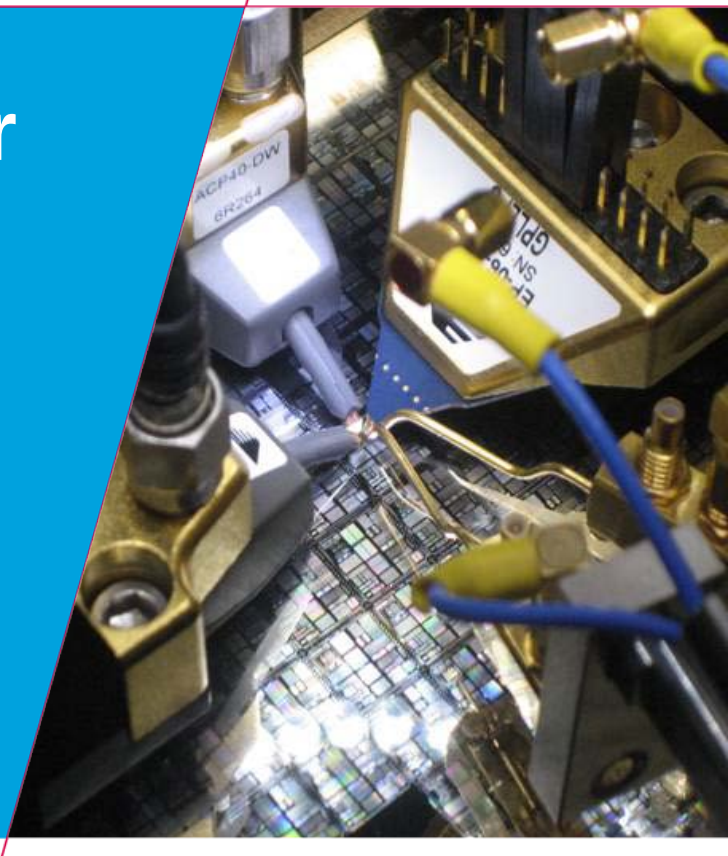
CWTe
Centre for Wireless Technology Eindhoven

Small Temperature Sensor Using mm-wave data and power transfer



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dr. Dusan Milosevic

MSM

TU/e Technische Universiteit Eindhoven University of Technology

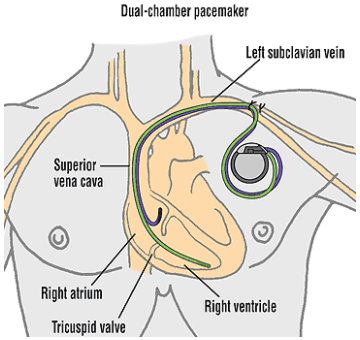
Where innovation starts

Outline

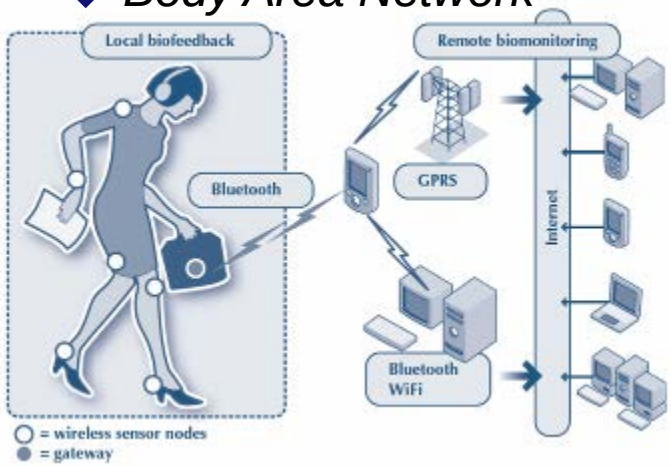
- Sensors with Wireless Power Transfer
- Mm-wave RF Wireless Power Receiver
- Mm-wave RF Tag
- 60 GHz Ultra Low Power Radio
- Conclusion

Sensors with Wireless Power Transfer

- *Medical and Health monitoring*



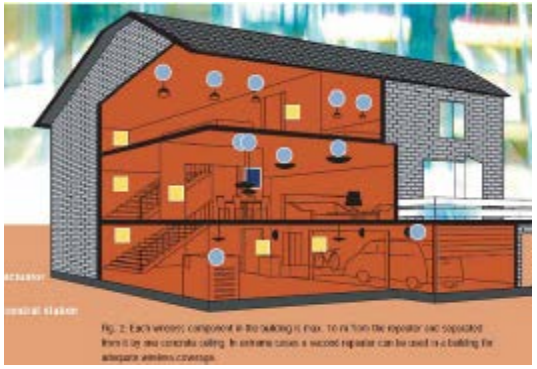
- *Body Area Network*



- *Structure Health monitoring*

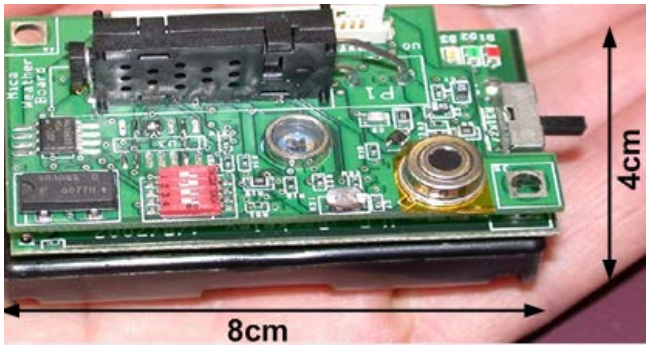
- *Wireless Sensor Networks*

- *Smart building*

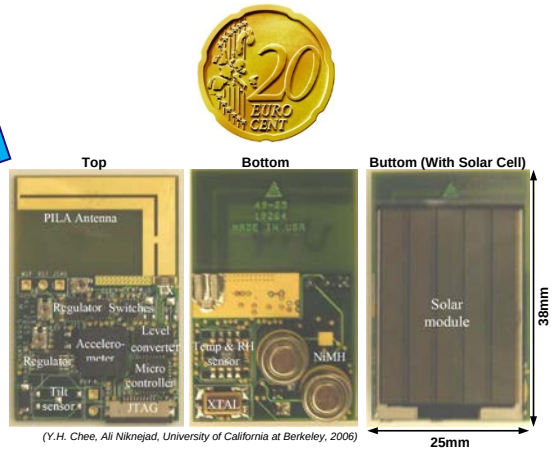


Low data rate / low duty cycle / ultra-low power

Sensor Evolution



÷ 3.3



(Y.H. Chee, Ali Niknejad, University of California at Berkeley, 2006)

÷ 475

$8\text{cm} \times 4\text{cm}$
32cm^2

$3.8\text{cm} \times 2.5\text{cm}$
9.5cm^2

$0.2\text{cm} \times 0.1\text{cm}$
0.02cm^2

Cons.:

- *Antenna Integration*
- *Assembly Components*
- *Battery Size*
- *Hight Cost*

(2.4 GHz)

Cons.:

- *PCB Based*
- *Harvesting Method not easy to integrate*

(1.8 GHz)

(© BWRC,UCB, US, 2006)

