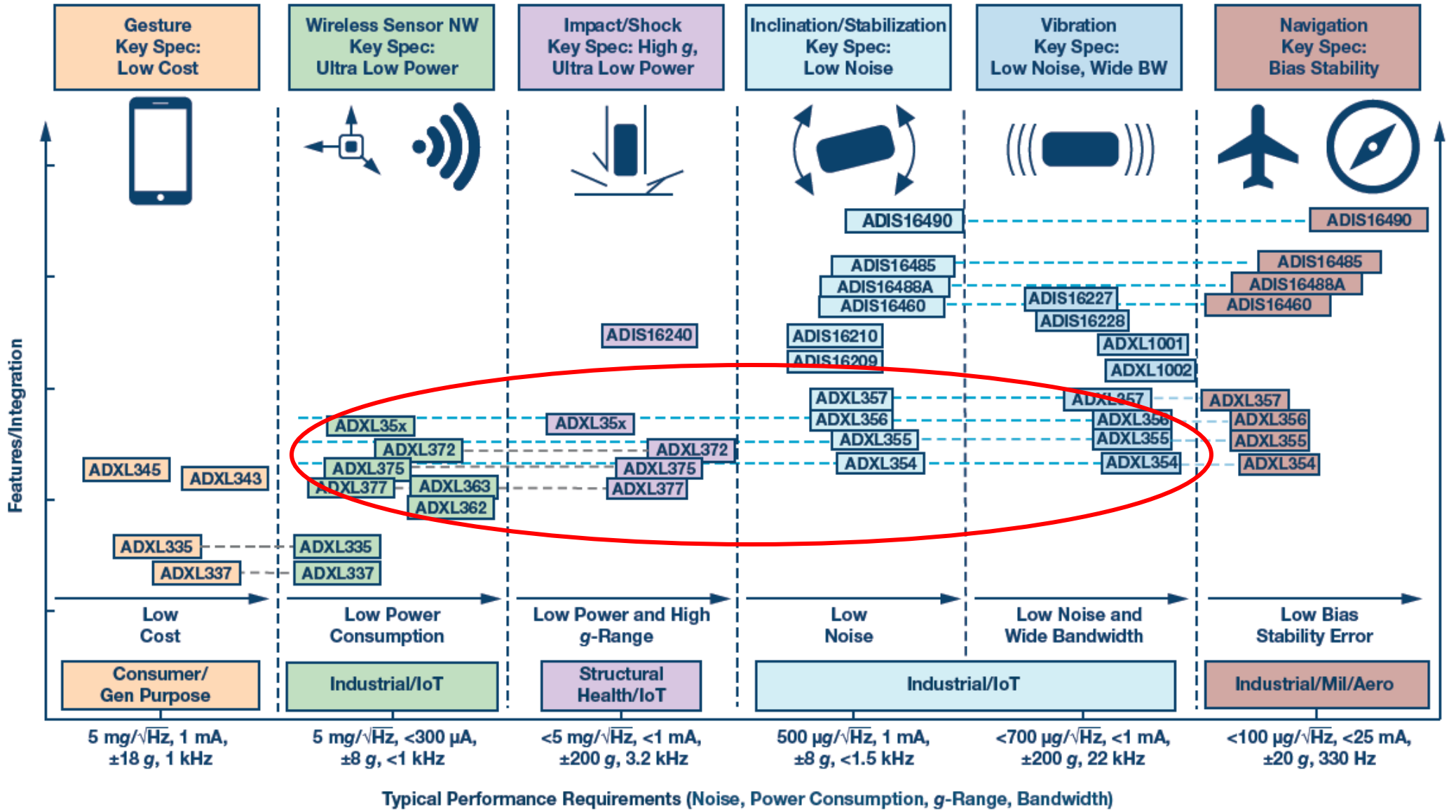
Typical MEMS Accelerometer Applications



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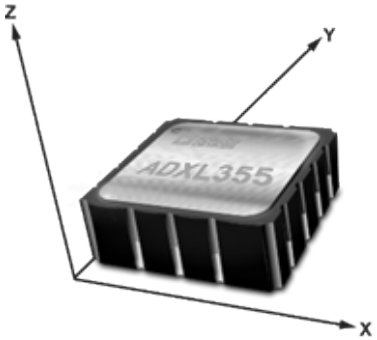
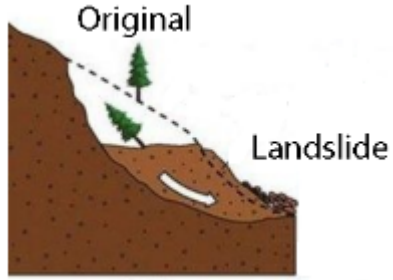
Ultra Low Noise
ADXL354/355 Enable High Accuracy Inclinometer In IIOT

