New Inroads in Ultra Low-Power Wireless Sensor Nodes

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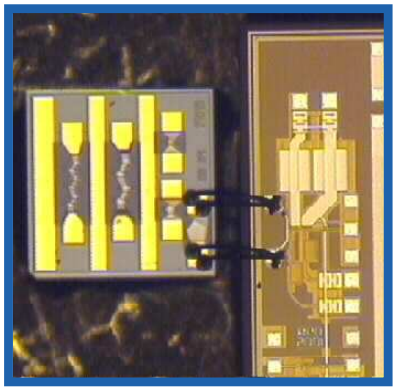
Micro-Power/Cost Wireless

- Advances in micro-fabrication, novel devices and heterogeneous integration create new opportunities for circuit designers
- Unique characteristics of DR application drive new radio architectures
- Combination of advanced devices and new radio architectures delivers wireless communication with very low power and cost

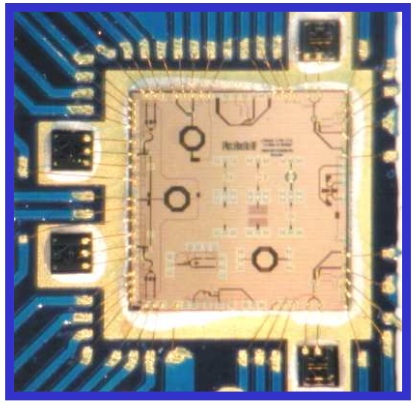
Radio History in the Group

FBAR-base low power oscillator



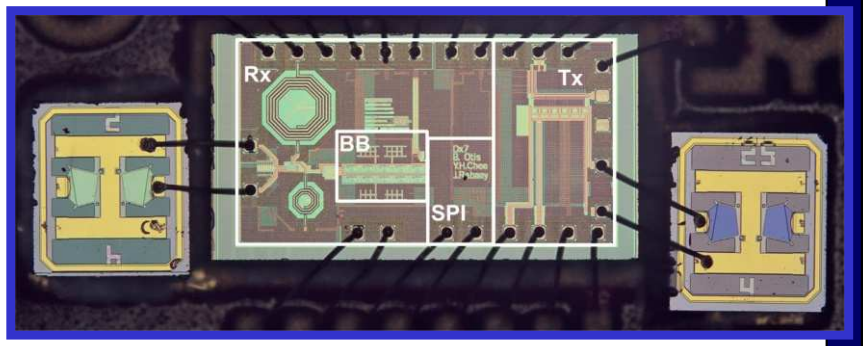
ESSCIRC 2002 (Otis)

2-Channel Transceiver



VLSI 2004 (Otis et al)

Super-Regenerative Transceiver

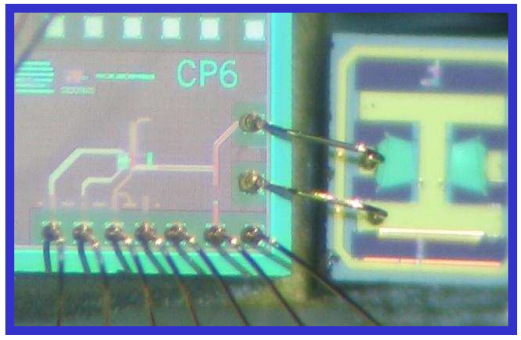


ISSCC 2005 (Otis /Chee)

ISPLED 2003 (Roundy et al)

Transmit Beacon

2004 (Pletcher / Otis)



