

Piezoelectric Floating Gate Sensor

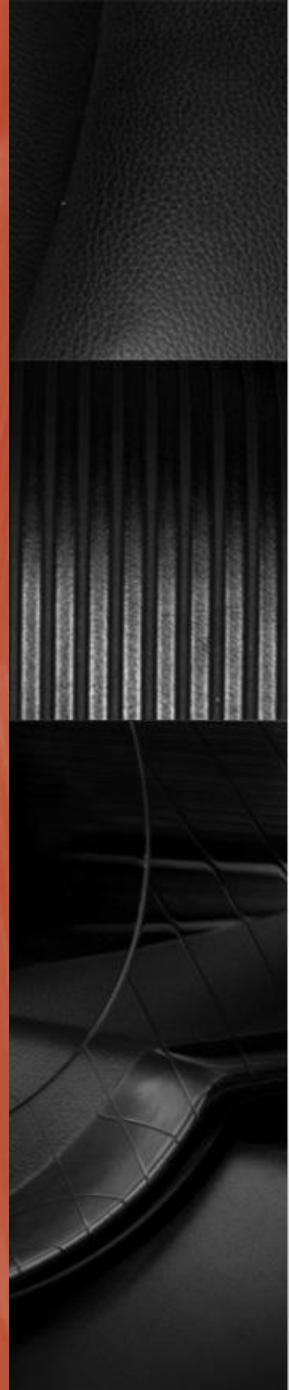
Design Team 1

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Overview

- Head Impact Statistics
- Technical Comparison
- Piezoelectricity
- MSU Prototype
- Circuits Differences

#14 Kyle Jefferson Takes a Big Hit - Michigan State @ Wisconsin



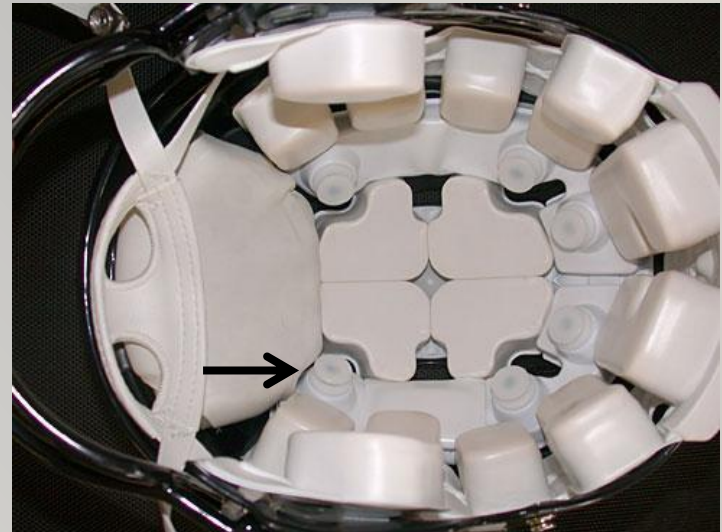
Head Impact Statistics

- Brain Damage
- High level energy impulse
- Acceleration levels exceed 100g
- Ideas? Sensors utilize energy



Tech Comparison

	Contemporary	MSU
Complexity	Significant	Small
Cost	\$1000/helmet	<\$1
Power	Battery	Self-powered