- Selectable measurement range: ±2*g*, ±4*g*, ±8*g*
- Offset temperature coefficient of <0.15m*g*/°C (max) with minimal hysteresis
- Ultralow noise density: 25µ*g*/√Hz
- Hermetic ceramic package for long-term stability
- Low power:
  - 200 µA in measurement mode
- Analog and Digital SPI/I2C interfaces
- Integrated temperature sensor
- Operating Temperature Range: -40°C to 125°C
- Repeatability: ±3.5m*g for X and Y,* ±9mg for Z
- Repeatability is predicted for a 10 year life and includes shifts due to the high temperature operating life test (HTOL) (TA = 150°C, VSUPPLY = 3.6 V, and 1000 hours), temperature cycling (−55°C to +125°C and 1000 cycles), velocity random walk, broadband noise, and temperature hysteresis.





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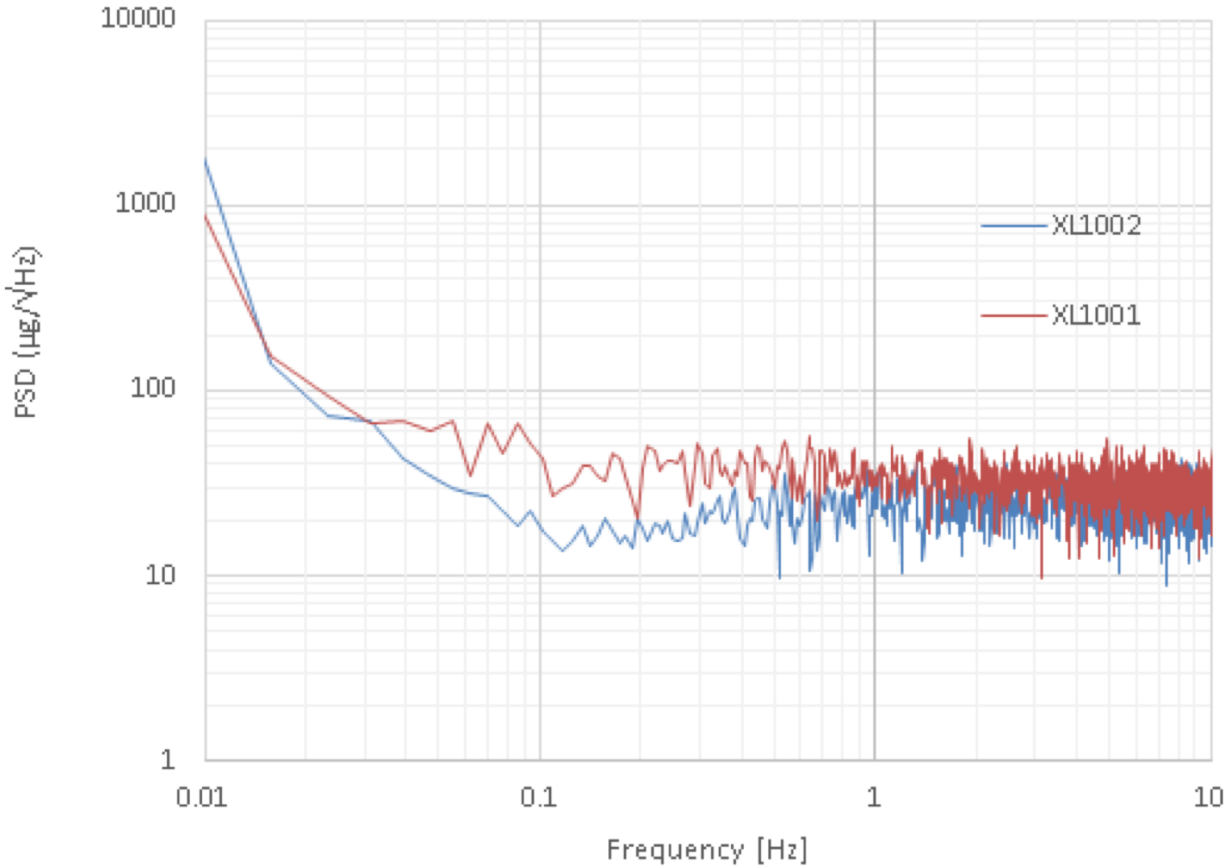
High Frequency Accelerometers for Condition Monitoring
ADXL1001 / ADXL1002 / ADXL1003 / ADXL1004 / ADXL1005

