ActiveRFID: Towards a Self-Powered Wireless Sensing Platform

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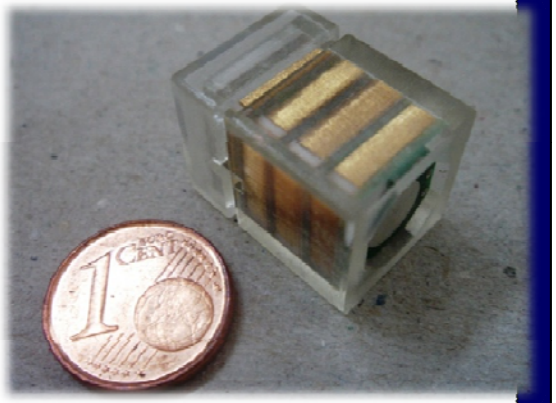
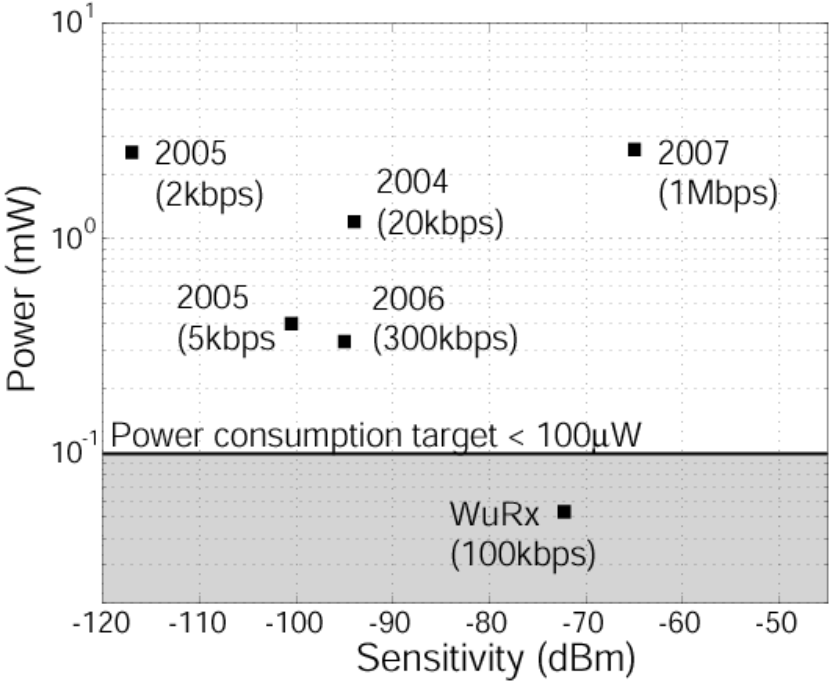
Wireless Sensing – Today

- Wireless sensor networks:
  - Cost, size and power consumption goals for single devices within technology reach
  - Communication distances from cm's to 10's of meters



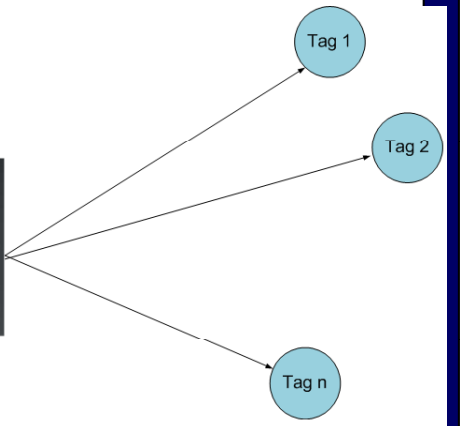
UCB PicoCube



- Drawbacks:
  - Need network support to be functional – causes major deployment and reliability issues
  - Energy still a major issue

