FTF | FREESCALE TECHNOLOGY FORUM 2015

Device Longevity Considerations for Embedded IoT Applications

FTF-INS-F1125

Bob Johnson | Business Development Manager, Sensors

JUNE.2015

freescale™

External Use

Agenda

- Device Longevity vs. Product Longevity
- Notable Industry Challenges
- Robust Device History
  - Real Life Proof Points
- From Automotive to Everything Else
- Summary

Device Longevity Considerations for Embedded IoT Applications

During this session you will gain knowledge of Freescale's sensor devices duty cycle longevity

- Benefits of attending this session are:
  - Greater knowledge of Freescale sensors robustness
  - Appropriate positioning from automotive to the IoT
  - Awareness of how we reached (and exceeded) today's robust requirements
  - Greater value and decision making when reliability matters
  - Seed ingenuity of designs to find novel solutions

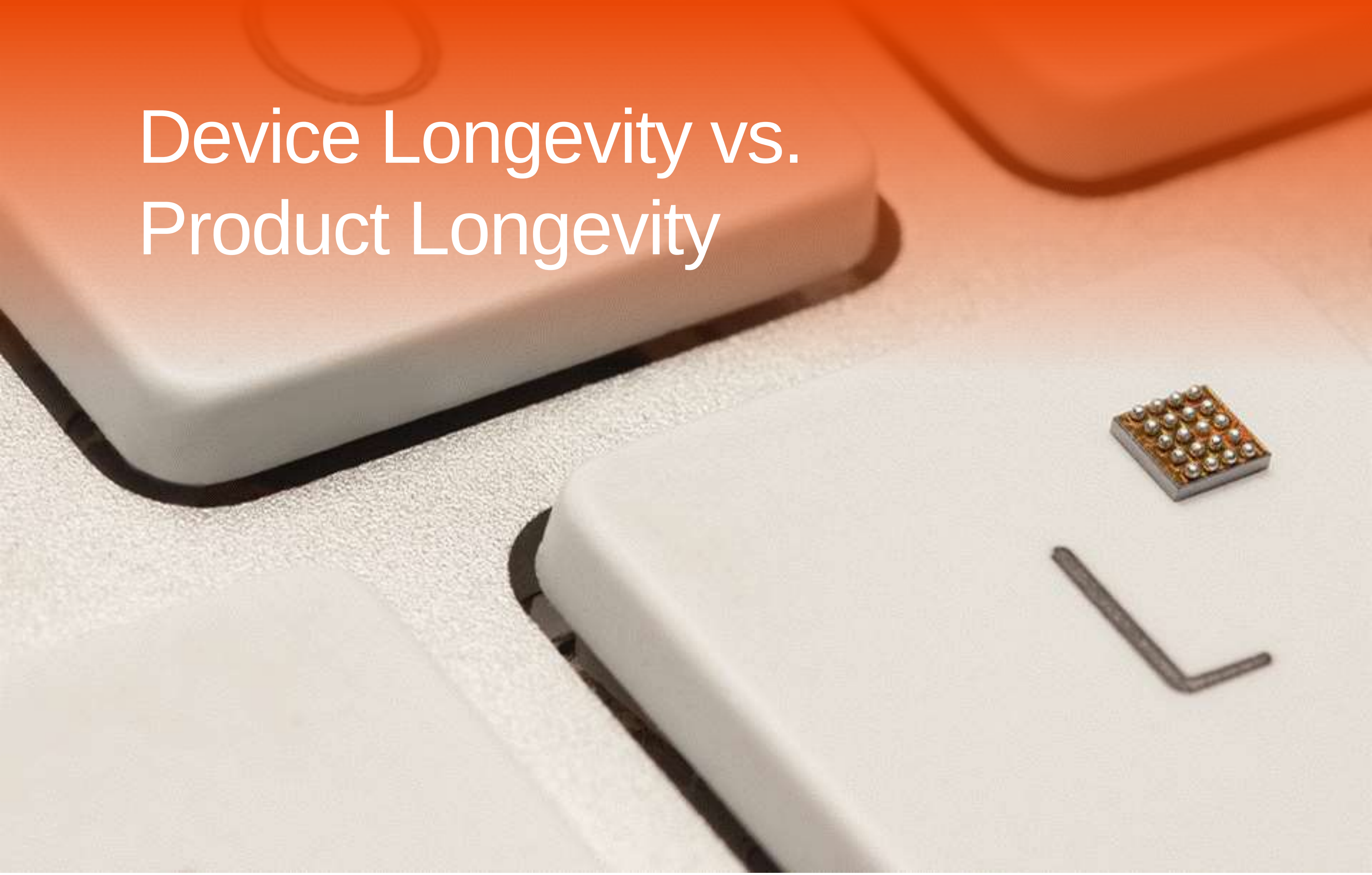
Session Objectives

- After completing this session you will:
  - Gain a brief understanding of how **Device Longevity** is Freescale's legacy
- Bob Johnson, Business Development Manager, Sensors

  - bobjohnson@freescale.com 480-363-5332 mobile
  - matt.muddiman@freescale.com 480-413-4429 office

- One hour allocated with time reserved for Q/A at the end

Device Longevity vs. Product Longevity



Product Longevity Program (PLP)

Not the subject of this Session

- Created in 2009 Freescale offers a minimum of 15 years availability for automotive, telecom and medical segments
- For our other market segments, a minimum of 10 years
- Time zero starts at the product launch date
- PLP makes up >90% of everything we ship
- Freescale end-of-life notification policy applies

Device Longevity

- Talks to the Reliability of the device

Notable Challenges from Industry Leaders