- Breakthrough MEMS accelerometer achieves ultra low noise performance over frequency

- Key Benefits
  - Wide bandwidth **(10+ kHz)** enables bearing fault detection and diagnosis
  - Low noise density down to dc
  - Integrated electro-static self test enables *in situ* testing for embedded applications
  - Stable sensitivity removes need for calibration
  - Over range indicator flags saturation
  - Single supply, low power operation
  - Small footprint 5×5 mm LFCSP package
  - –40°C to 125°C operation



ADXL1001 / ADXL1002
<25 µg/√Hz noise density down to 0.1 Hz enables low frequency vibration measurement for low rotation rate equipment such as wind turbines

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Application in Asset Health Monitoring – ADXL372

- Capturing Impact events in battery powered, wireless sensor nodes
  - Long life between battery charges
  - Long shelf life before transit
  - Hard to reach assets
  - Moving assets

- Applications
  - Asset Health Monitoring
    - Collateral
    - Infrastructure
    - In factory
    - In transit
    - Remote
    - Concussion

Highway Guardrail Monitoring

Train Derailment Detection and Prevention

Commercial Cargo Container Tracking
Theft, Loss, Damage

Civilian / Soldier Protection

Yard & Terminal Infrastructure

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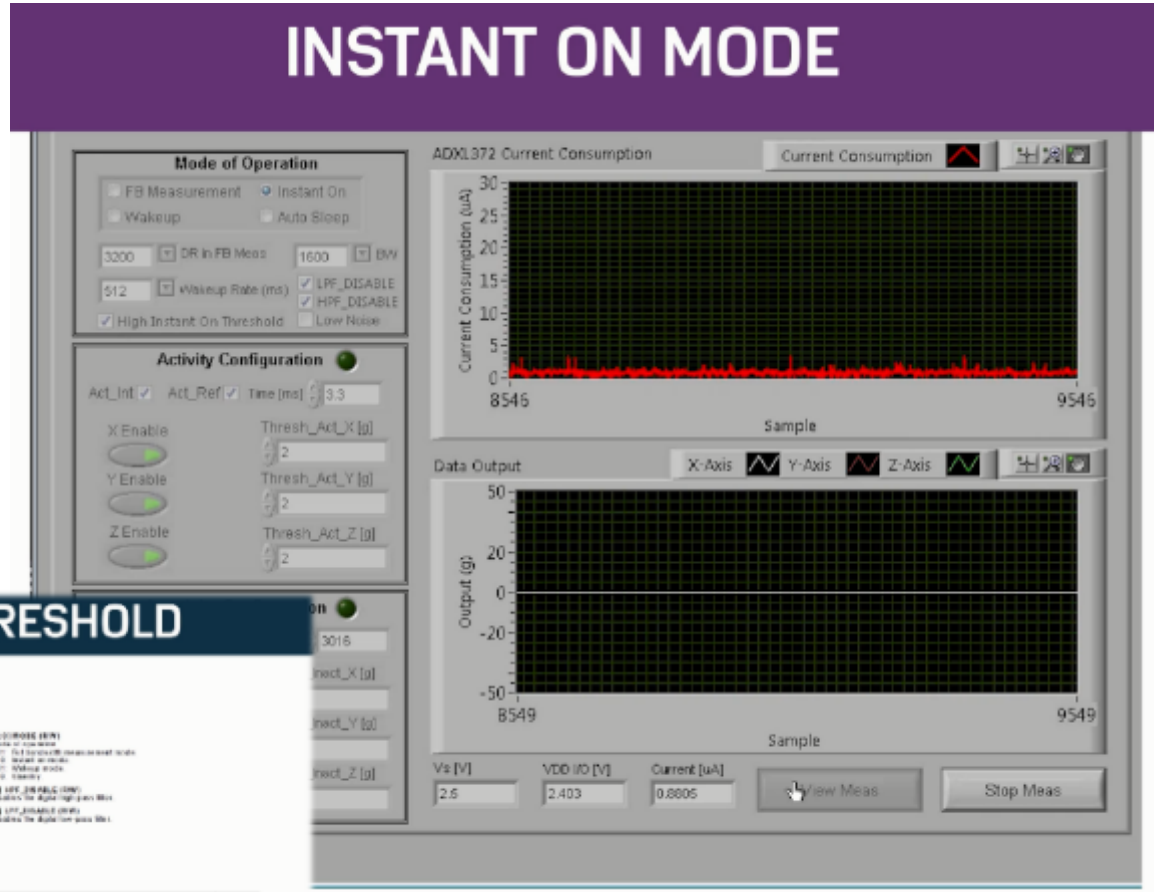
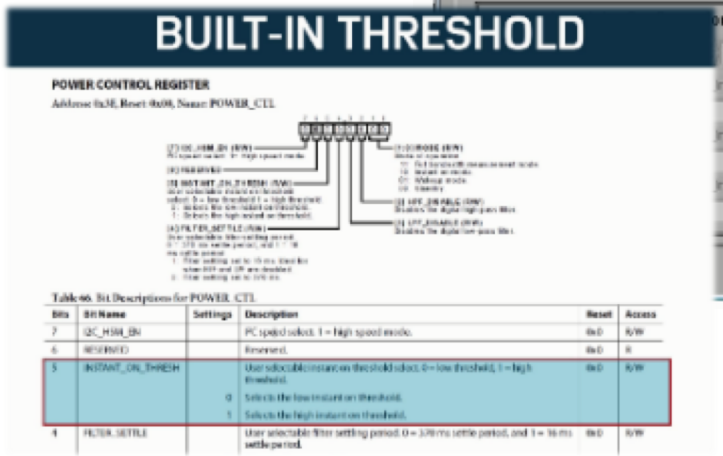
Latest power saving technology - Instant On Mode – ADXL372

- What is Instant On mode?
  - When an event that exceeds an internal threshold is detected, the device switches into measurement mode to record the event, otherwise, the accelerometer constantly monitor the environment at very low current consumption
- What's the advantage to use the instant on mode?
  - Immediately start capturing the impact waveform up to 200g within 1ms
  - **1.4uA** current consumption
  - User selectable threshold
  - uC set sensor in Instant on mode