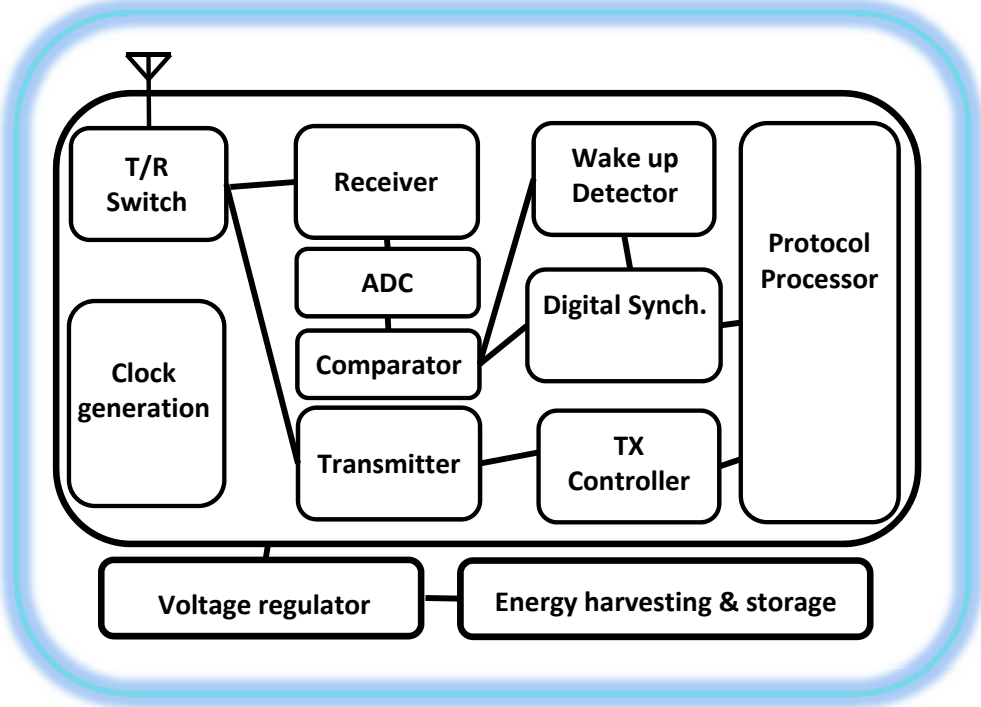
"Self - Contained" Active RFID

- Combines advantages of WSN & passive RFID tags:
  - With power source, enable interrogation from distances >10m
  - Compatible with existing RFID protocols
  - Easy deployment, low cost, secure…
- Opens the door for new applications:
  - Enables querying for portable mobile devices (e.g. cell phone) or from a deployed network (WiFi)



- Tag is self-contained, harvesting energy from solar cell.

Specifications (Target)



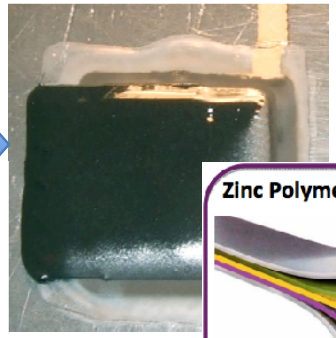
- Fully integrated
- Postage stamp size
- Communication range >10 m
- Datarate of 100 kbps
- Compatible with RFID link and MAC specification

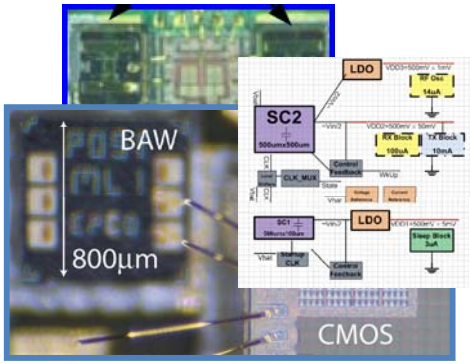
- Can operate indefinitely (for 24 hours/day) from single solar cell – average power dissipation on the order of µWs

Enables querying from portable mobile devices (e.g. cell phones), or from a deployed network