Notable Challenges from Industry Leaders

1980s – Chrysler, more to the point Lee Iacocca, issued the challenge: "If you can find a better car, buy it!"

Catalyzed the company to add new features while improving life-cycle costs, i.e. improving reliability

- Market share increased
- Profit margin increased
- Paid off government loans ahead of schedule

Notable Challenges from Industry Leaders

- 1992, Chrysler, Delco Electronics, and Ford sponsors Automotive Electronics Council:

- Defined a set of stress tests and acceptance criteria design to simulate more than 10 years in less than 4 months.

- Latest version is AEC-Q100 H

Notable Challenges from Industry Leaders

- Late 1990's – Hyundai issued a challenge to suppliers:

- Announced an industry 1st 10 year / 100,000 mile warranty
  - Market share increased to the point of becoming the fastest growing OEM

- Suppliers at the time were largely not capable

- Entire supply chain, including semiconductors, invested in continuous improvement strategies

By the way, these improvements have been made to components that are generally *serviceable*…

What happens when we need to embed sensors and control electronics into concrete?

Robust Device History

Sensors Have to be Just as Robust…

Long life is typically gauged by abuses more so than normal uses:

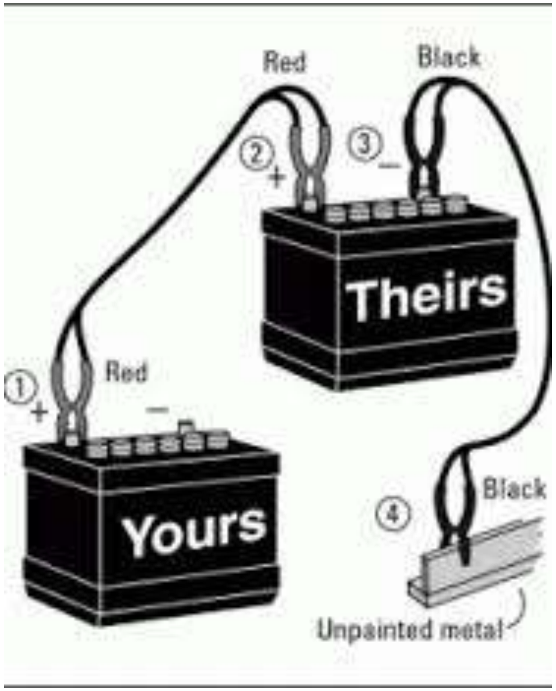
- Temperature &/or Voltage excursions typically can weaken without breaking immediately
- Vibrations, Shocks, Drops can result in long term fatigue, etc.

Sensors Have to be Just as Robust…

In the early days of sensor development, poly-silicon structures were all that were available:

- Randomized grain structures can be fatigued by overstresses
- Differing temperature expansion coefficients can result in de-lamination, cracks, etc.