Passive receiver

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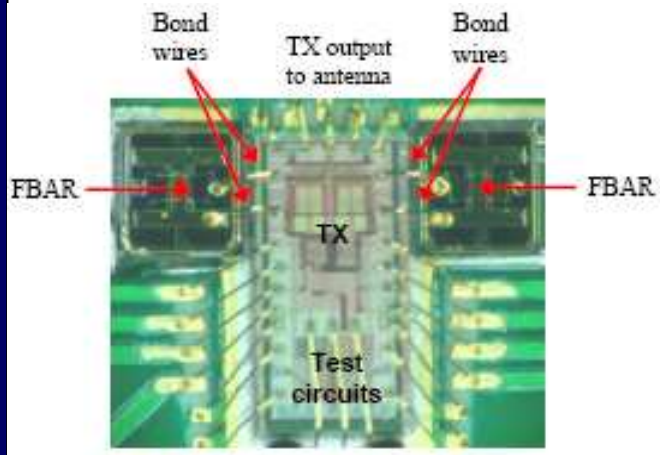
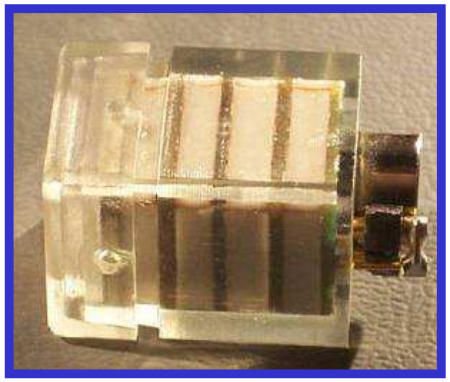
(More) Radio History in the Group

Active Antenna Transmitter



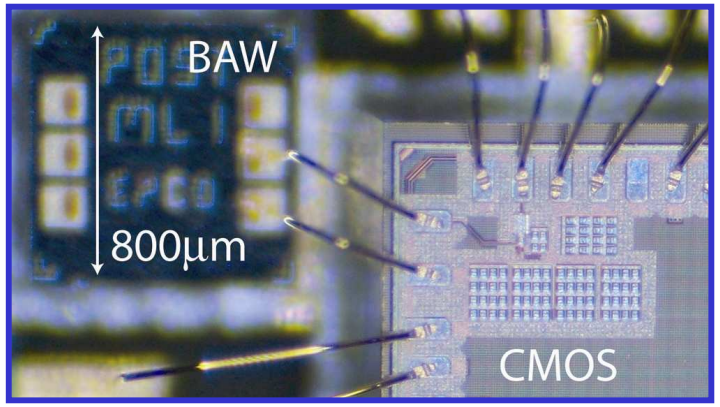
VLSI 2006 (Chee)

PicoCube



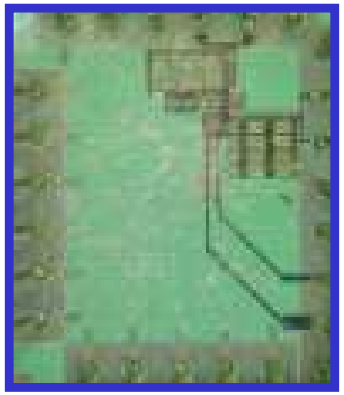
2006 (Burghardt et al)

Wakeup Receiver



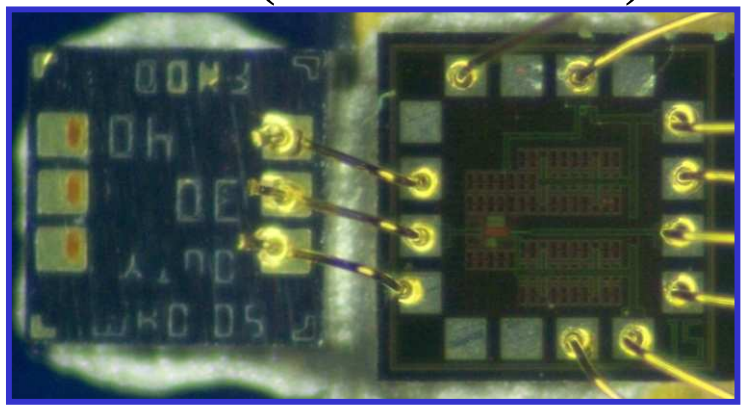
2008 (Pletcher)