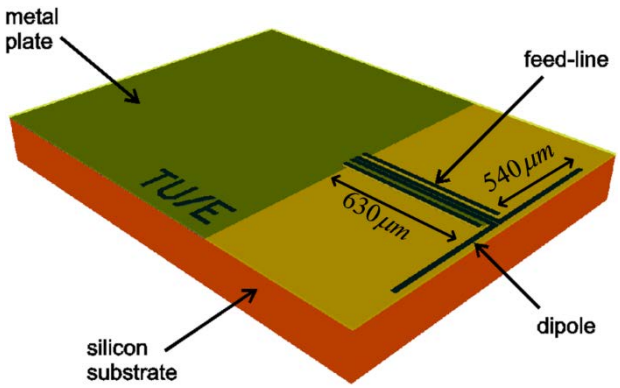
Solution:

- *mm-Wave*
- *On-chip antenna*

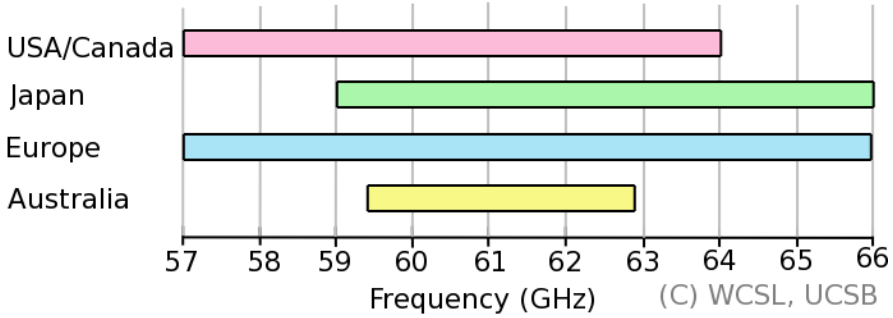
(60 GHz)

Why mm-Wave ?

- **Small wavelength enables:**
  - **Integrate antenna on-chip**
  - **Develop antenna arrays to**
    - **Provide high antenna gain**
    - **Provide highly directional pencil beams**

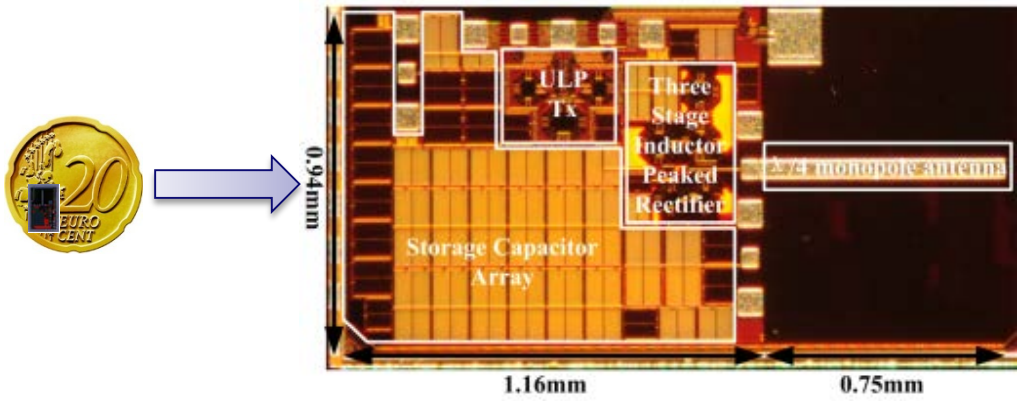


- **Wide bandwidth available at 60 GHz enables**
  - **High data rate in the order of Gbits/s**
  - **Short transmission burst**

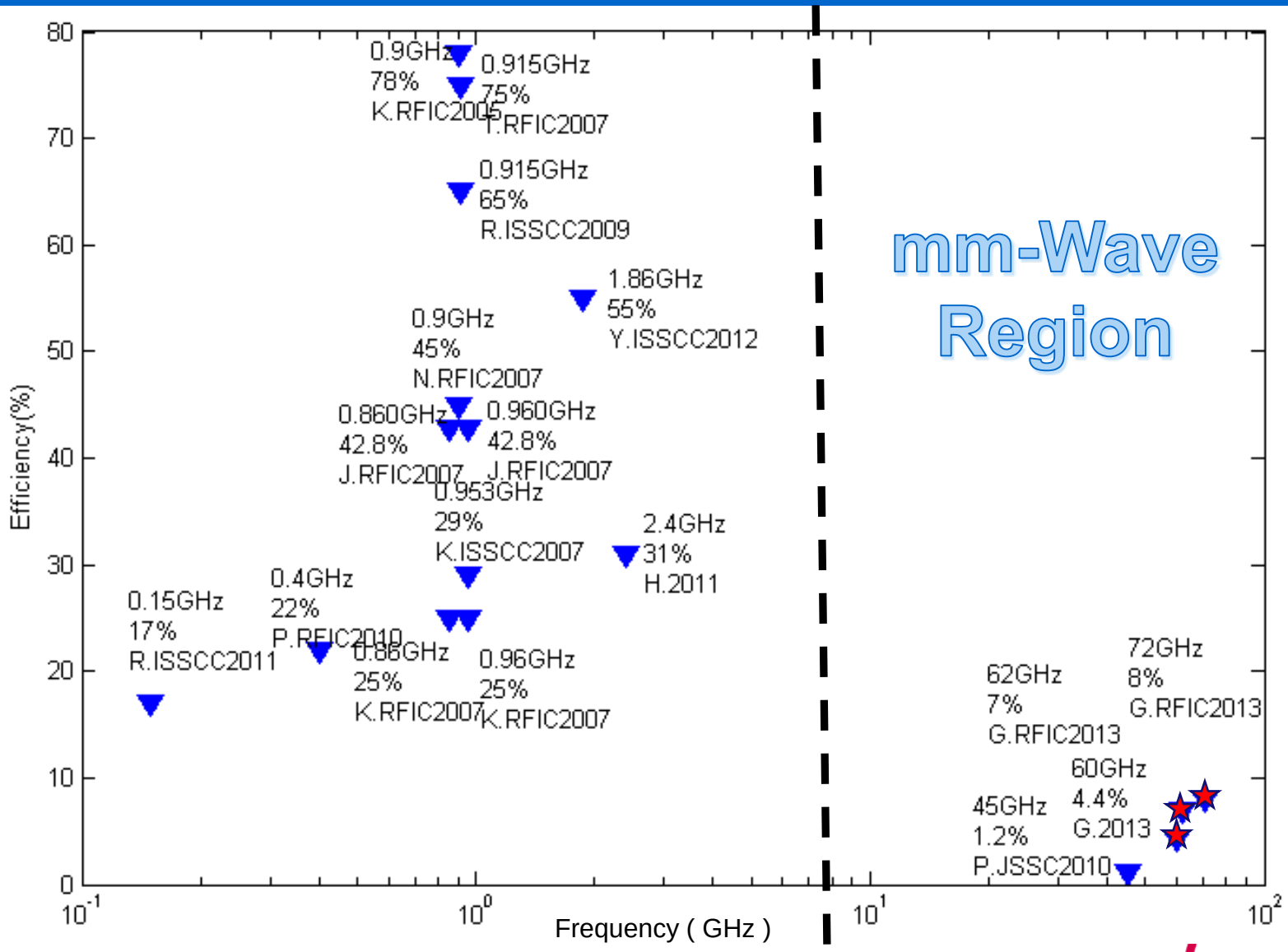


mm-wave Problem

- Rectifier performance conflicts with antenna size.
  - mm-Wave enables antenna on-chip.
  - Wide bandwidth available at 60 GHz.
    - High data rate in the order of Gbits/s.
    - Short transmission burst.
  - Rectifier performance at mm-Wave : Efficiency is low.