Sensors Have to be Just as Robust…



Automotive use cases arrived, including a long list of possible abuses, drove the need for long life:

- Structures that provide high mechanical strength, and tolerate numerous overstress exposures
- Low temperature coefficients to provide minimal shifts, drifts, and predictable behaviors
- High voltage capabilities to provide margins for otherwise unstable supplies

Recent Example: FXTH87 Extended Reliability Testing

- The TMPS 7x7 family was fully qualified per the Freescale qualification standards as well as AEC-Q100 guidance

- To validate even further the TPMS 7x7 robustness, Freescale has performed a test to fail at **4x AEC-Q100** stress conditions. All tests completed with no failures.

Test	Conditions
HTOLP (High Temperature Operating Lifetime, pressure)	4032 hours
THB (Temperature, Humidity, Bias)	4032 hours
TC (Temperature cycles)	4100 cycles
Thermal Shock	3000 cycles
RDE (Rapid Decompression Event)	40 cycles
Centrifuge	3500g, 15 min

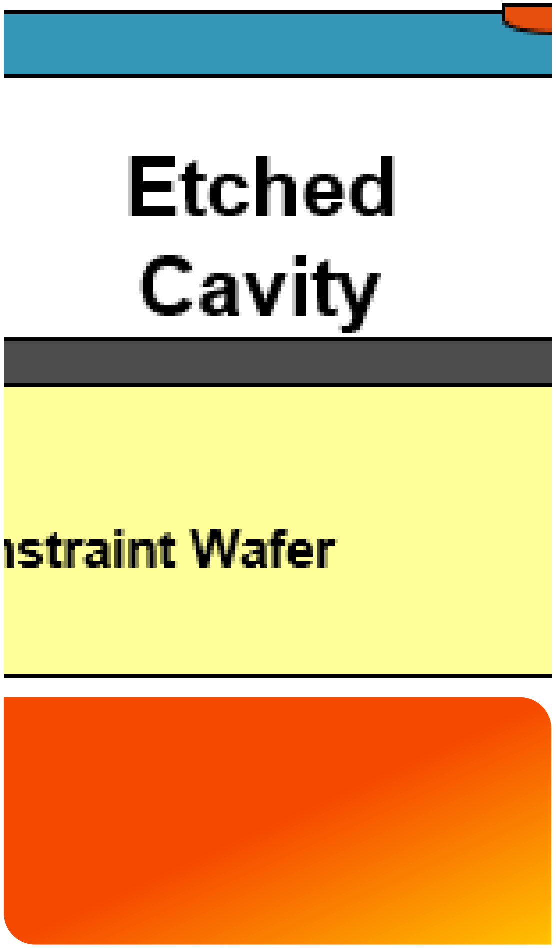
An overview of the migration of sensor designs to support the expectations of robustness…

Pressure Sensors

Pressure Sensors Enabled Electronic Fuel Injection

- By the late 1970's, due to federal EPA mandates, car manufacturers began converting carbureted cars to EFI
  - In 1980, Motorola (now Freescale) introduced the first electronic engine control unit (ECU)
  - Also in 1980, Motorola introduced the first manifold absolute pressure (MAP) and barometric absolute pressure (BAP) sensor
    - Instantaneous MAP information to the ECU
    - The data is used to calculate air density
    - Determines the required air fuel mixture
- These pressure sensors are still in production today winning >75 (and growing) new unique designs per year

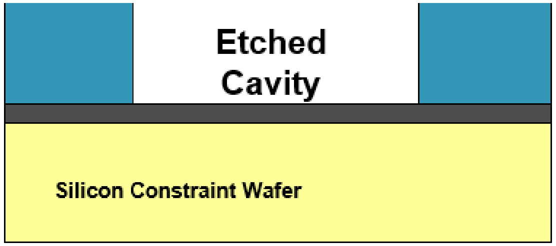
Pressure Sensor Evolution

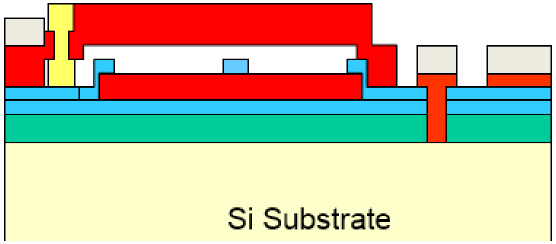


Early versions are essentially an impedance bridge implanted at the edge of a diaphragm