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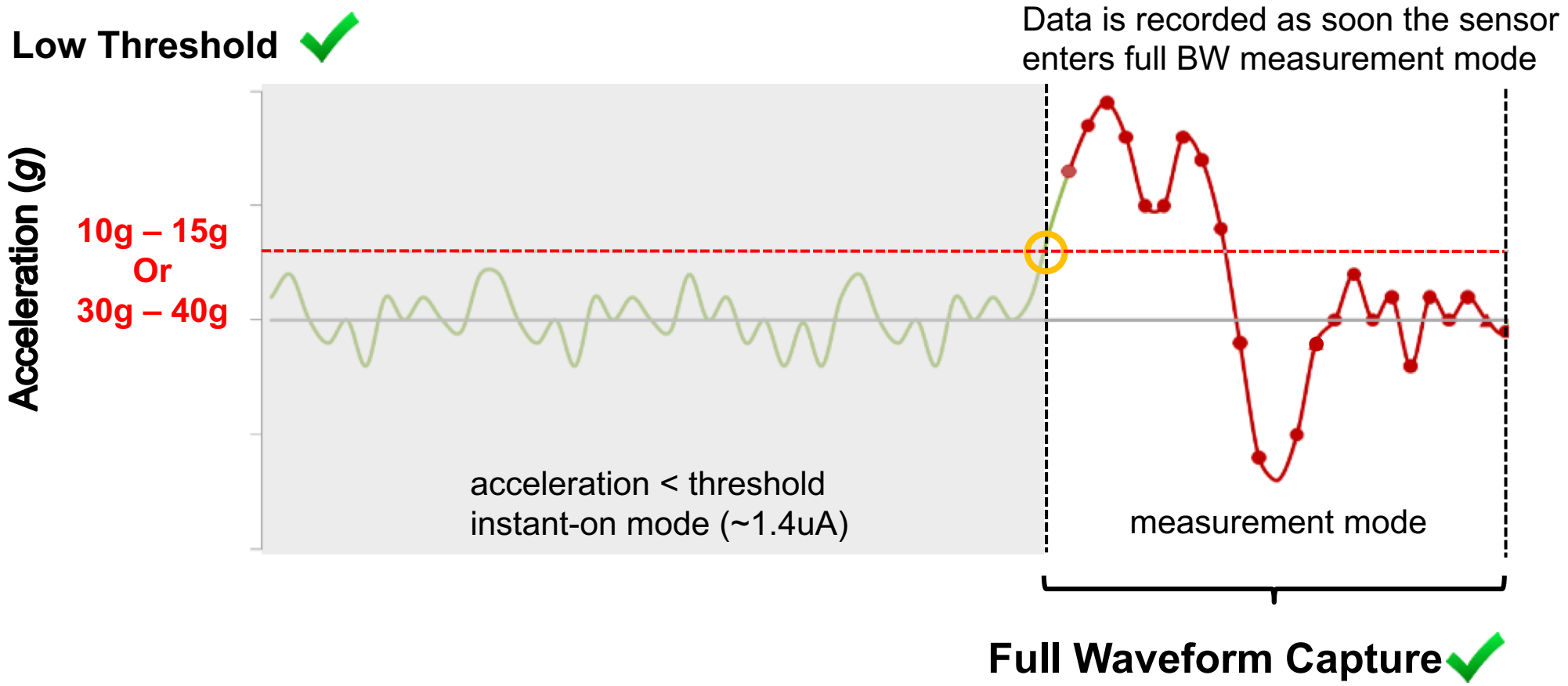
Ultra-low Power Full Impact Waveform Capture – ADXL372

- Threshold is monitored in the analog domain using an analog comparator in the ASIC
- Transition to measurement mode in <2 samples