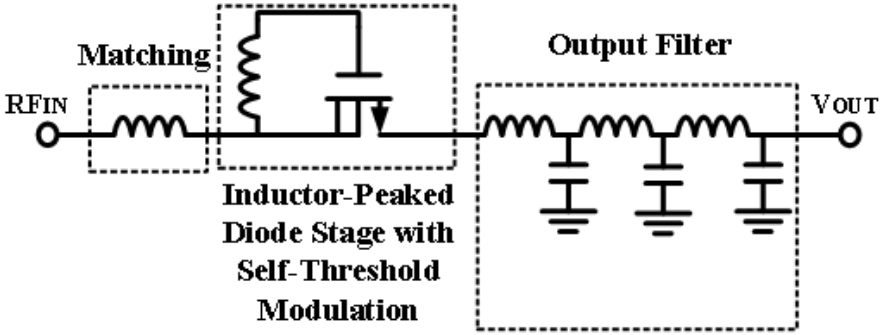
Benchmarking

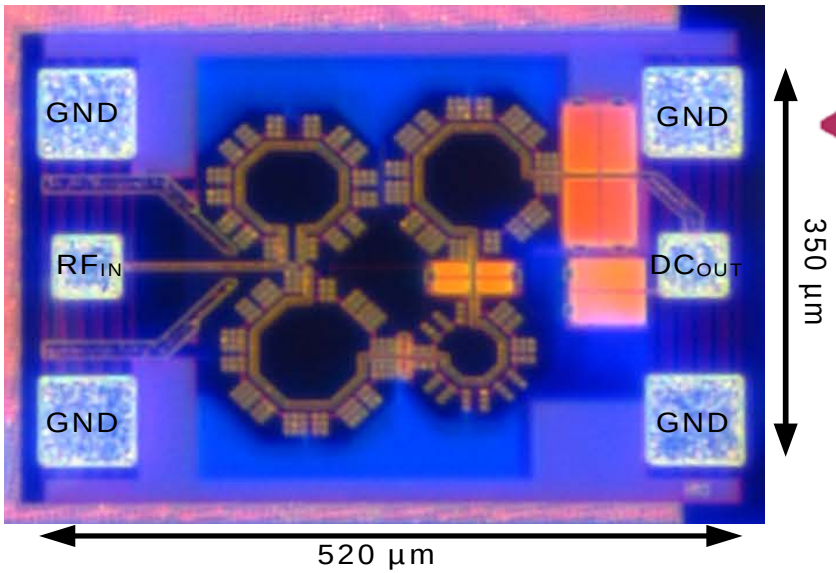


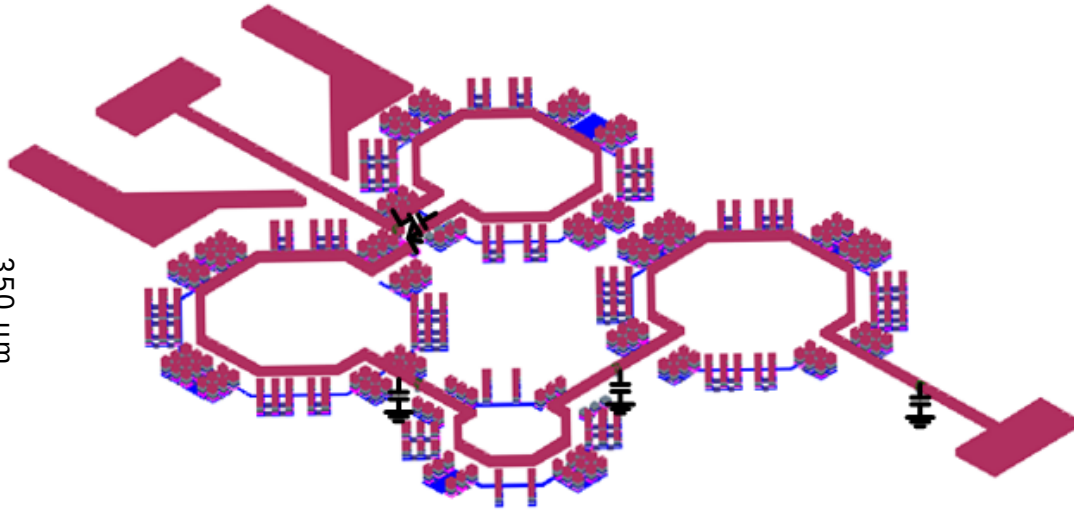
60 GHz mm-wave Inductor-Peaked Rectifier

Problems:

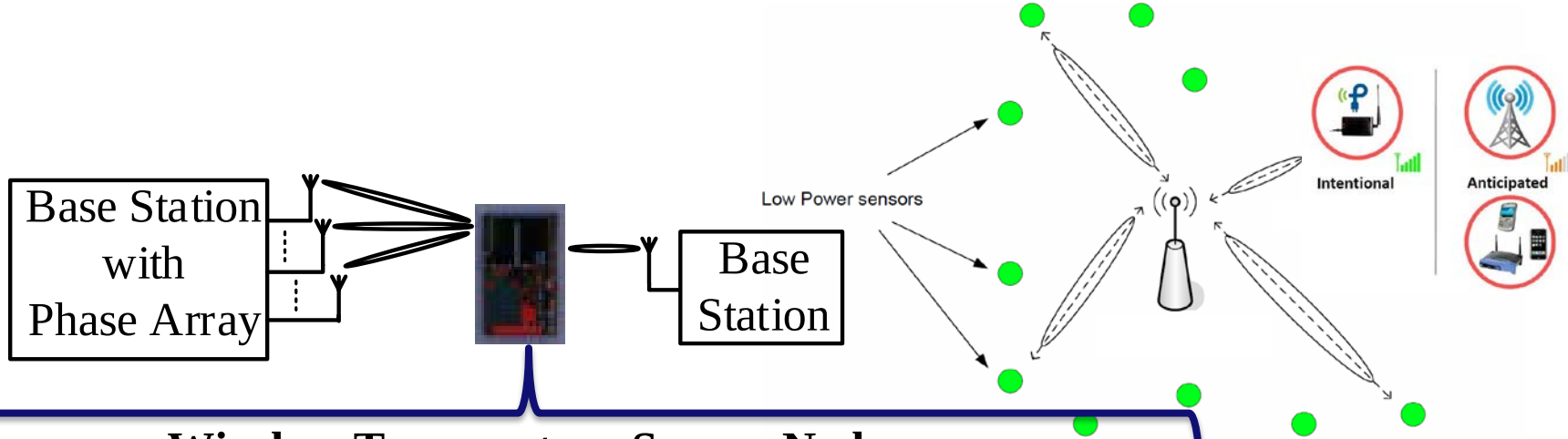
- Low input voltage
- High threshold voltage
- Signal feed through