JSSCC 2006 (Chee)



Injection Locked Transmitter

2007 (Mark/Richmond)



Temperature compensation

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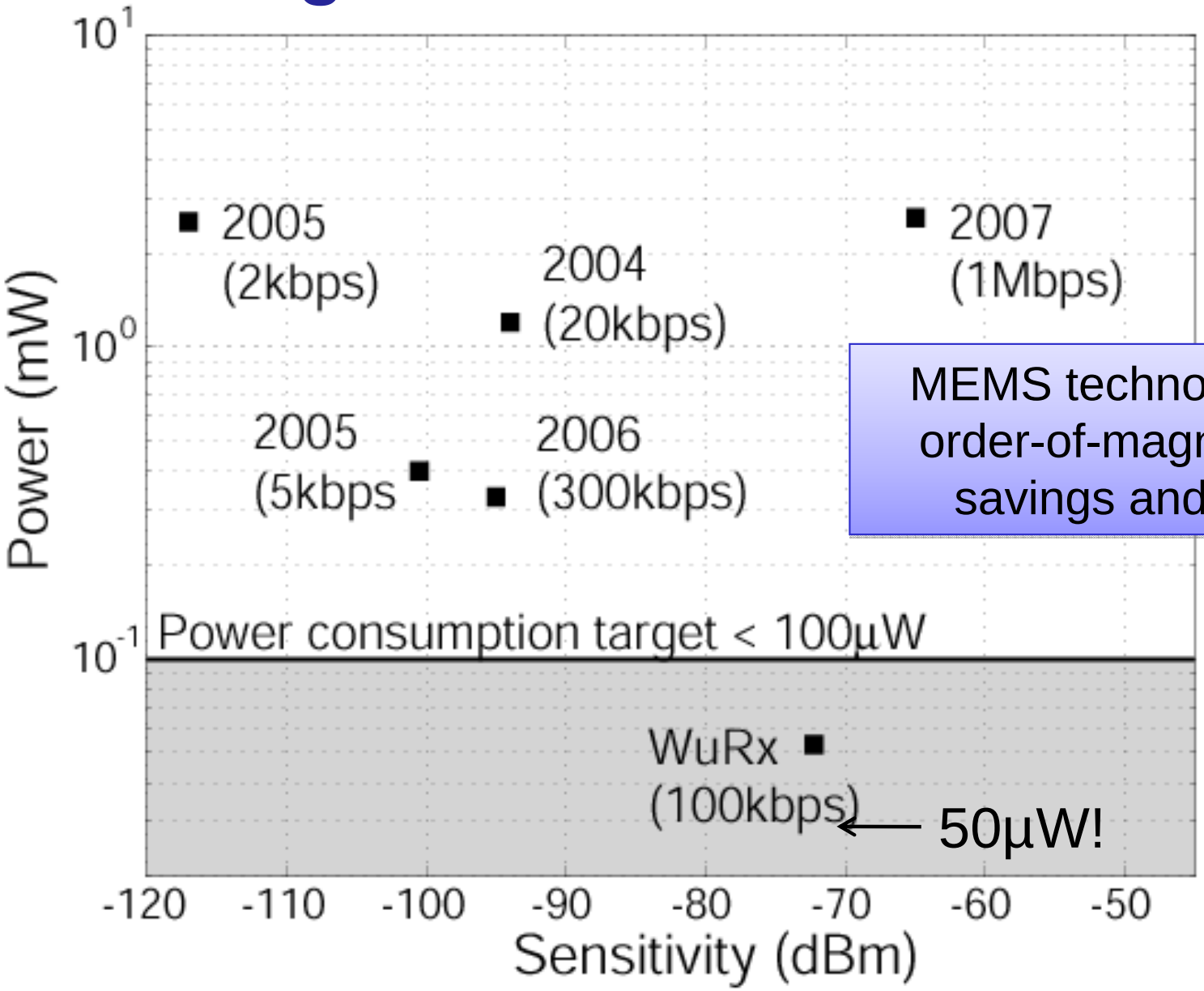
Breaking New Ground in ULP Receivers