Riddell Helmet Sensor

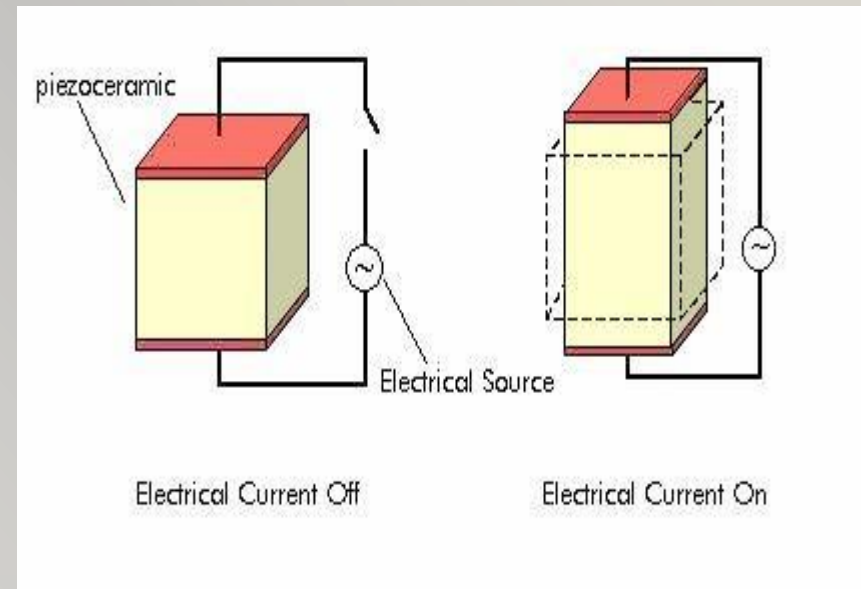
Conclusion:

- expensive circuitry
- high energy → some shorted to ground

MSU Solution: **Piezoelectric-sensor**

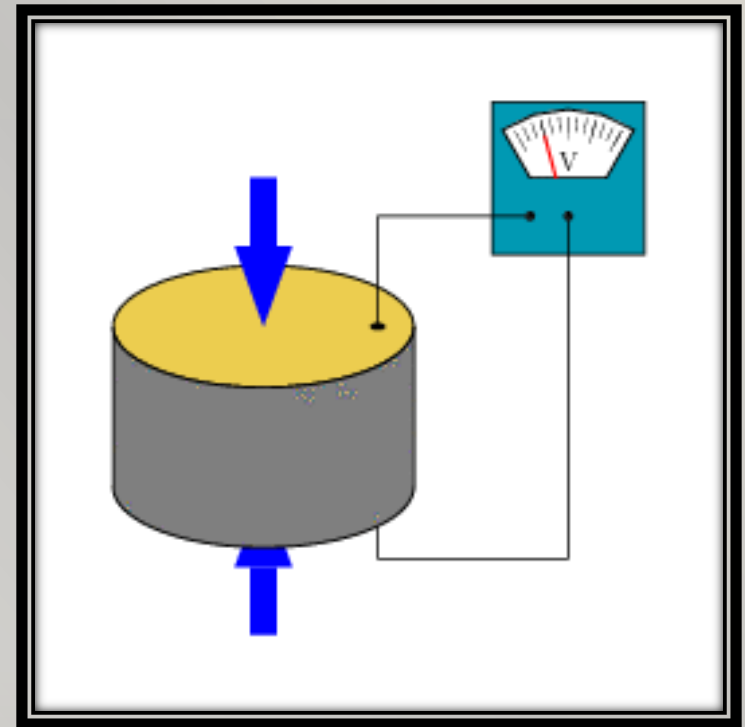
Piezoelectricity

- Piezo - *piezein* - greek: pressure
- **Piezoelectricity**: electromechanical relationship in crystalline materials in which pressure or physical strain induces electrical charge
- Induced charge $\propto$ Strain magnitude