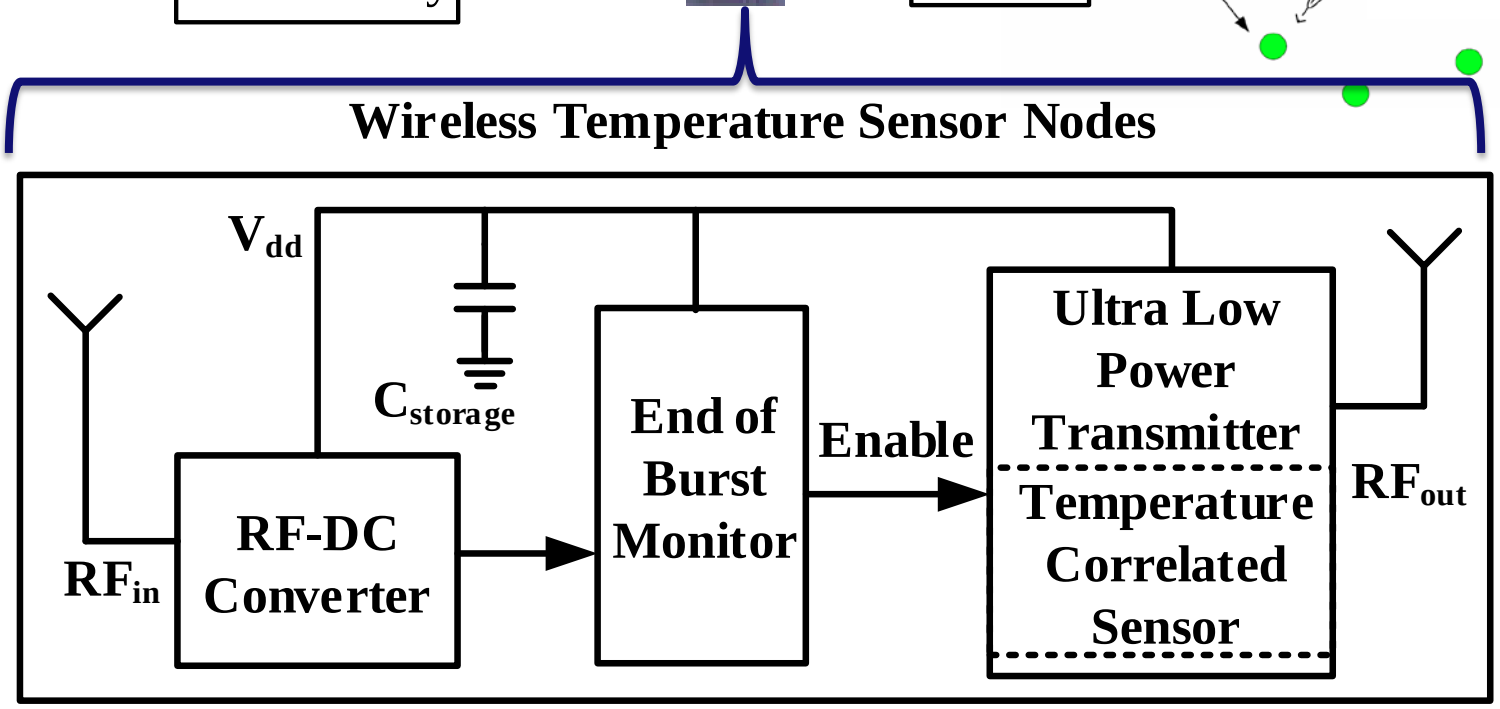




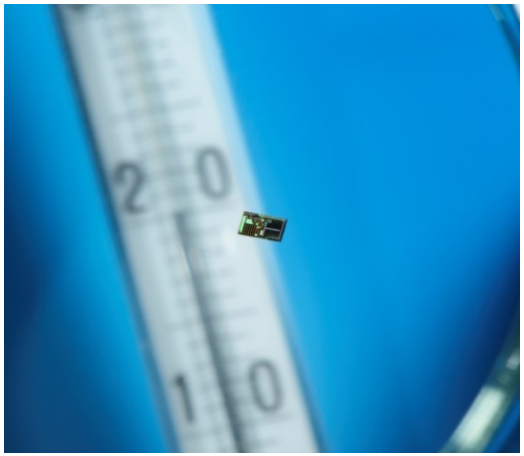


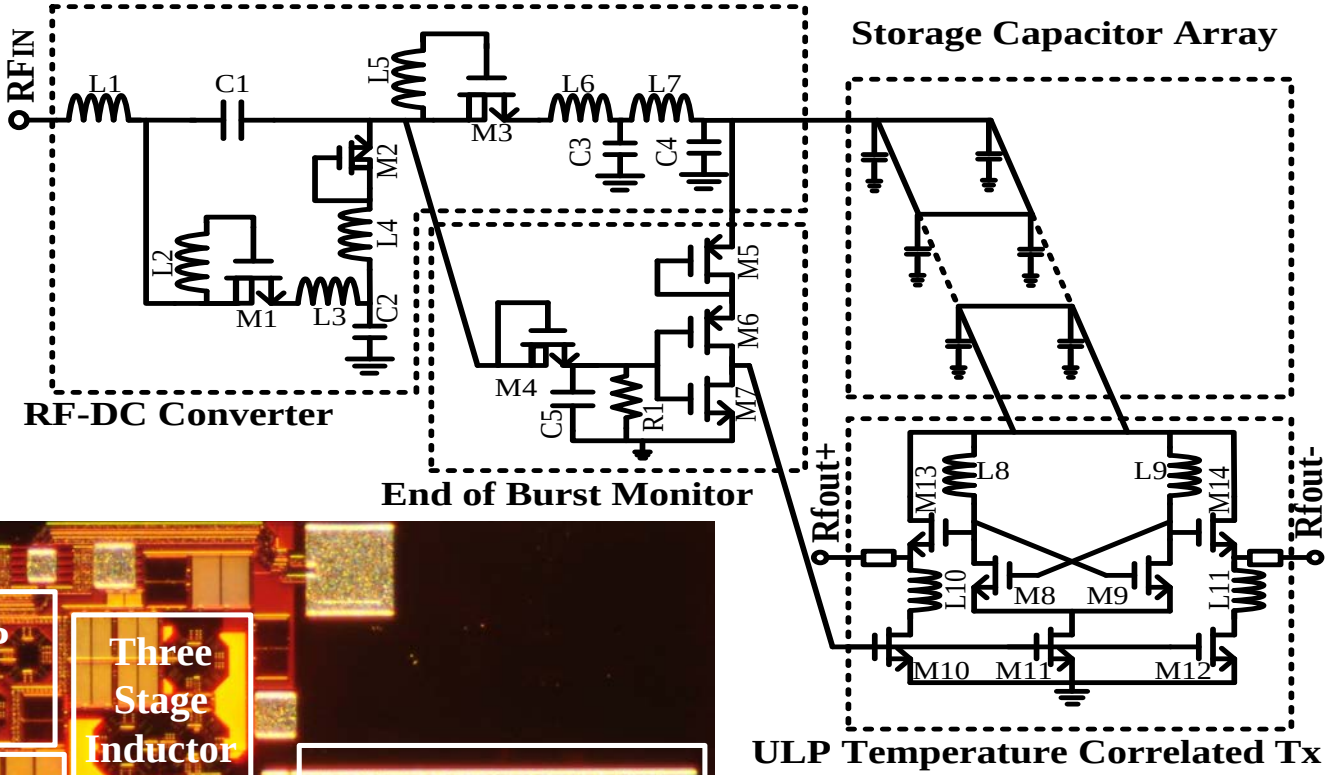
Mm-wave Wireless Temperature Sensor

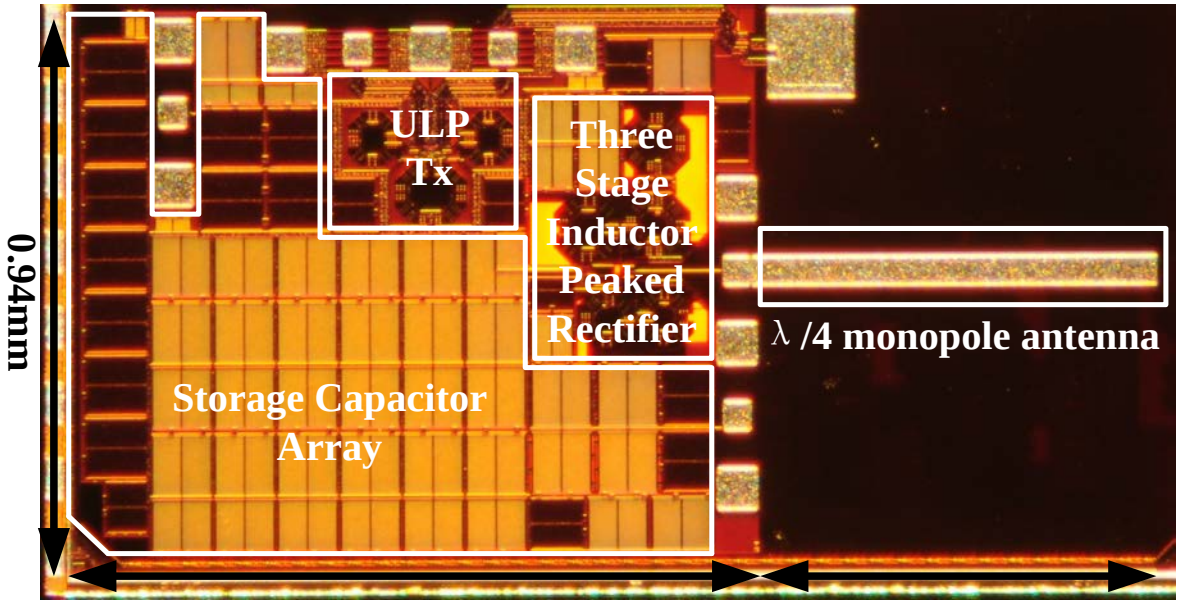




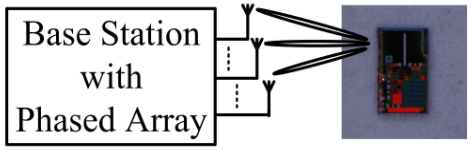
Mm-wave Wireless Temperature Sensor