MEMS technology enables order-of-magnitude power savings and small size

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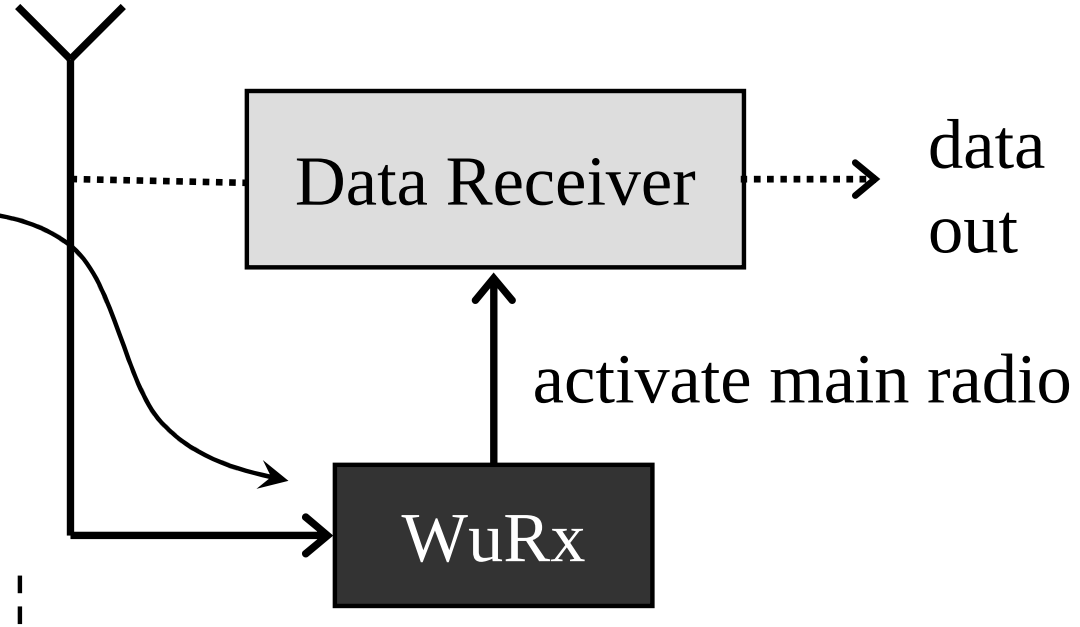
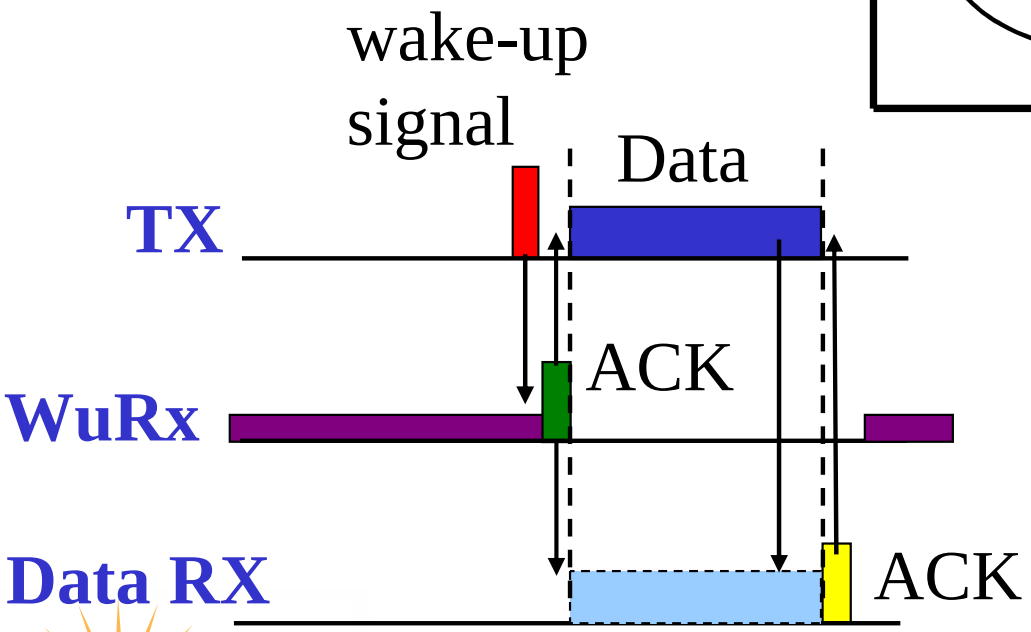
Duty-Cycling with Wake-up