- As the diaphragm becomes stretched by pressure, the bridge is also stretched, and the impedance changes
- Signal conditioning aligns the non-linear transfer function of P vs R to become more linear, and corrects for offsets
- Being a diaphragm, too much pressure can cause it to burst…

Pressure Sensor Evolution





Newer generations are essentially capacitive domes

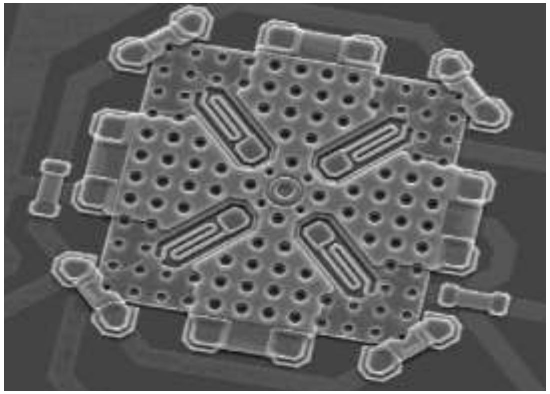
- Dome design is far more robust against overpressure
- Signal conditioning aligns the non-linear transfer function of C vs V to become more linear, and corrects for offsets
- Capacitance consumes far less power vs. impedance bridge

Accelerometers

Accelerometers Enabled Solid-State Airbag Deployment

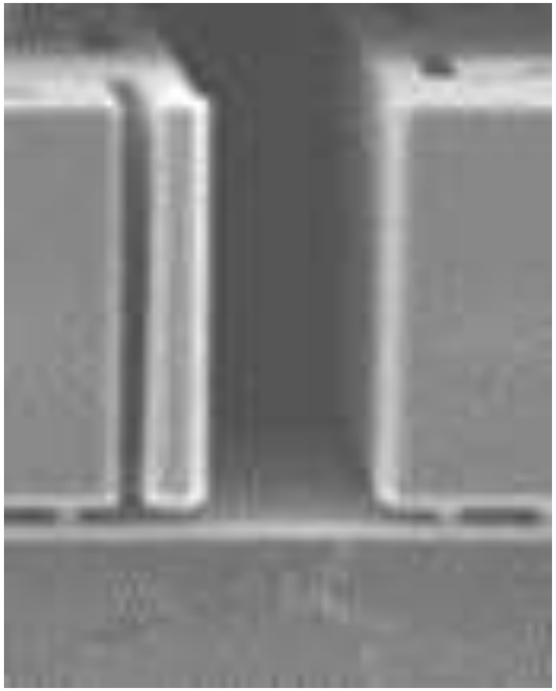
- In the late 1980's and early 1990's, most auto manufacturers began offering airbags, some as standard equipment
- The first airbag deployment means were primarily *ball in can* switching devices
- In 1989 Motorola (now Freescale) developed the first MEMS based accelerometer for airbag deployment
  - This created a solid-state sensing method for airbag deployment
- These airbag sensors are still in production today