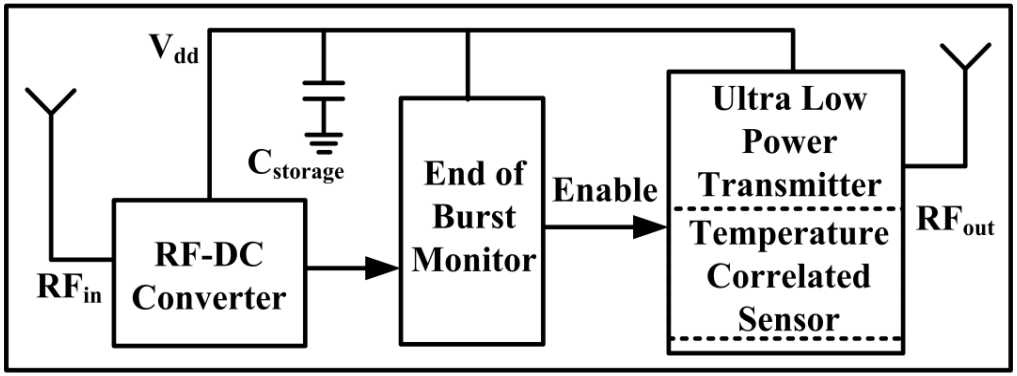


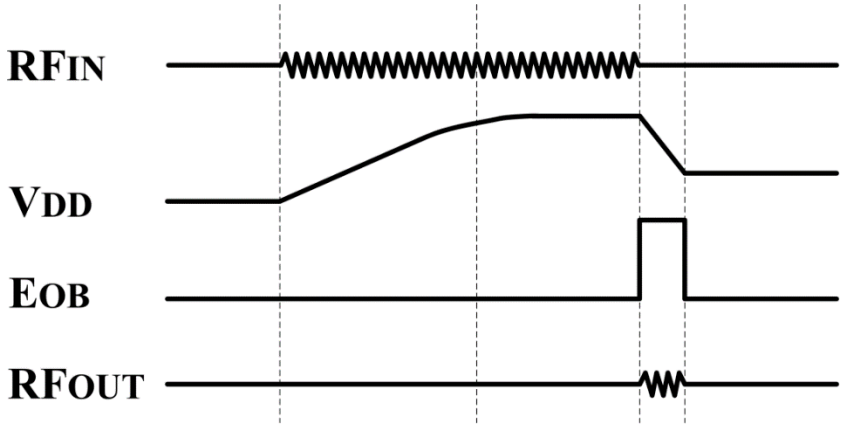


71 GHz Tags : Block Diagram



Wireless Temperature Sensor Nodes





On-Chip Antenna:

- *Small size*

Rectifier:

- *Used as the supply voltage generator*

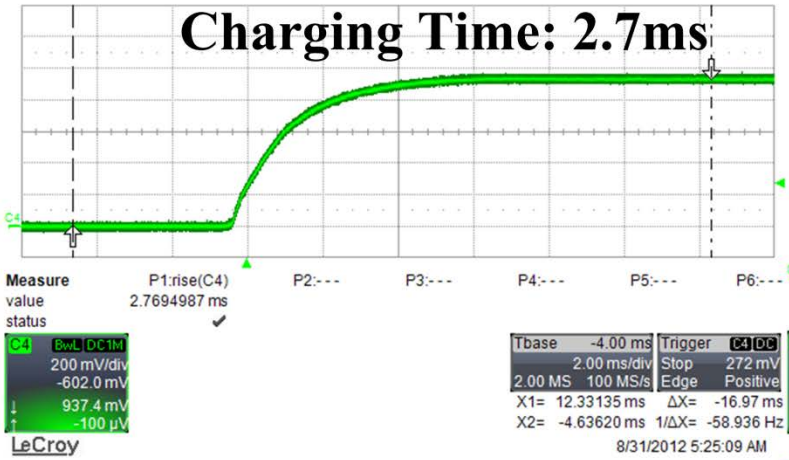
End-of-Burst:

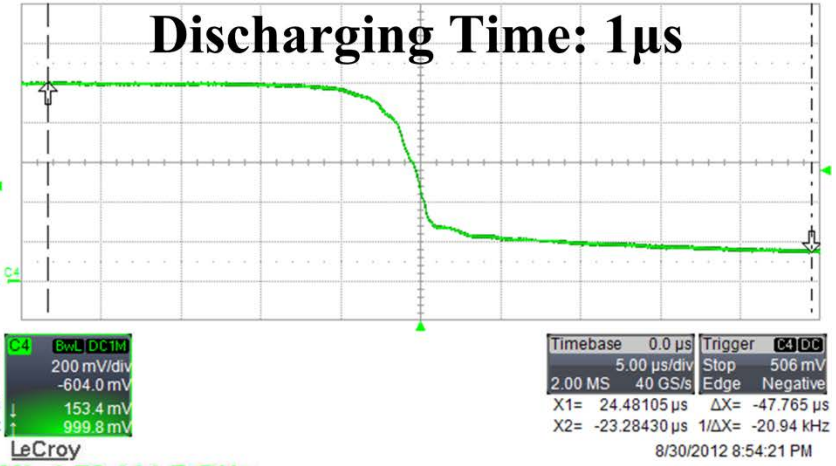
- *Used as the input power monitor*

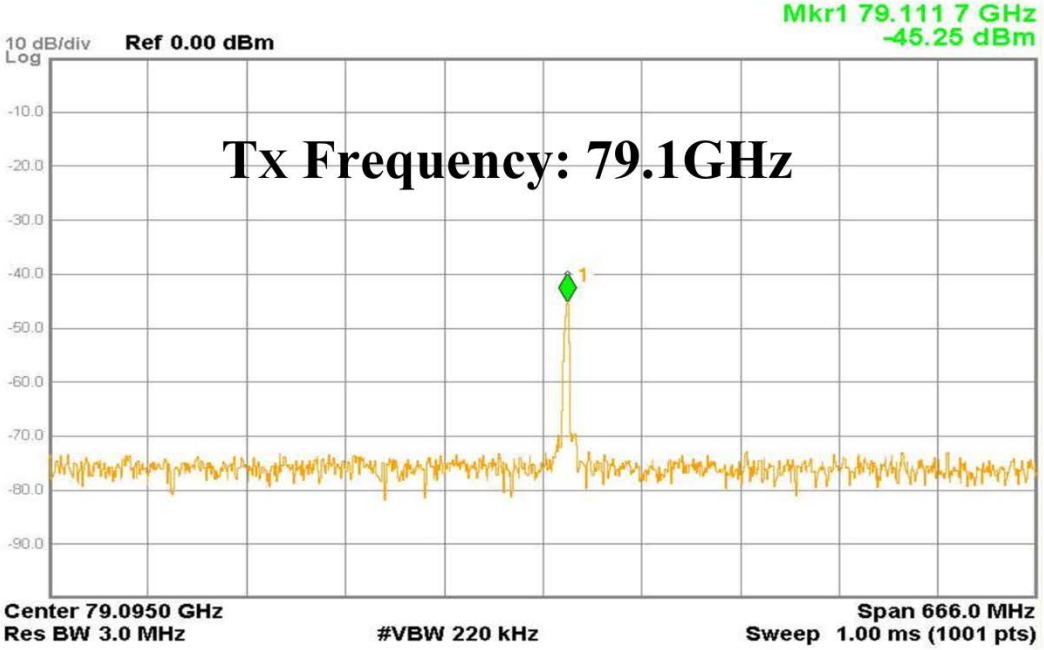
Advantage:

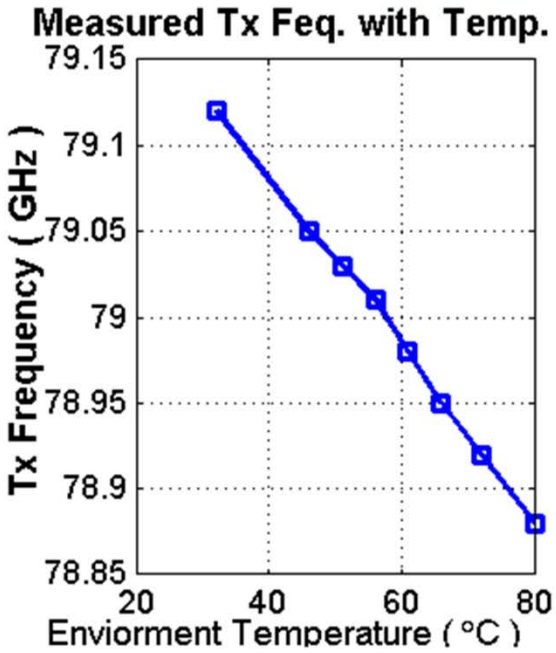
- ***Monolithic, fully integration***
- ***Small size, 2mm ×1mm***