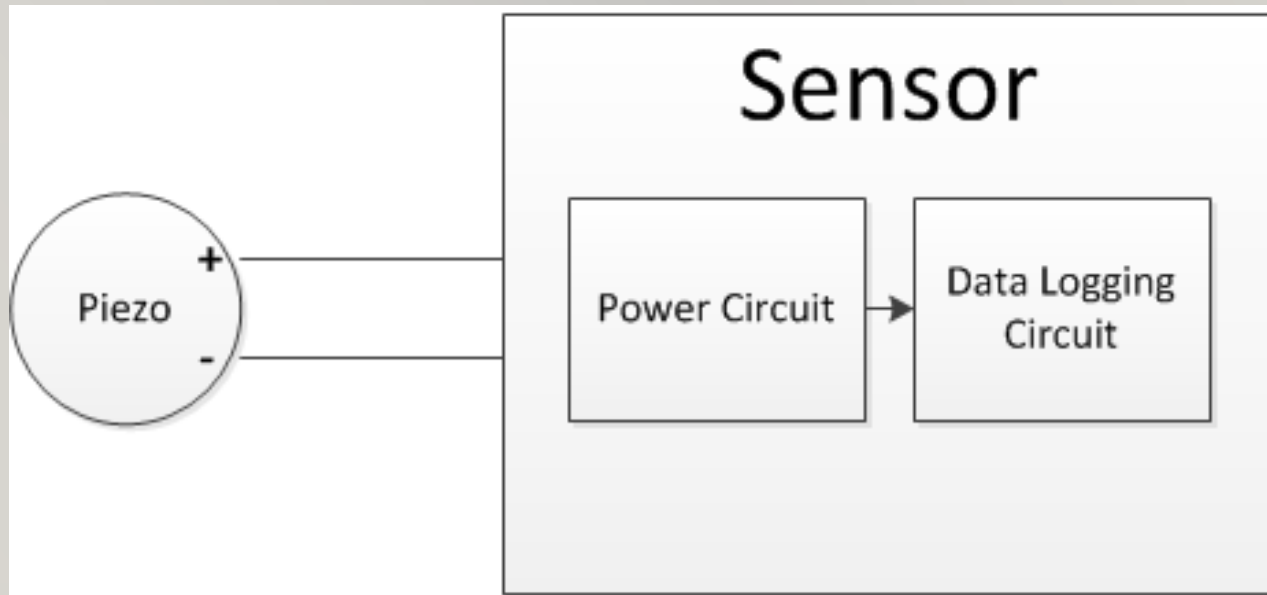


How Piezoelectric Materials Work

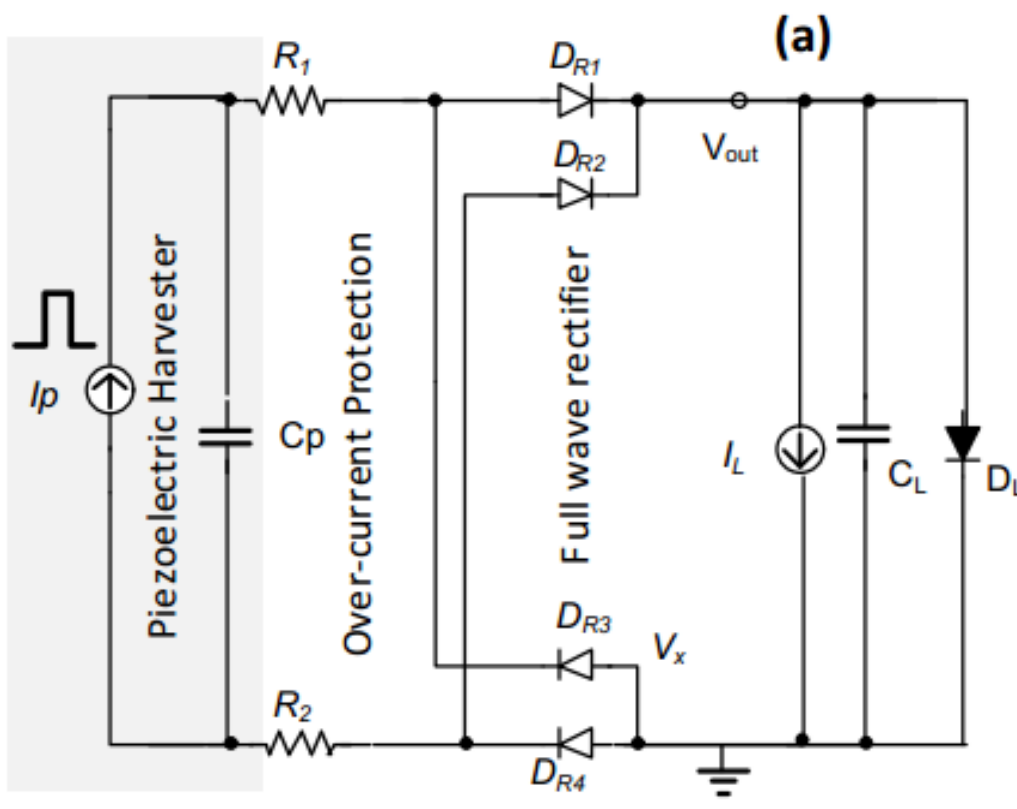
- Apply force to piezoelectric membrane
- Deformity in the lattice structure: electron flow creates electrical charge
- Harvested energy produces current