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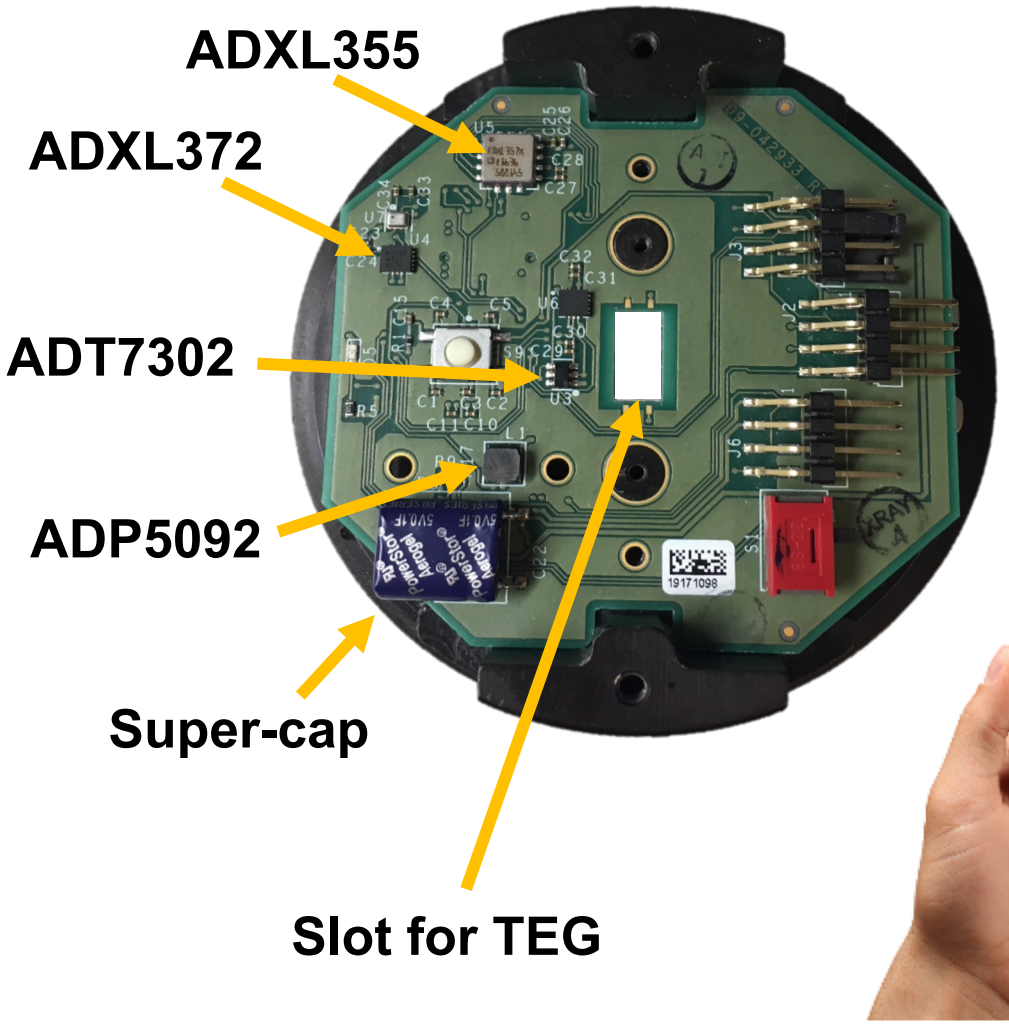
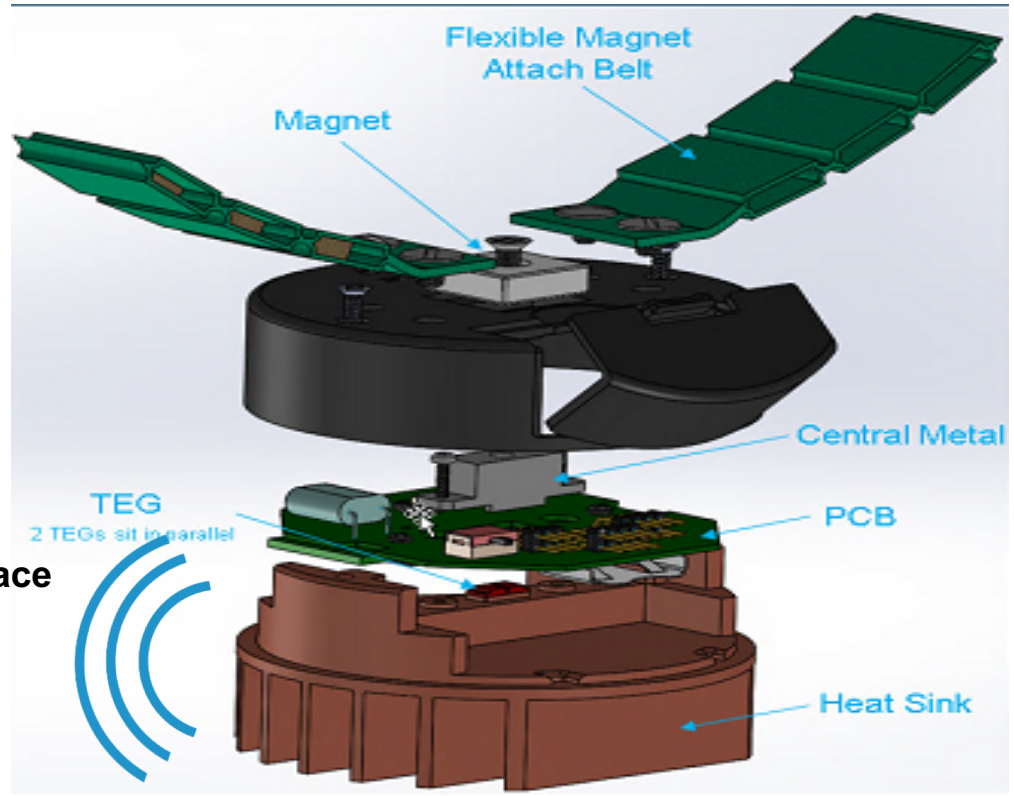
Development Prototype