71 GHz Tags : Measurement









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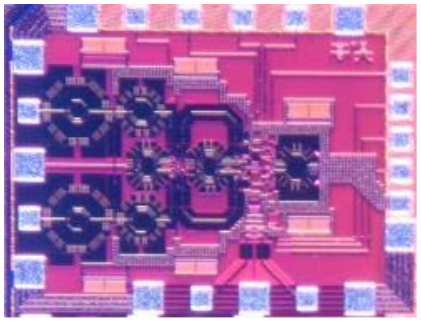
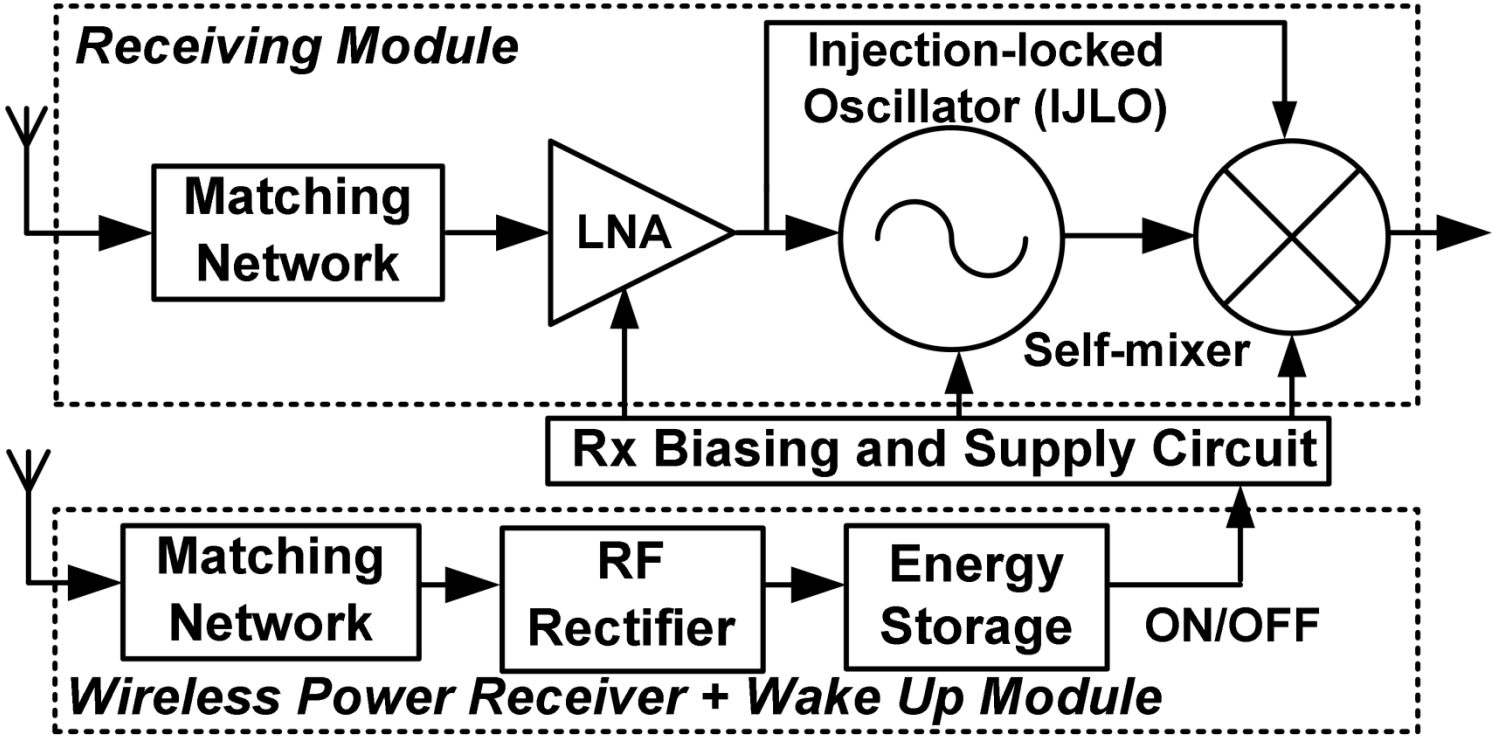
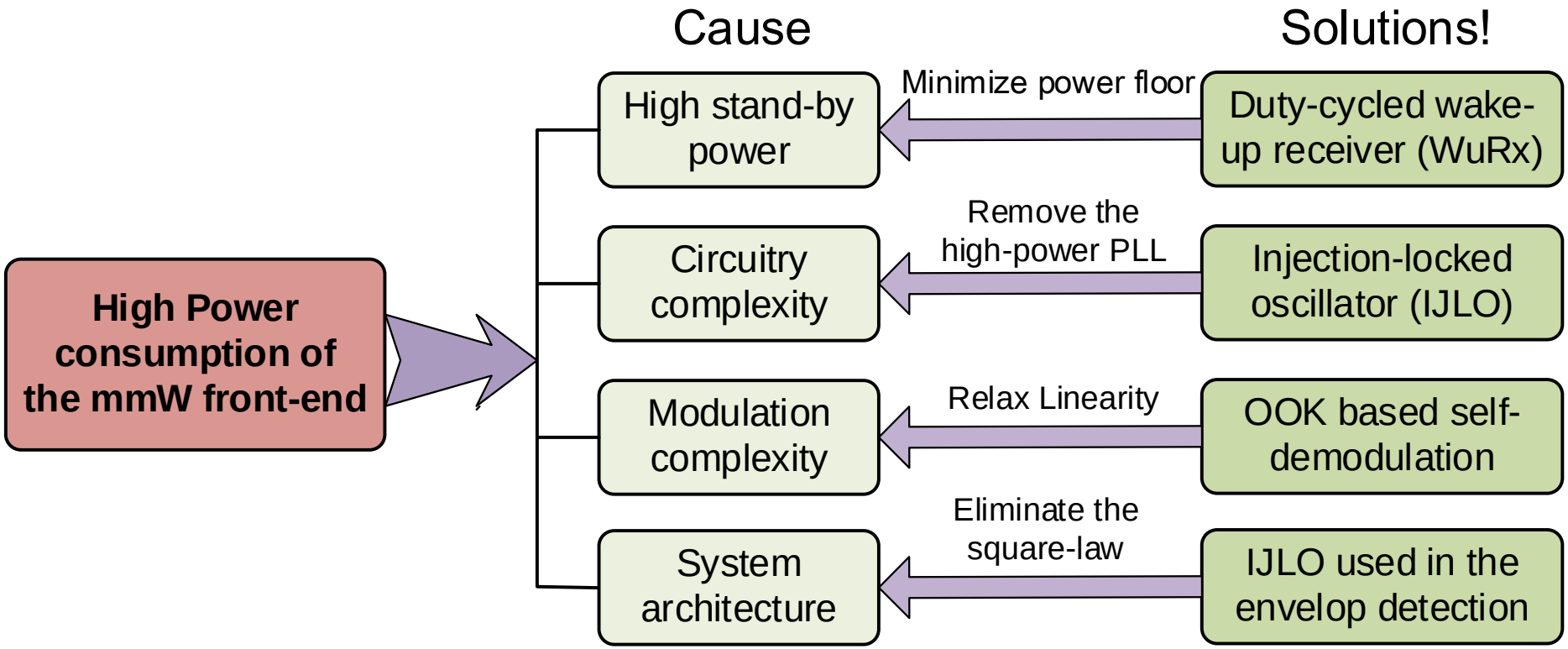
Future : 60GHz Radio-Triggered Monolithic Wireless Sensor Node



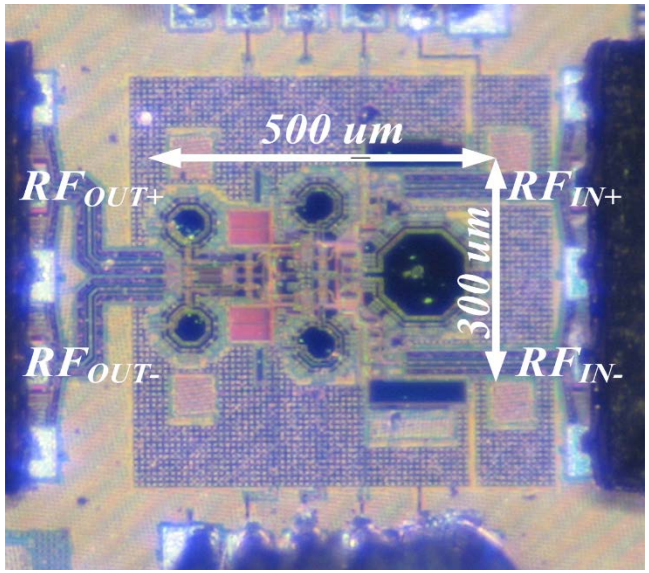


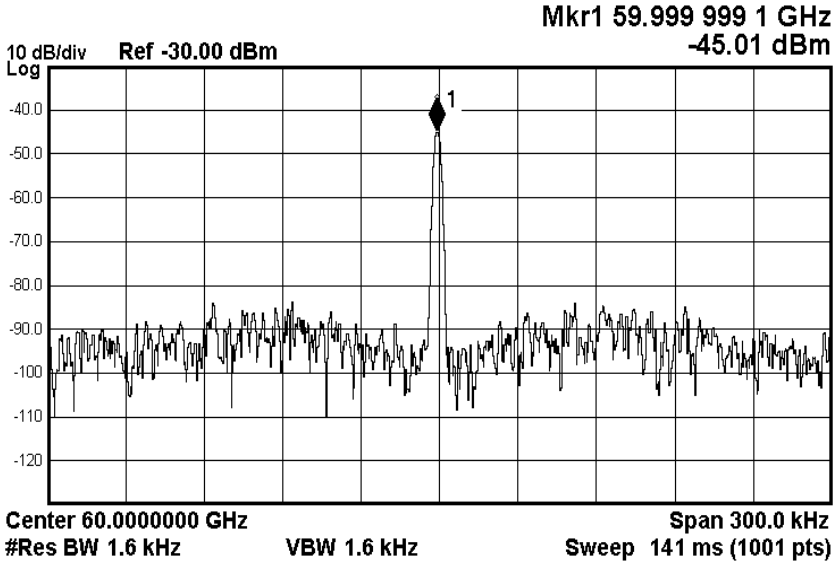
60GHz data transfer: Ultra Low Power Radio