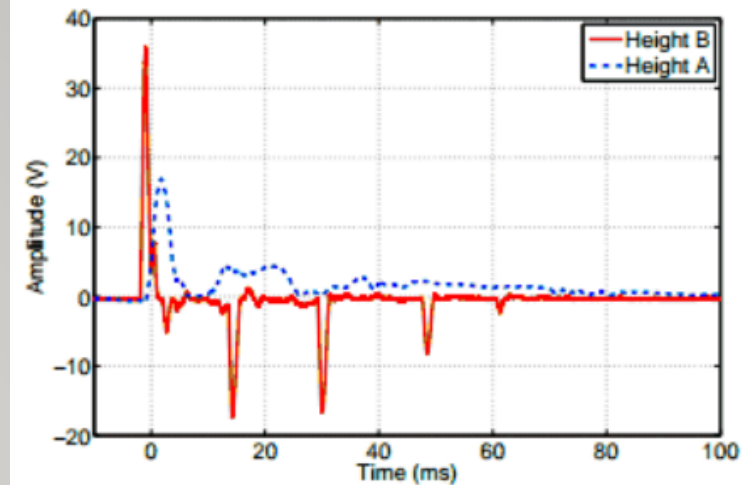
MSU Prototype



Sensor Power Circuit

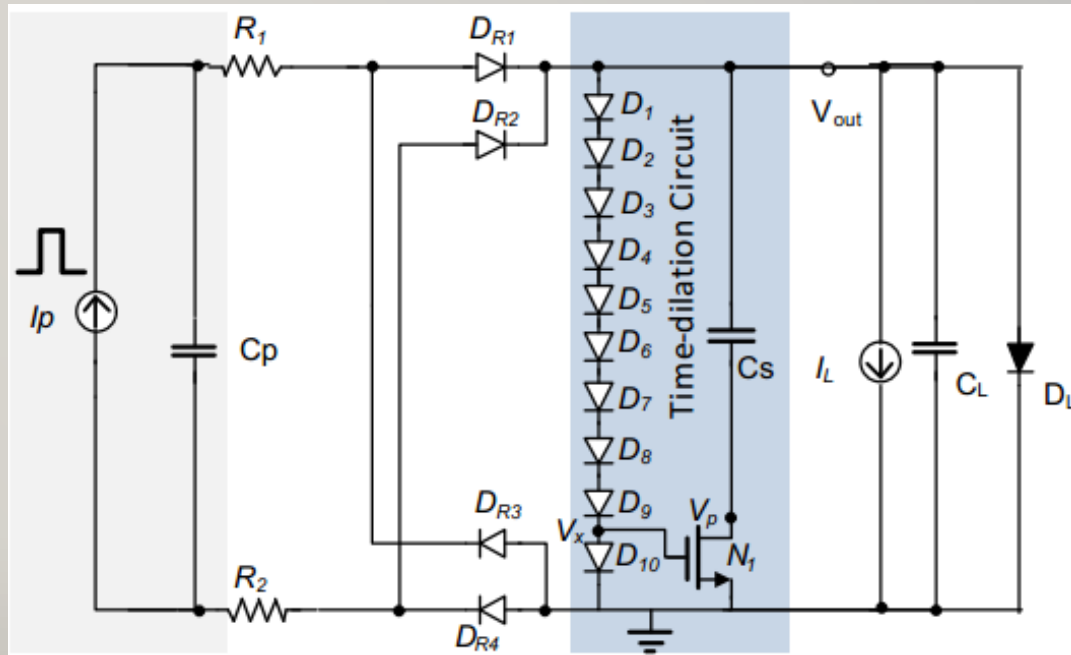