Wake-up receiver (WuRx) listens for requests and controls duty-cycle



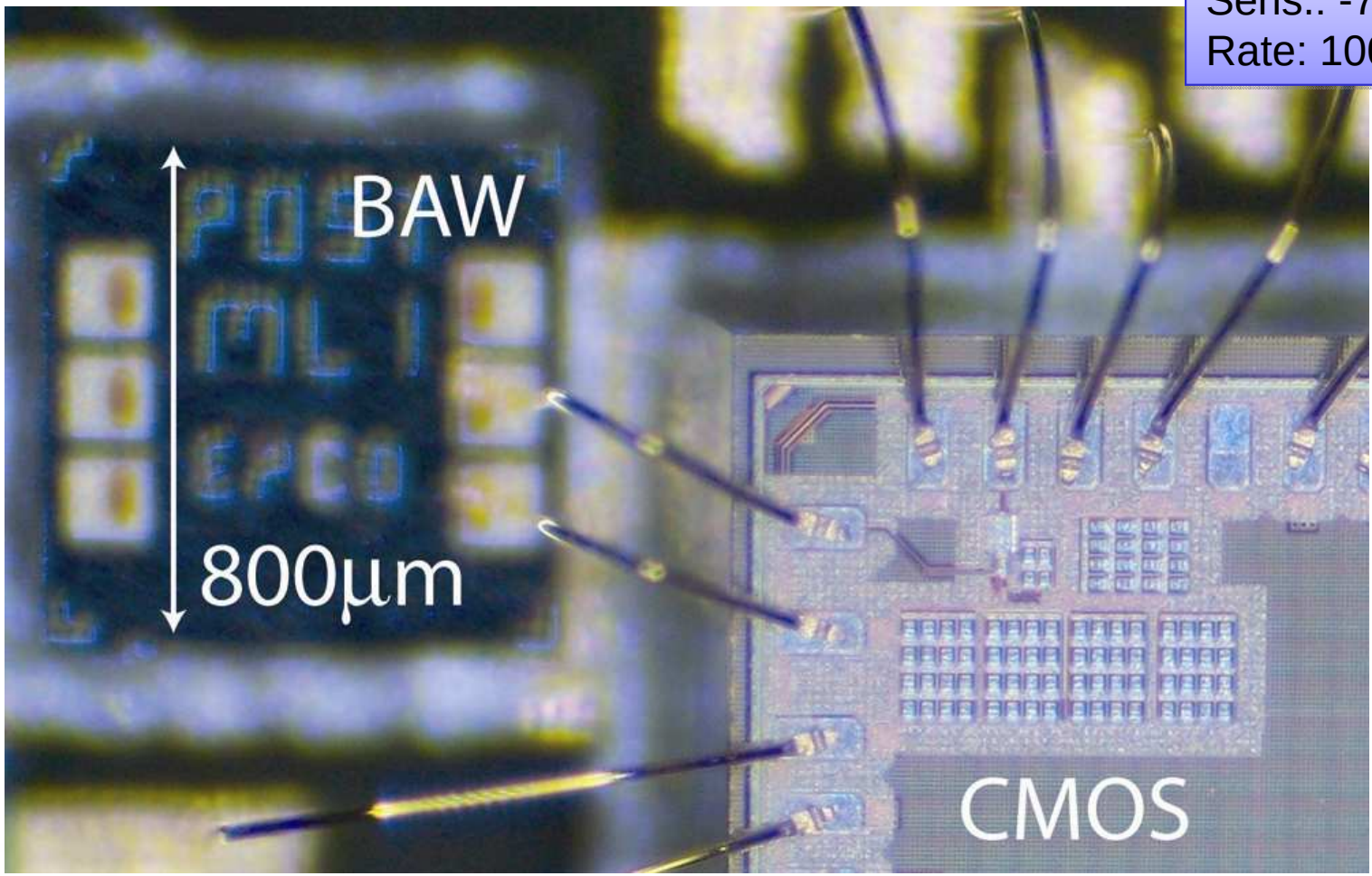


- Reduces network latency
- Requires ultra-low power (<100µW)

Prototype Wake-up Receiver

90nm standard digital CMOS

Power: 52 µW
Sens.: -73 dBm
Rate: 100 kbps

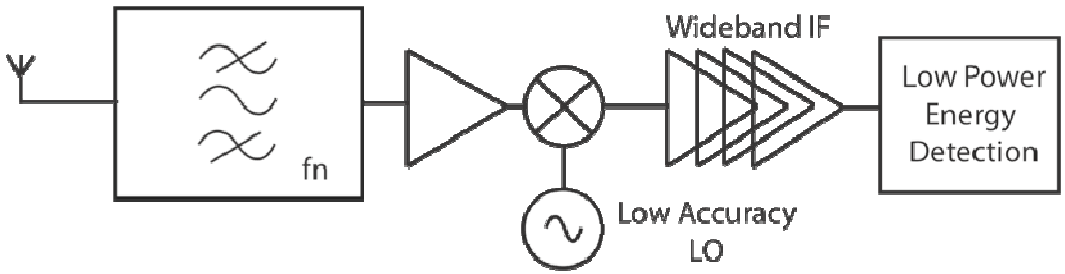