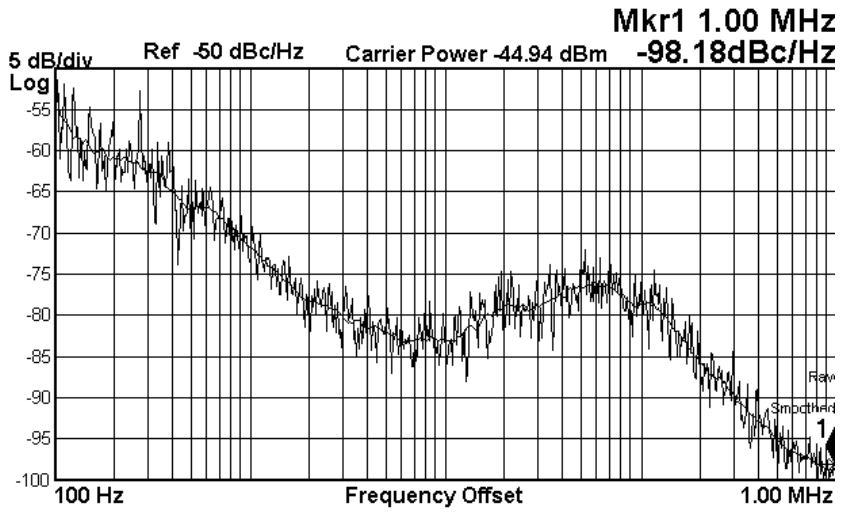
- ***Average power consumption optimization***



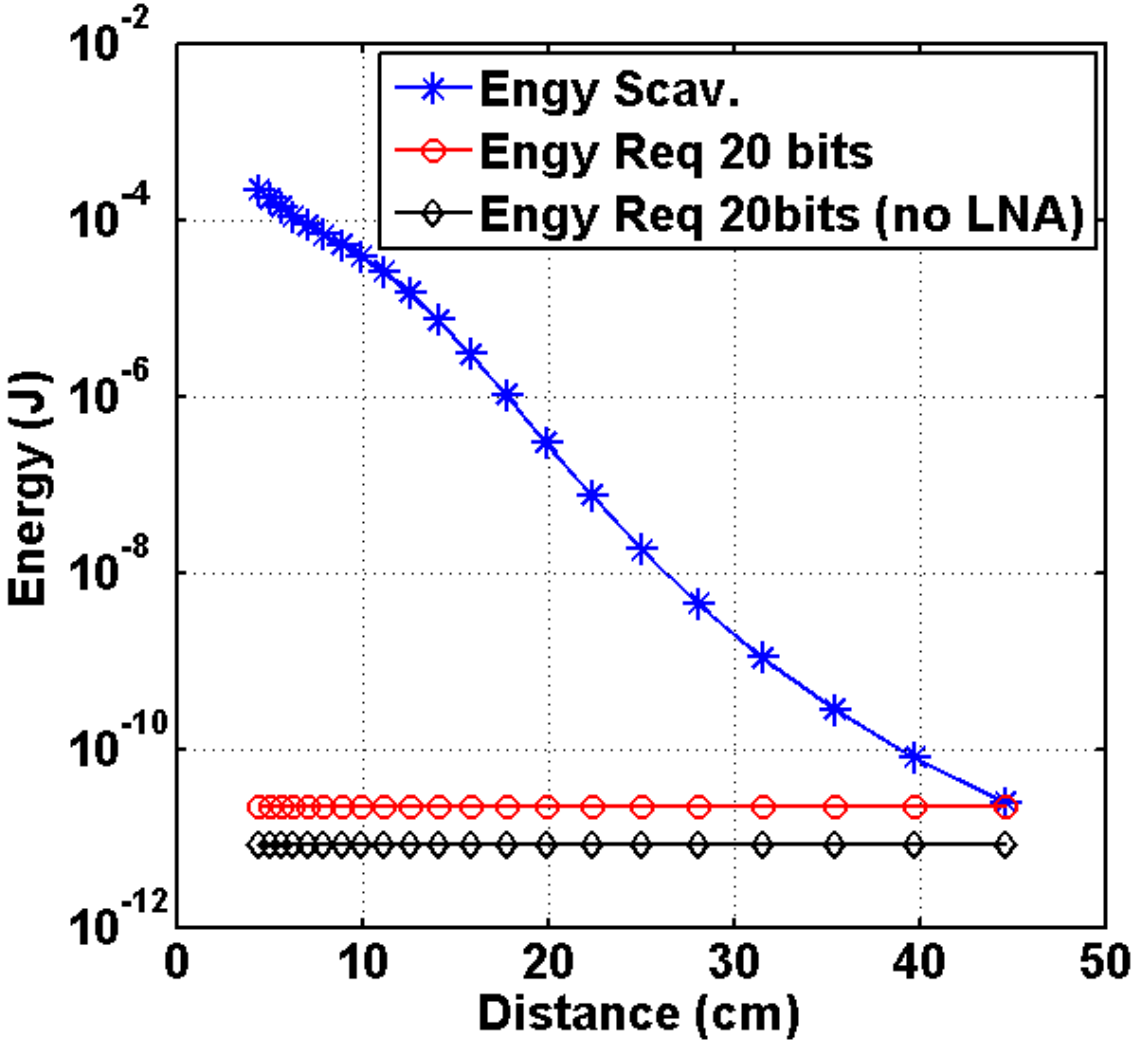
60GHz Injection-locked Oscillator







Wireless Sensor System Evaluation



TX Power	Ant Gain TX	Ant Gain Rx	Modulation
10 dBm	30 dBi	0 dBi	OOK
BW	**T_{scav}**	**Pac. Len**	**Rx %**
2 GHz	10ms	20 bits	50
System parameters			

	Gain (dB)	NF (dB)	IIP3 (dBm)	P_{dc} (mW)
LNA	16.2	4.8	-18	5
Mixer	-15	15	-22.4	
	f_{rf} (GHz)	**P_{out} (dBm)**	**Sensitivity (dBm)**	**P_{dc} (mW)**
IJLO	61.6	-22.5	-60	3
60 GHz RF Front-End Parameters				

Conclusion

Battery-less sensor nodes enable many applications

Mm-wave wireless power transfer with integrated on chip antenna is an elegant way for low cost solution

- ***Key Circuit Blocks: High efficiency rectifier***
- ***System Level : 60 GHz ultra low power radio***

Acknowledgment

CWTe
Centre for Wireless Technology Eindhoven

STW

PHILIPS

Holst Centre
Open Innovation by IMEC and TNO