BTLE Interface



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System-level Optimization

Objective

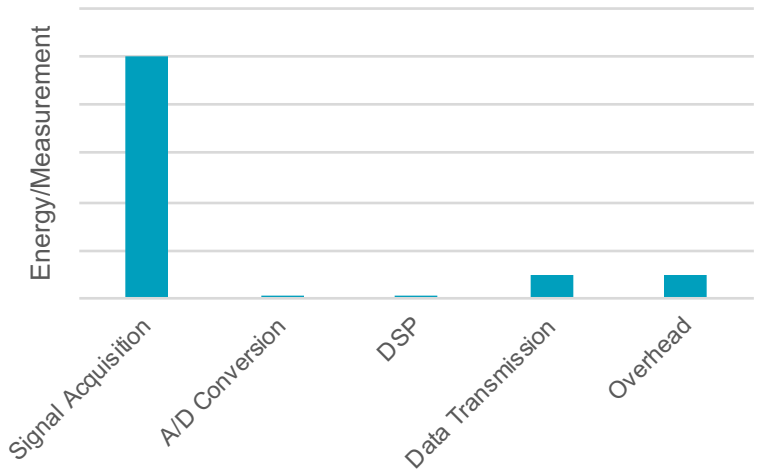
- Optimize power consumption of the complete sensor node

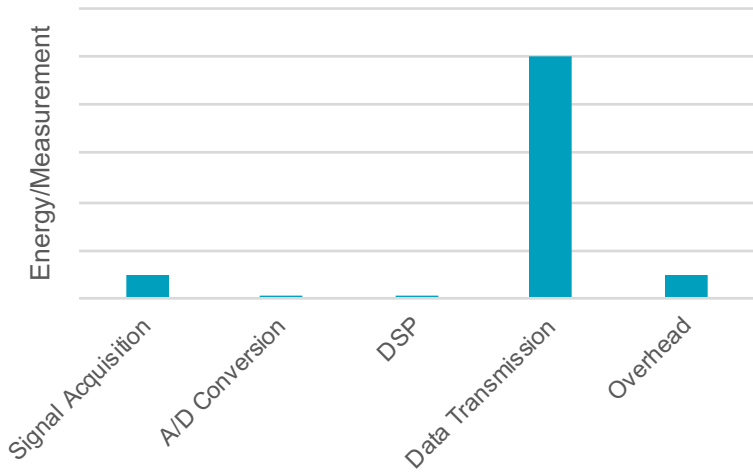
Results

- Case studies carried out to better understand how energy is consumed in sensor nodes—developed some classifications and improvements

Next Steps

- Apply the analysis and optimization method to real hardware platforms
- Develop better system power simulation tools





Sensor-limited

- Highest-precision, low data rate
- Examples
  - ECG
  - High-performance MHM
  - Toxic gas sensor
- Power-reduction techniques
  - Analog techniques
  - Adaptive sampling

Connectivity-limited

- Low-precision, high data rate
- Examples
  - Mainstream MHM
  - Activity tracker
- Power-reduction techniques
  - Signal Analytics
  - ULP Radio