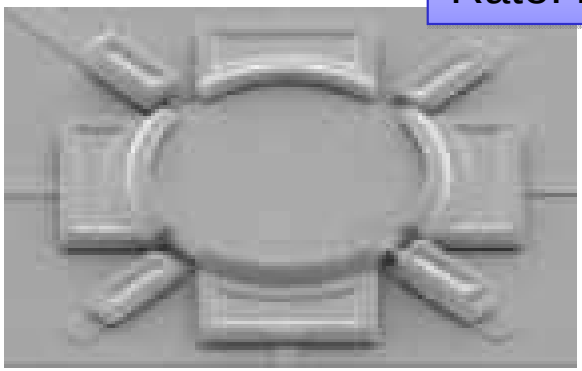
Further Opportunities in Wake-Up Radio Design

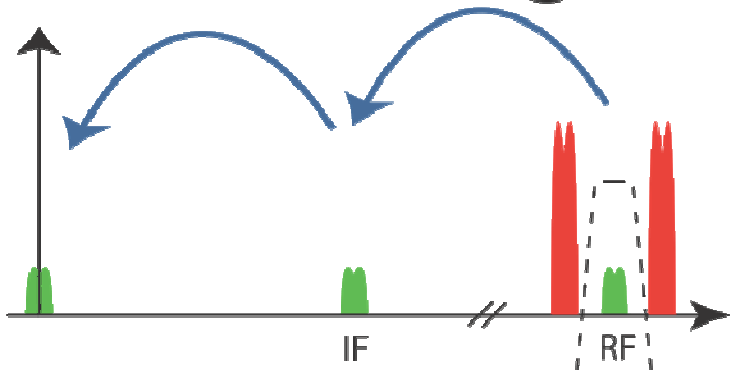
- Improve sensitivity and reliability through usage of RF-MEMS
- Active RF-ID tags change the sensing paradigm
- Improve energy-efficiency of existing wireless protocols (802.11, (ULP) Bluetooth, Zigbee

