Fraunhofer IZM

Fraunhofer Institute for Reliability and Microintegration IZM

Electronic Packaging Days 2025

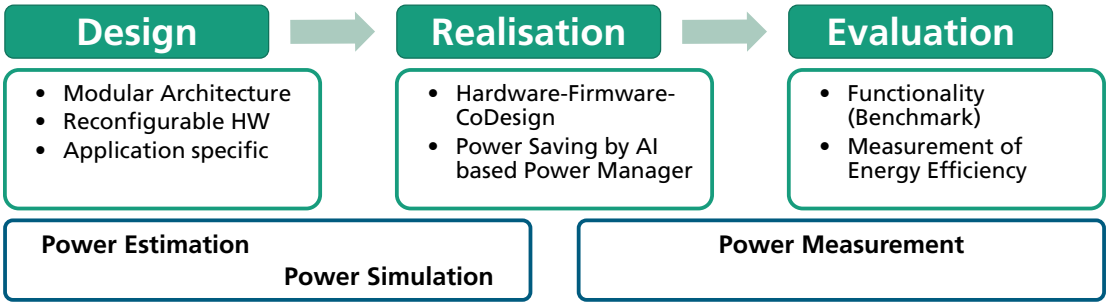
Carsten Brockmann

Green Deal for Microelectronics – Material & Energy Efficiency by Design

Material & Energy Efficency by Design

- Distributed connected devices drive the market of wireless sensors and embedded systems
- Estimated ca. 28 billion WiFi/BT-connected end consumer devices world wide in 2030, most equipped with batteries
- Increasing efficiency helps reducing waste of battery or oversized power supplies
- Especially batteries and rechargebles have a high ecological footprint
- We can show reduction of power demand up to factor 5 which means elongation of lifetime

How can we save energy without loss of fuctionality
Methodical Design of Energy-Efficient Systems



Concept for modular and reconfigurable platform design

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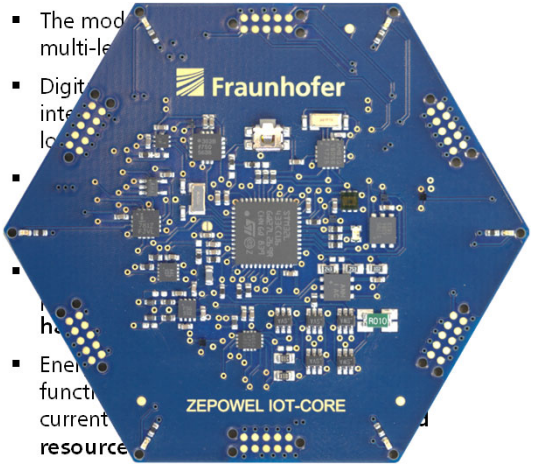

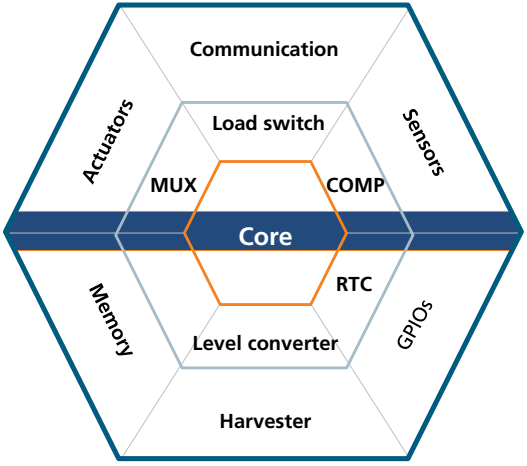

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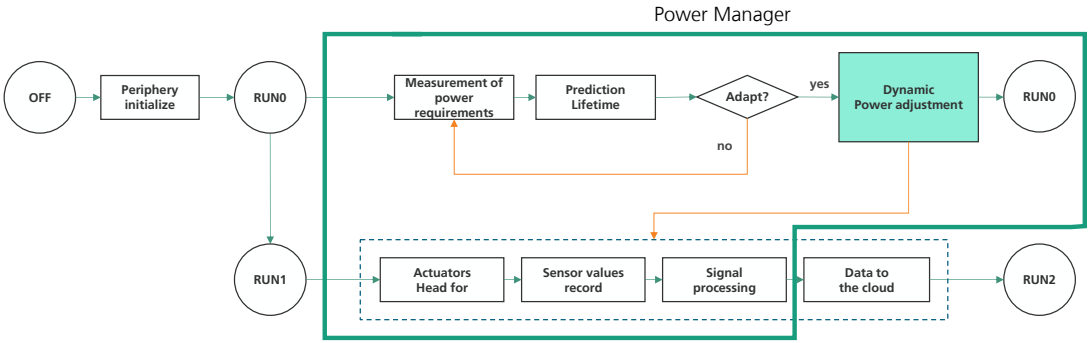
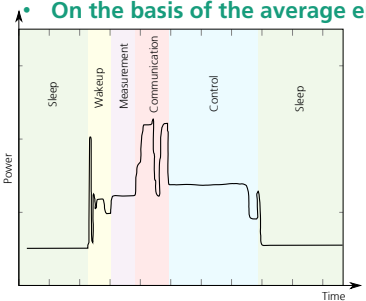
Simplified State Diagram of Power Manager



Power demand simulation and calculation

- Based on the planned functionality and the associated system states, an estimate of the average energy demand can be carried out
- It is based on the assemblies used in the design and their specified power consumption
- On the basis of the average energy requirement, operation life time can be estimated



Block Humi. Temp.