Circuit Response to Impact

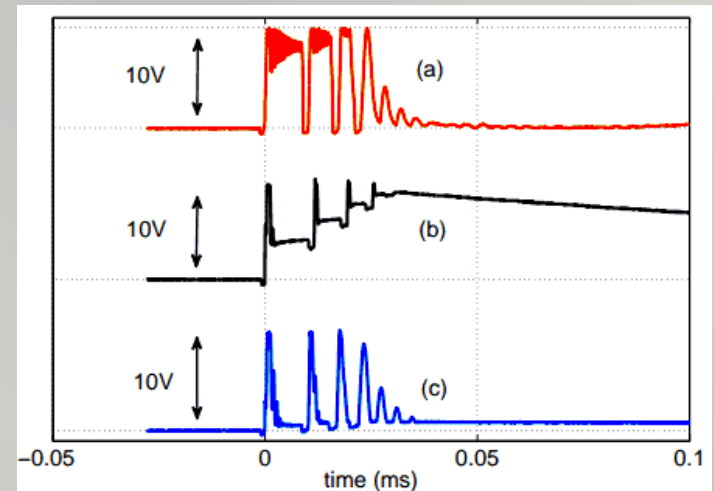


Circuit with Time Dilation

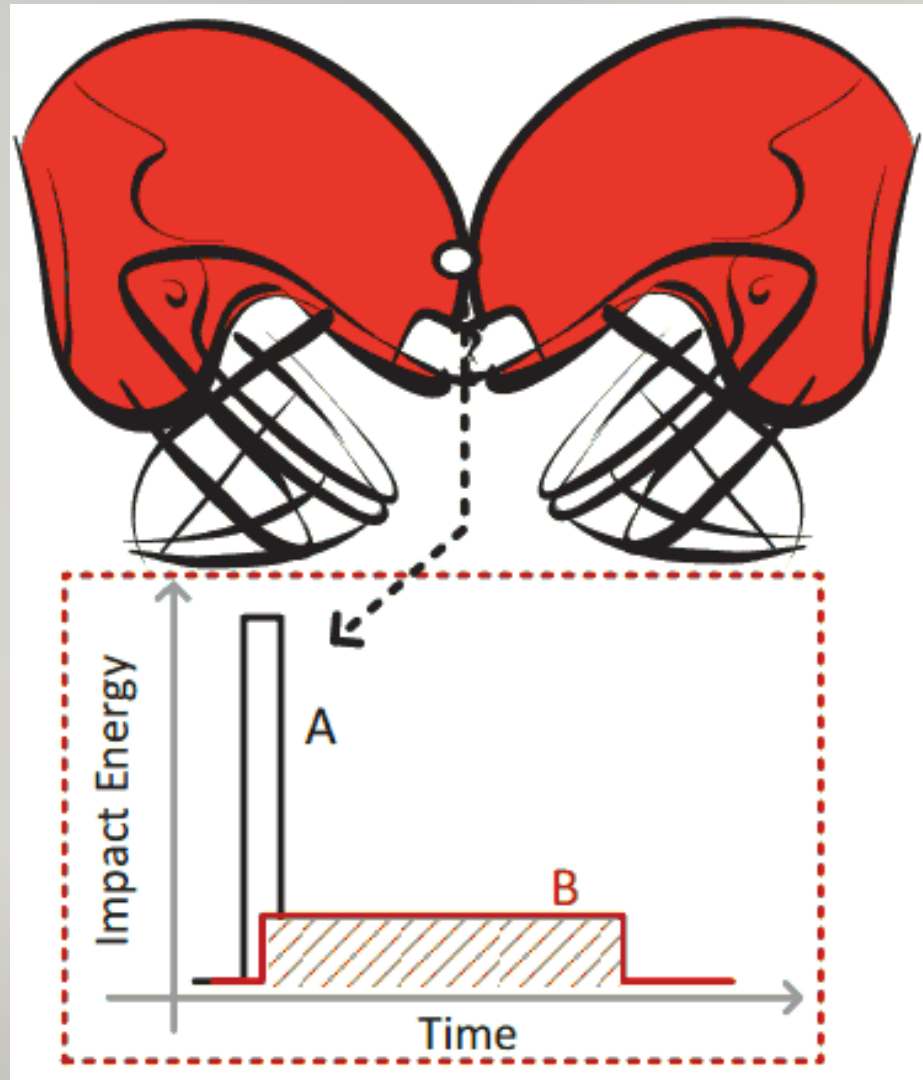