Providing Reliability and Flexibility

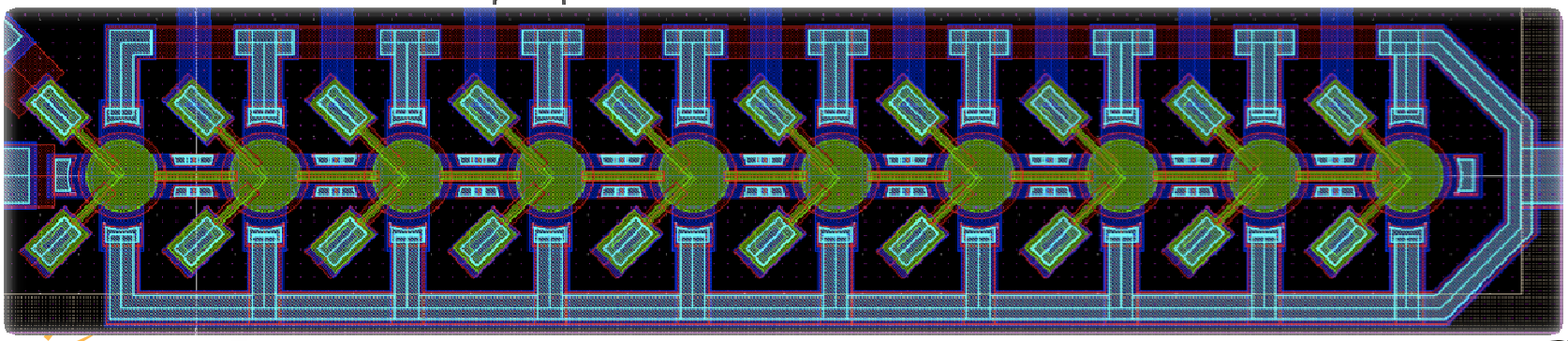
Power: 50 μW
Sens.: -90dBm
Rate: 100 kbps







- Electrostatic (above silicon) resonators provide high selectivity and high integration
- Offer opportunity to provide multiple channels to combat interference and fading
- First prototype filter in fab!



J. Richmond, in collaboration with Prof. C. Nguyen

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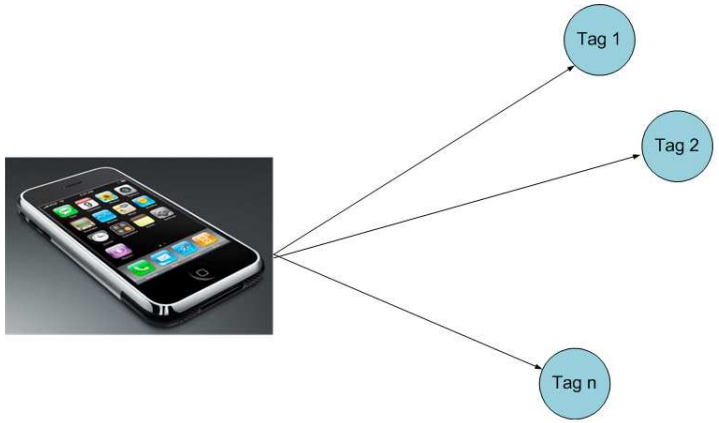
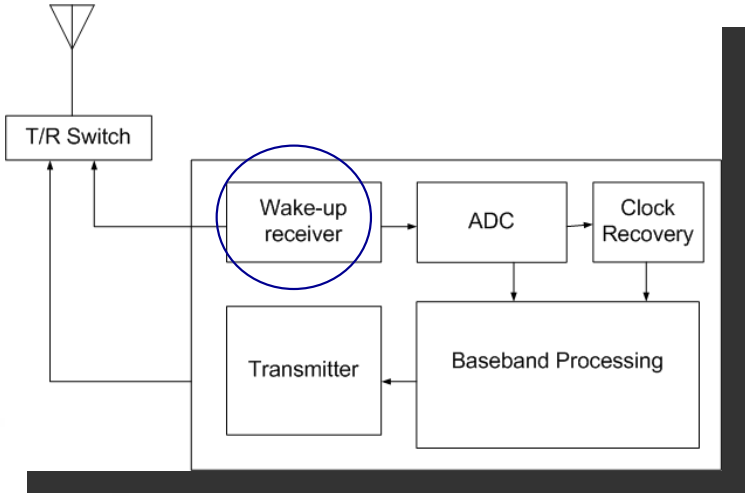
Active RFID Tag – Interogatable Sensors