Powering the Active RFID

- Self-powered Active RFID Tag
  - ***Self-contained*** (postage stamp footprint but only mm's thick)
  - ***Fully integrated*** IC (single die)
  - ***Small solar cell*** harvests enough energy for 24 hour operation





Solar Cell
- 2cmx1cm
- **10µW** avg (Indoor)
- V_{oc} = **2.4V**, I_{sc}=10uA

Printed Battery
- 1cmx1cm
- V_{bat} ~ **1.1-1.8V**
- Integration w/ substrate

Loads (on Single Die)
- 50 µW RX
- 1mW TX
- **0.5V** Logic
- On-chip power management

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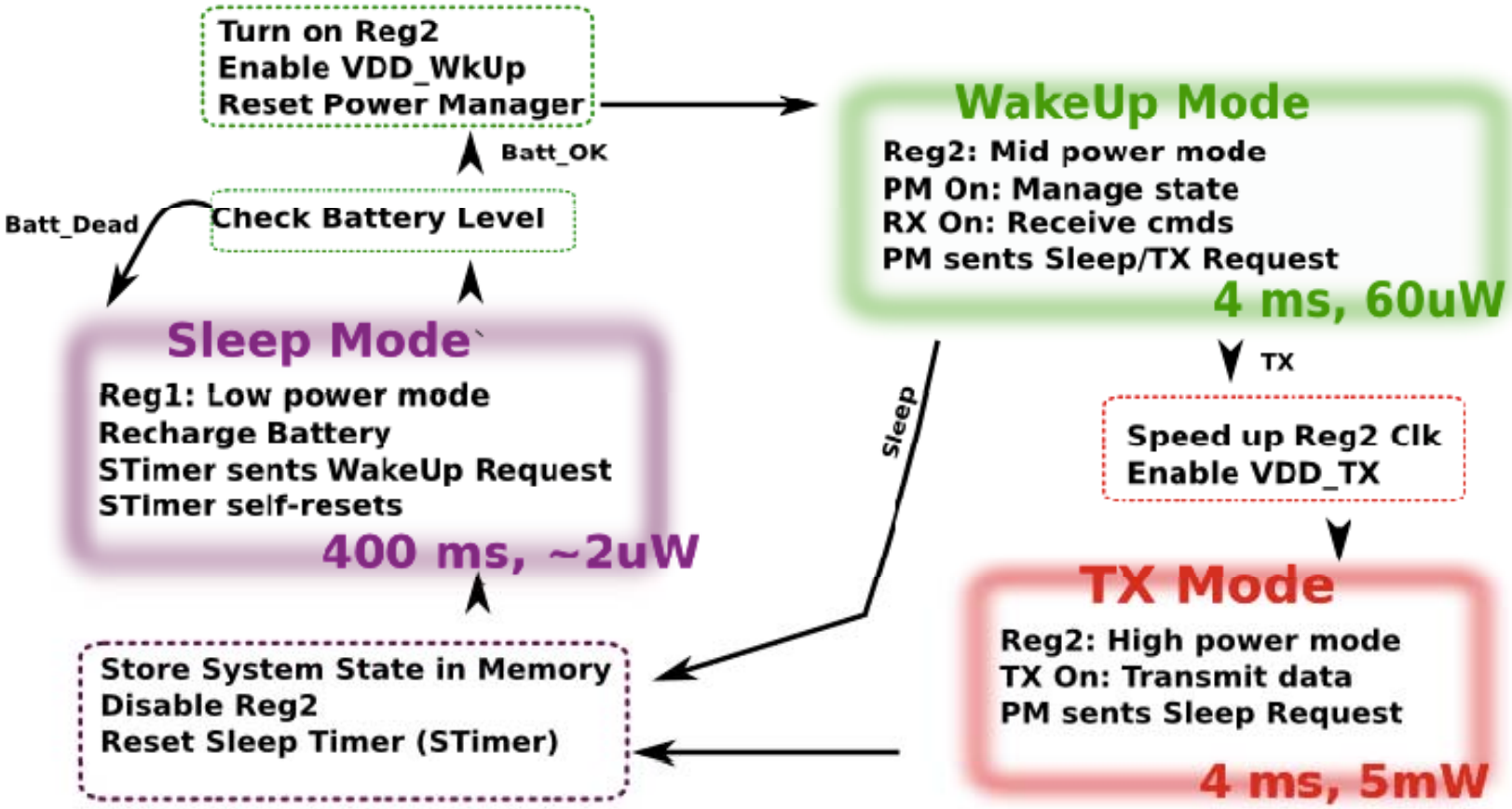
System Power Modes