			W [ ]
>	Required repetitions for 1 day	86400	792,572377 mWs
^	Conversion to [Wh] for scenario (1 day)		0,000220159 Wh
	Option -- number of days for scenario	30	0,00660477 Wh
	Specify mode sequence in percent/day?		
^			

< Recurring mode sequence

Mode	Reps. [num.]	Duration [s]	P [mW]	W [mWs]	Dur_tot [s]
0	1	0,0018	0,081	0,0001458	0
0	1	0,00091	0,081	0,00007371	0
3	1	0,01088	0,774	0,00842112	0,01
1	1	0,98641	0,00054	0,000532661	0,99
			0	0	0
5	0	1	0,00882	0	0
		0,01358	0	0	0
		0,00018	0	0	0
			total	0,009173291	1

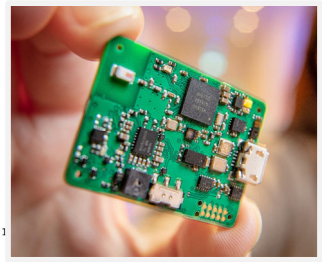
Definition **Humi. Temp.**

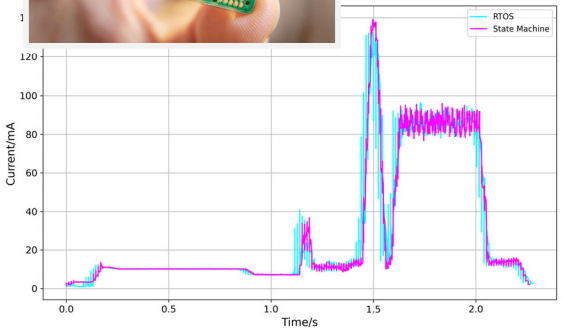
Type	SHTC3
Extra	
U_{Core} typ.	1,8 V
$U_{Feature\ (I/O)}$ typ.	V
Scaling factor	(is applied to each mode of the block)

				Requirement (stat., moment.)			
Mode	Task	I_{Core} [mA]	@ U_{Core} [V]	$I_{Feat.}$ [mA]	@ $U_{Feat.}$ [V]
0	Idle	0,045			
1	Sleep	0,0003			
2	Meas LP	0,27			
3	Meas NP	0,43			
4	Avg 1hz LP	0,0005			
5	Avg 1hz NP	0,0049			
6	Meas Period				
7	Soft reset				

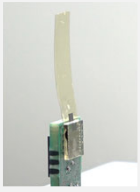
Measurement and Validation

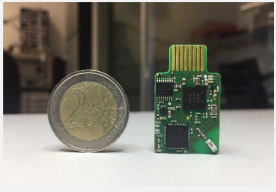
- With precise measurements and long term logging the simulation results are proofed and refined.
- Simulated application and environmental conditions are additional stimulus parameters
- All functional building blocks are validated
- The comparison of classic "state-machine" to RTOS-based implementations reveals only marginal differences in energy consumption

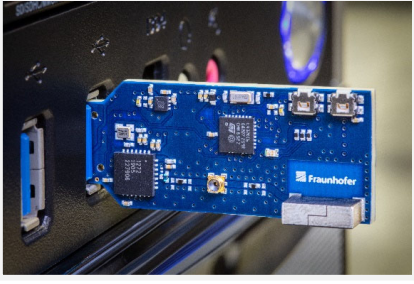


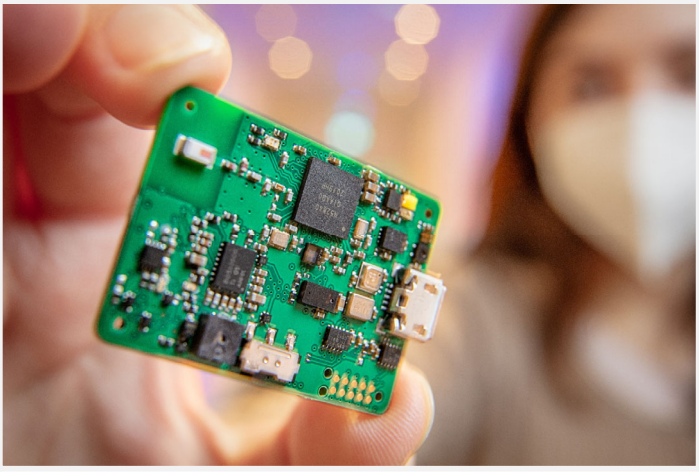


Wireless Sensor Platform „Swarmy“





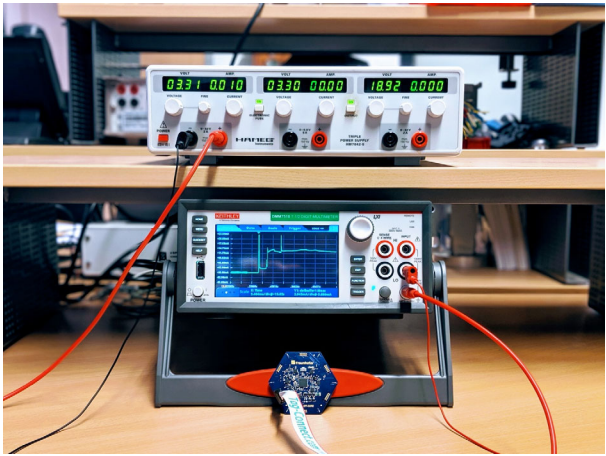




Conclusion

By implementing hard- and firmware on a demonstrator, the concept of the low power design methodology could be verified by performing measurements on the test bench:

- **Synergy effects in the ultra-low power range** achieved through the developed HW-SW co-architecture
- Test rig, for measuring power consumption in the **picoampere range** with a **high temporal resolution**, successfully commissioned
- Quantification of savings potentials and **minimization of energy consumption by a factor of 5** confirmed
- Dynamically **adjust performance at runtime of** the system
- **Modular connection** of external components successfully tested



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Thank you for your attention