Self-Powered Sensor with Time-Dilation



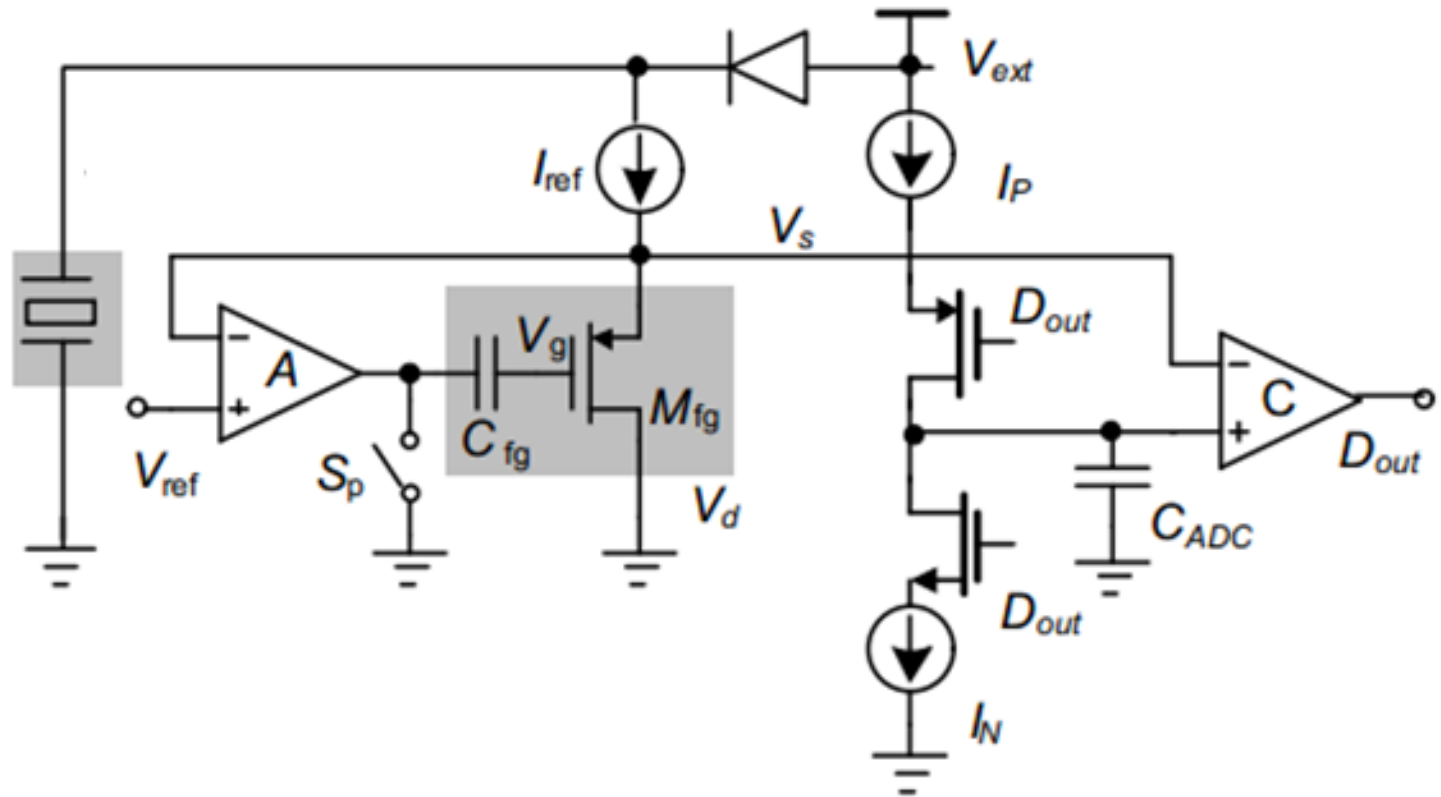
Measured V_{out} with and without Time Dilation