- Active tag has a small power source. Hence, can achieve higher sensitivity, releasing reader from transmitting high power.
- Enables new applications

E.g.: Remote sensor can be queried by general-purpose wireless device like a mobile phone

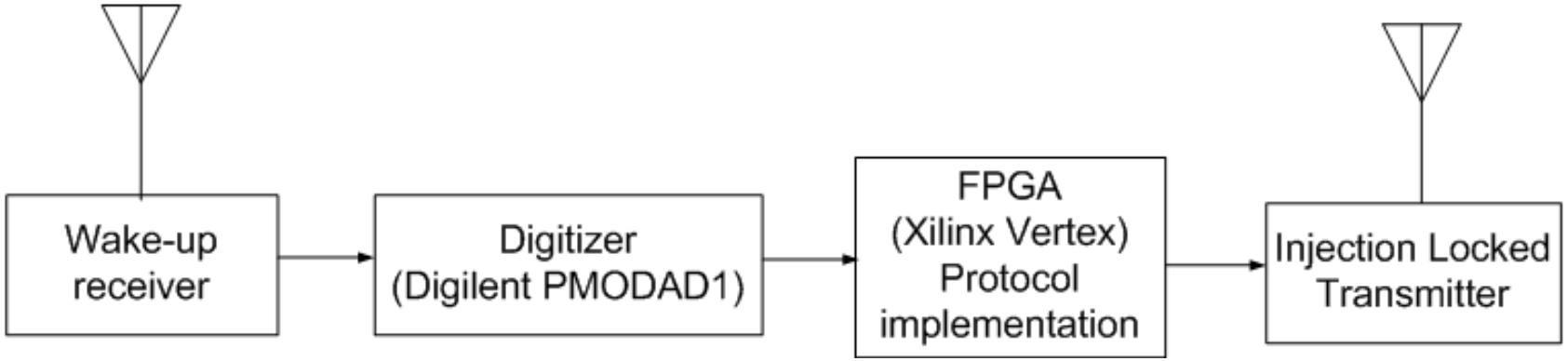




Building on BWRC Technologies:
-WuX (N. Pletcher)
- ULP TX (Y.H. Chee)
- ULP DAC (S. Gambini)
- ULV digital logic (L. Alarcon, T.T. Liu)
- RF-MEMS (J. Richmond)
- Integration: W.T. Zhou

W.T. Zhou

Active RF-ID Prototypes (under development)



Prototype from Existing Components

- Integrated solution
  - Carrier Frequency – 2-2.4 GHz
  - Baseband Data Rate – 100 kbps
  - Average Power Consumption < 100uW
  - Zero latency!
  - Communication Range – 10m

Longer Term Goals

- Create wake-up (WuX) standard that can support most wireless standards (ULP-BT, WIFI, Zigbee)
- Allows for more effective sleep-modes, while guaranteeing low-latency connection
- Uses separate signaling WuX channel to provide synchronization information