Powering 1 Trillion Sensors in 2025

CPSS-PSMA Workshop 11-6-18

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Industry 4.0

Industrial Revolutions

1st: Mechanization, water power, steam power
2nd: Mass production, assembly line, electricity
3rd: Computer and automation
4th: Cyber Physical Systems
Industry 4.0 + IoT

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+ 

Energy Harvesting
Energy Storage
Power Management
System Integration
1,000,000,000,000 Sensors in 2025

• Janusz Bryzek, The Trillion Sensor Summit 2015

• How to power each sensor?
  • Efficiently
  • Cost-effectively
  • Practically
  • Perpetually
1,000,000,000,000 Sensors in 2025

• System Approach
  • Eliminate the need for battery replacement where possible
  • Reduce power consumption
  • Develop energy harvesting solutions

• Research excellence challenge

• Academia & Industry
  • Work together
  • Work in parallel
  • Work to the same target
  • Accelerate development
PSMA Energy Harvesting Committee

**EnerHarv 2018**

- First international workshop, [www.EnerHarv.com](http://www.EnerHarv.com) 28th-30th May 2018
- Tyndall National Institute, Republic of Ireland
- Creating an ECOSYSTEM to ‘power the internet of things’
- >80 attendees from 4 continents
- Very successful, big need for cross-functional / academic-industry work
  - Energy harvesting, energy storage, micro-power management solutions
  - Share knowledge and best practices, define roadmaps
  - Encourage collaborations, identify synergies
Energy Harvesting: Self-powered Devices

Mechanical Age
- Limited Functions
- Short Range
- Unreliable when energy source removed (waves)

Digital Age
- More Functions
- Longer Range
- Higher reliability (multi-modal energy sources - wave, solar)
- Energy storage, power management
- (Difficult to change the battery)
Energy Harvesting: System Challenges

1. Intelligent switching between sources
   1. Ambient energies
   2. Battery
   3. Storage devices

2. Cold start
   1. Voltage conversion, impedance matching

3. Charge management
   1. Peaks, transients
   2. Status monitoring

Ambient energies
(sporadic, low power levels)
Conditional Monitoring: Reflow Oven Fan Reliability

• Fans (blowers) in SMT reflow ovens wear out. Failure is expensive
  • Downtime, emergency (unskilled) repair, damaged WIP, possible fire risk

• Old method – noisy fans are replaced manually
  • Increase from 70-80dB to ~ 90-120dB.
  • Poor detection, rely on operators

• New method - Fan noise measured using acoustic sensors
  • Self-powered (energy harvesting) using VEH (Vibration Energy Harvesting) / TEG (Thermo-Electric Generator)
  • Avoids extra cost of unreliable AC-DC or DC-DC converters for sensors in high temperature environment
  • Predictable, safe, skilled maintenance
Implanted Energy Harvesting (concept)

- Potential energy sources
  - Piezo-electric (muscle flex)
  - Fluid (embedded nano-impellor)

- Energy capability
  - Piezo using Si ~0.352 µW per cantilever
  - Piezo using MEMS ~5.9 µW per cantilever

EU-funded MANPOWER project
Courtesy of Tyndall, Sorin

horizon-magazine.eu/article/harnessing-vibrational-energy-can-mean-heartbeat-powered-pacemakers_en.html
Food Cold Storage Compressor Control
(Temperature & Humidity Sensor)

Feed temperature data back to compressor to reduce stress & optimise energy efficiency
Eco-System: Energy Harvesting + Power Management

- Energy Harvesting
- Power Management
- Energy Storage
- System Integration
Eco-System: Enabling Technologies

- Sensors
- ICT
- Power Electronics
- MEMS

ICT

Information & Communications Technology

Micro Electro-Mechanical Systems
Eco-System: Partners, Stakeholders

Developers

Integrators

Suppliers

Users
ENERHARV 2020

Planning
- PSMA Energy Harvesting committee meetings – welcome CPSS members
- At APEC 2019 – welcome CPSS input
- Target 200 attendees, welcome more from China
- Location, date TBD

Program
- Energy harvesting
- Power management topics
- Software / protocols, “How do we process data efficiently?”
- MEMs (packaging, industrial design, system-level multi-modal modelling)
- EnerHarv Technology Roadmap

Expand the Energy Harvesting eco-system / teamwork

谢谢