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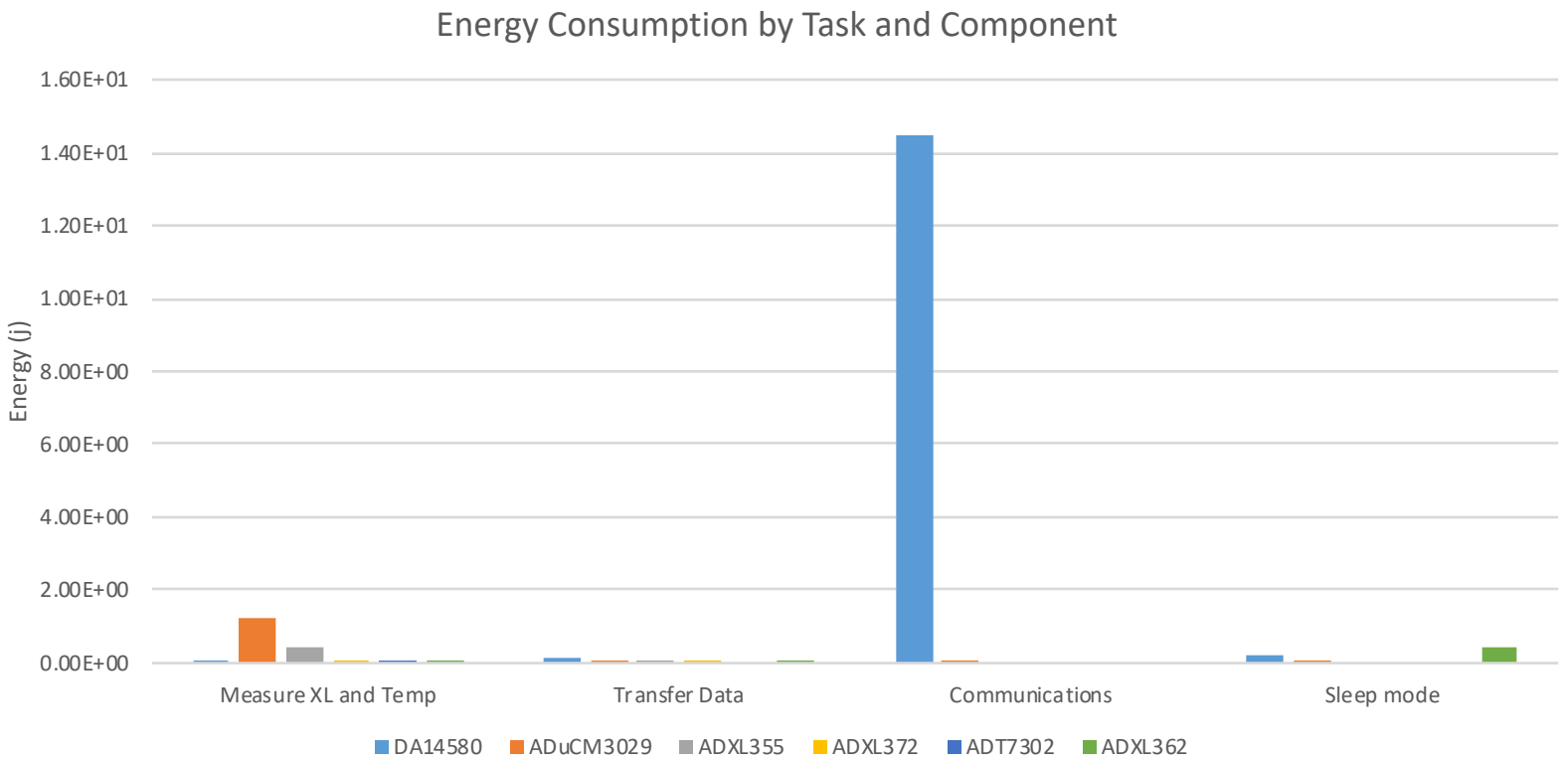
TEG Puck with Optimizations (30s update rate)

- Changes from original solution:
  - XL measurements conducted concurrently, using FIFOs to buffer data
  - Flexi mode used when transferring data on ADuCM3029
- Average power reduced from 340uW to 200uW **->10 uW** (update rate)
  - Dominated by RF



		Total	DA14580	ADuCM3029	ADXL355	ADXL372	ADT7302	ADXL362
Grand total	Energy (J)	1.72E+01	1.49E+01	1.39E+00	4.80E-01	5.91E-02	2.07E-02	4.22E-01
	Average power (W)	2.00E-04	1.72E-04	1.61E-05	5.56E-06	6.85E-07	2.40E-07	4.89E-06
	Average battery current (A)	6.65E-05						

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Call to Action

- IoT is happening (it has been for 40+ years)
- LOW POWER IoT is really challenging
  - Task-based use cases help the design/analysis/optimization
- Sensor-limited nodes can be assisted with better/smarter sensors
- Deep applications knowledge makes better products
- Analog Devices is here to help

Paul “I’ll be at the bar for consultations later” Perrault

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