Wireless Condition Monitoring with Self-sufficient Sensor Nodes

Hannover Messe 2011: "Innovation for Industry" Forum Session: Energy Harvesting & Wireless Sensor Network

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Application: Condition Monitoring of Paper Mills

Problem:

- Sudden failures of critical machine components lead to unpredicted maintenance intervals
- High costs during shut-down (EUR 5000 €/h)





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Application: Condition Monitoring of Paper Mills

Solution:

- Self-sufficient sensor nodes form a network for wireless condition monitoring
- Early detection of failures through measurement of critical parameters, e.g. vibrations



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Components of the self-sufficient radio sensors

- Principle Schematic of the Sensor System
 - Acceleration sensor attached to vibrating machine surface
 - AD-Converter
 - DSP for FFT and analysis of characteristic spectrum
 - Proprietary communication standard
 - **Energy Harvesting device**



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Approach of Model-based Design



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Selection of the Ambient Energy Source



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Input Profiles - Ambient Conditions in Paper Mill











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Characterization of Thermoelectric Converter



5,0₇ Inner Resistance [Ohm] 0 0 4,5 0 0 4,0 0 ° ° o 0 3,5 0 0 40 60 80 100 20 Temperature [°C]

Seebeck-Coefficient vs. Temperature



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Serial Inner Resistance vs. Temperature

Conversion Chain – Characterization DC/DC Converter



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Simulink-Model: Source – Conversion – Sink



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Simulation Results



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Overall System Performance



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Piezoelectric Transducer

- PCT ceramics
 - Utilization of the transversal piezoelectric effect
 - High energy-efficiency only for excitations near resonant frequency => complicates a universal applicability





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Resonant Frequency of Vibration Transducers

	Prin- ciple*	F [Hz]	Bandwidth [Hz]	M [g]	V [cm ³]	Ρ [μW]	P-Density [µW/cm³]
Perpetuum PMG 17	EM	50,60, 100,120	>±20Hz	655	130	13000 (250mg)	99,5
AdaptiveEnergy Joule-Tief Module	ΡZ	60	?	43	34,5	~250 (200mg)	7,3
Cedrat APA400M-MD	ΡZ	110	?	270	35,2	95000 (max.)	2699
Volture PEH25W (V25W)	ΡZ	40	3	85	40,5	931 (250mg)	23
Baumer Piezo	ΡZ	265	10	500	140	3000 (250mg)	21,5
Baumer Stack8	ΡZ	300-800	500	1836	464	420 (200mg)	<1



*EM: Electromagnetic; PZ: Piezo

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Universal Piezoelectric Transducer

- Stack of 8 piezoelectric transducer with different resonant frequencies
 - Increased bandwidth of 300-800Hz
 - Power between 94 … 420µW at 2m/s²









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Further Activities: Wafer-Level Batteries & Fuel Cells



Wafer level batteries (silicon cavity battery)



Hydrogene fuel cell, 0.1 cm² active area (Pulse power of 200mW/cm² achieved)

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Thank you for your attention!







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- The project ECoMoS is funded by the German Federal Ministry of Education and Research.

04.04.2011

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