Circuit with Time Dilation

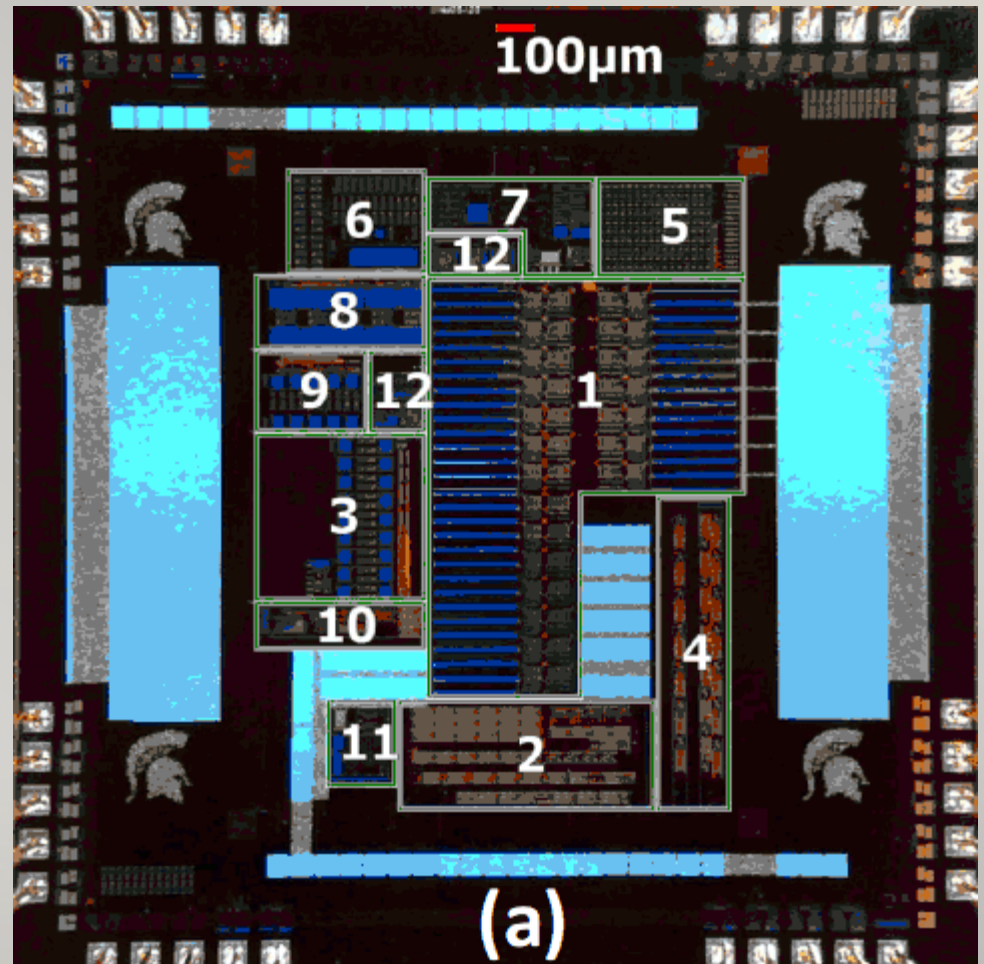


Data-Logging Circuit (DLC)



Features

- Self-powered
- Power consumption $\ll 1\mu\text{W}$
- Requires no maintenance
- Small size
 - 0.5 μm CMOS fabrication
 - 1.5cm x 2cm
- Low cost



Applications

- Kinesiology and Human Physiology
- Civil Architecture
- Mechanical Structure
- Automotive/Industrial



Q & A