Accelerometer (Inertia Sensor) Evolution



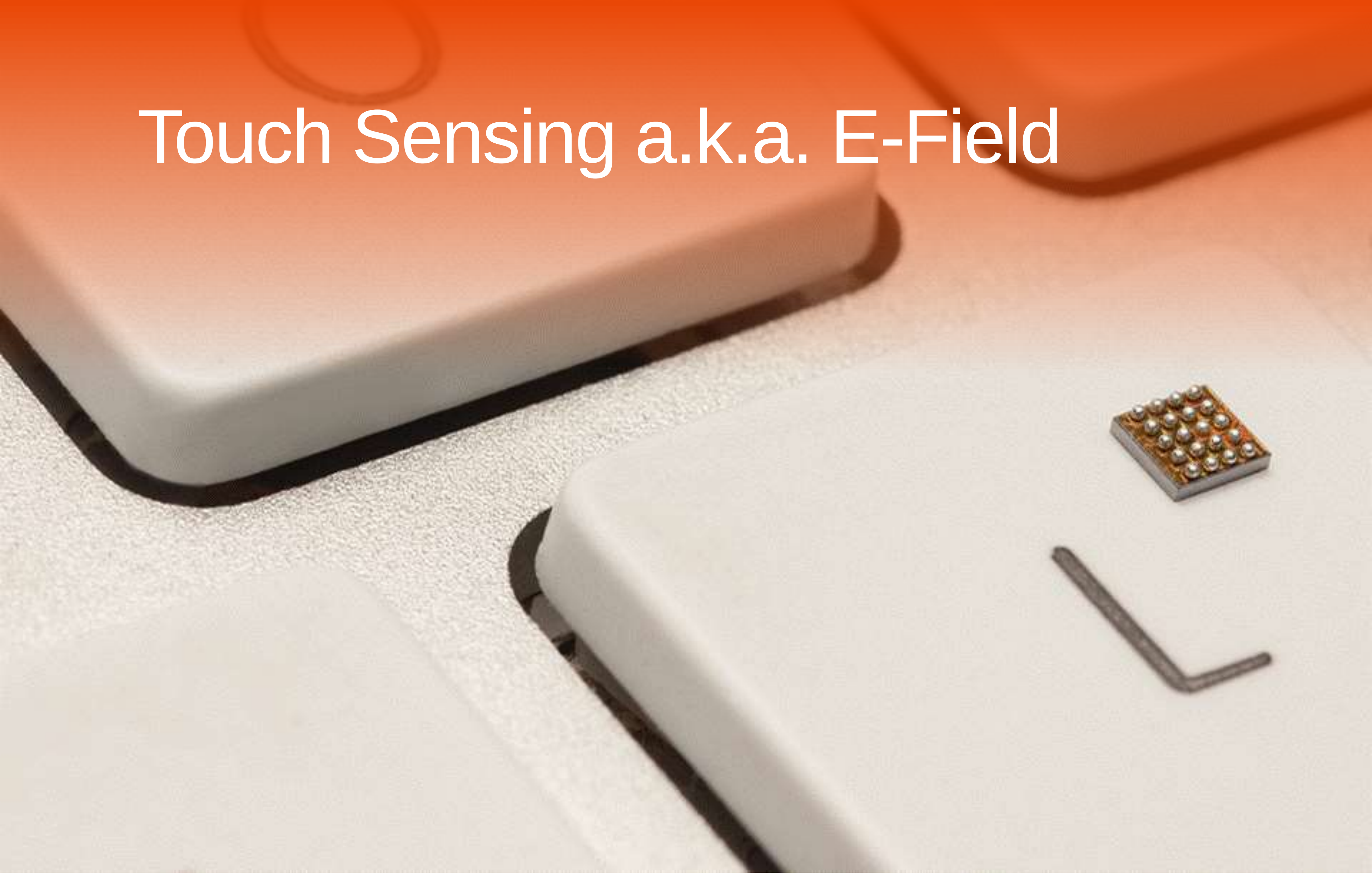
- Early versions are essentially stacked capacitors formed by a diaphragm between upper & lower electrodes
- As the diaphragm moves due to inertia, the two capacitors change
- Signal conditioning aligns the non-linear transfer function of C vs V to become more linear, and corrects for offsets
- Being a diaphragm, too much inertia can cause it to collide with the electrodes…

Accelerometer (Inertia Sensor) Evolution

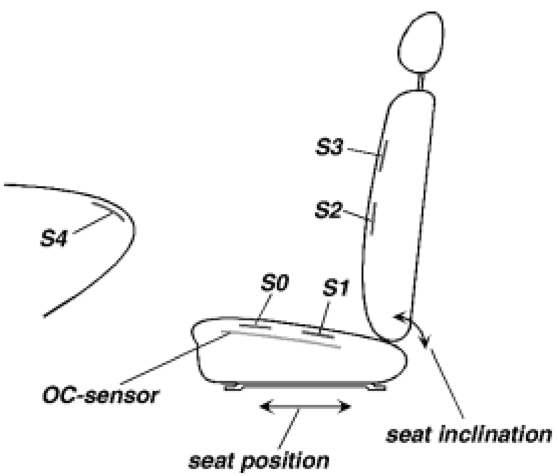


- Newer generations are essentially interleaved capacitive combs
- Interleaved comb takes advantage of hydraulic dampening
- Gas molecules being squeezed between the fingers provides the desired over-damped response
- Advances in silicon etching techniques create deeper and deeper fingers with each generation

Touch Sensing a.k.a. E-Field



E-field (Touch Sensor) Enabled Smart Airbag Deployment



- In the late 1990's most cars had front driver and passenger airbags, some as standard equipment
- At that time, the passenger airbag deployed at only one rate, in some cases fatally injuring smaller occupants
- In 1997, in a joint venture between Motorola and MIT, e-field technology was used to read a person's size and position to determine the most effective airbag action
- The 2000 Honda Accord 2dr was the first production car to use this technology

From Automotive to Everything Else

The migration of electronics from the benign table-top radios into today's long-lived vehicles provides the confidence that migrating into offices, factories, bridges, and tunnels can be accomplished at expected longevity.

Designs are Capable for Harsh Environments…

Back to the automotive heritage, consider that today's cars are designed to:

- Be abused for **10 years**
- Temperatures ranging from **-40º to over 250º F**
- Voltages ranging from:

  -13V when the tow truck driver reverses the jump cables

  24V when he leaves the generator set for delivery trucks

  Over **2kV** when you slide across the seat & touch the radio buttons…
- Mechanical shocks ranging from stones being thrown up from the gravel road to:
  - Thumping into a pot-hole,
  - Smacking the railroad crossing,
  - Backing into a telephone pole,
  - **Sensing when it's time to save your life…**

How This Effects IoT?

- Things connected to the Internet today are largely portable and serviceable:
  - Such as mobile phones, tablets, laptops, TVs
- And, we are encouraged to get new ones about every 2 years or so to remain “up to date”
- New things connected to the Internet of Tomorrow are expected to be stationary and un-serviceable

Wrap-up and Summary

Sensor Sessions at FTF

Sensor Data Analytics technical details

- INS-F1124 (Mon: 3:15pm) **Monetizing Sensor Data: Uncovering Valuable Information from Raw Sensor Data**
- INS-F1126 (Tue: 12pm) **Sensor Data Collection and Processing for Sensor Data Analytics, Part 1**
- INS-F1127 (Tue: 2:30pm) **Sensor Data Collection and Processing for Sensor Data Analytics, Part 2**
- INS-F1128 (Tue: 4:45pm) **Sensor Data Collection and Processing for Sensor Data Analytics, Part 3**
- INS-F1129 (Wed: 2:30pm) **Sensor Data Collection and Processing for Sensor Data Analytics, Part 4**

Hands-on sessions

- INS-F1220 (Mon: 3:15pm) **Sensor Data Collection and Mining, Part 1**
- INS-F1221 (Tue: 11am) **Sensor Data Collection and Mining, Part 2**
- NS-F1222 (Thu: 9am) **Sensor Data Collection and Mining, Part 3**

Related topics

- INS-F1522 (Mon: 3:15pm) **Monetizing Sensor Data (panel)**
- IHCW-F1202 (Tue: 2:30pm) **A Healthy Dose of Data: Sensor Applications for Patient Monitoring and Dosimetry**
- INS-F1271 (Tue: 11am) **Freescale TPMS for Heavy Trucks, Buses and Construction Vehicles: More than Monitoring Tire Pressure for Fleet Management**
- INS-F1125 (Tue: 2:30pm) **Device Longevity Considerations for Embedded IoT Applications**

Related Demo Resources

Pedestal ID	Demo Title
A13	1500 kPa range Tire Pressure Monitoring Sensor (TPMS)
Z20	Water Pump Condition Monitoring
P75	KegData monitoring with Freescale Pressure Sensors
W5	Sensor Fusion Development Kit
P74	Intelligent Stovetop
S40	MonBaby

Summary

Freescale is uniquely positioned to provide the type of robustness needed for the expected expansion of the Internet of Tomorrow:

- ✔ Long history of continuous improvement investments in circuit design, protection schemes, packaging, and tests
- ✔ Long history of developing devices that can withstand not only the normal uses, but also withstand the abnormal abuses
  - wide temperature ranges
  - over- & under-voltages
  - mechanical over-stress
  - exceeding life expectancy

www.Freescale.com