3 orders of magnitude difference within power!

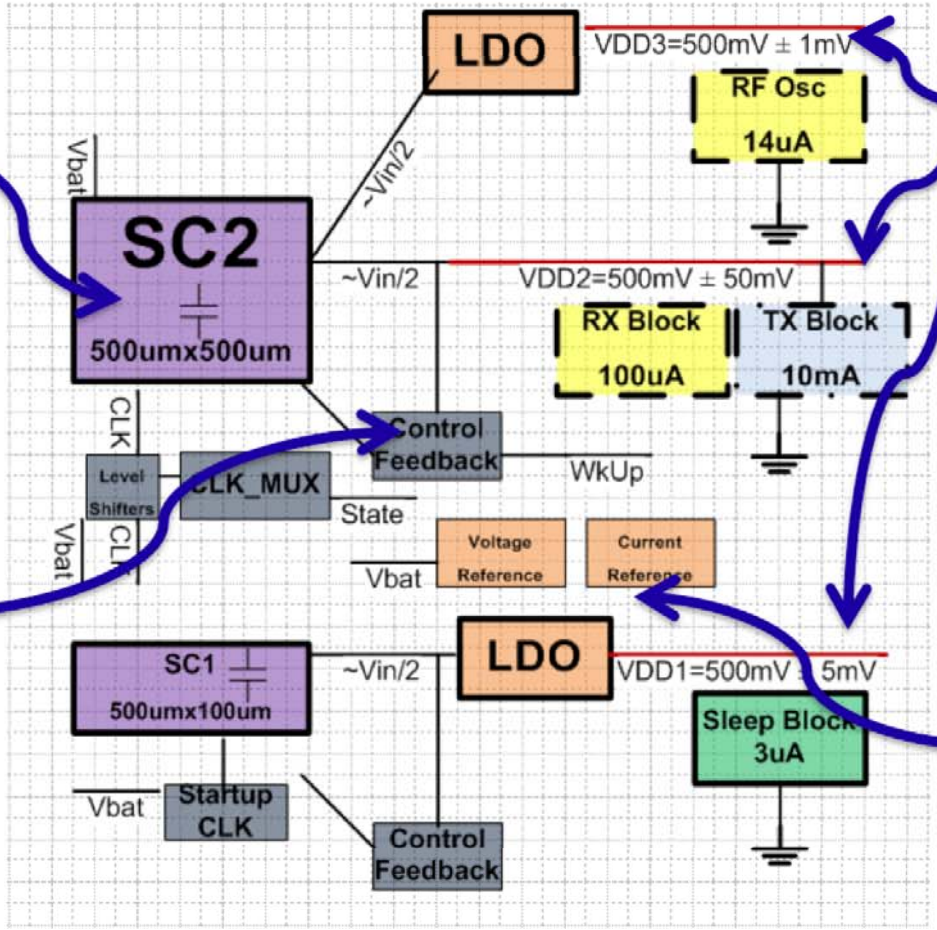
Integrated Power Management

On-Chip Integrated Caps

- ~0.3mm^2
- Multi-topology for coarse regulation
- Multiple cells interleaved to reduce clock ripple

Control Logic

- Regulation Scheme
- Dynamic frequency & switch Scaling



Multiple Supply Rails

- 500mV V_{dd}
- Ripple, Current specs vary

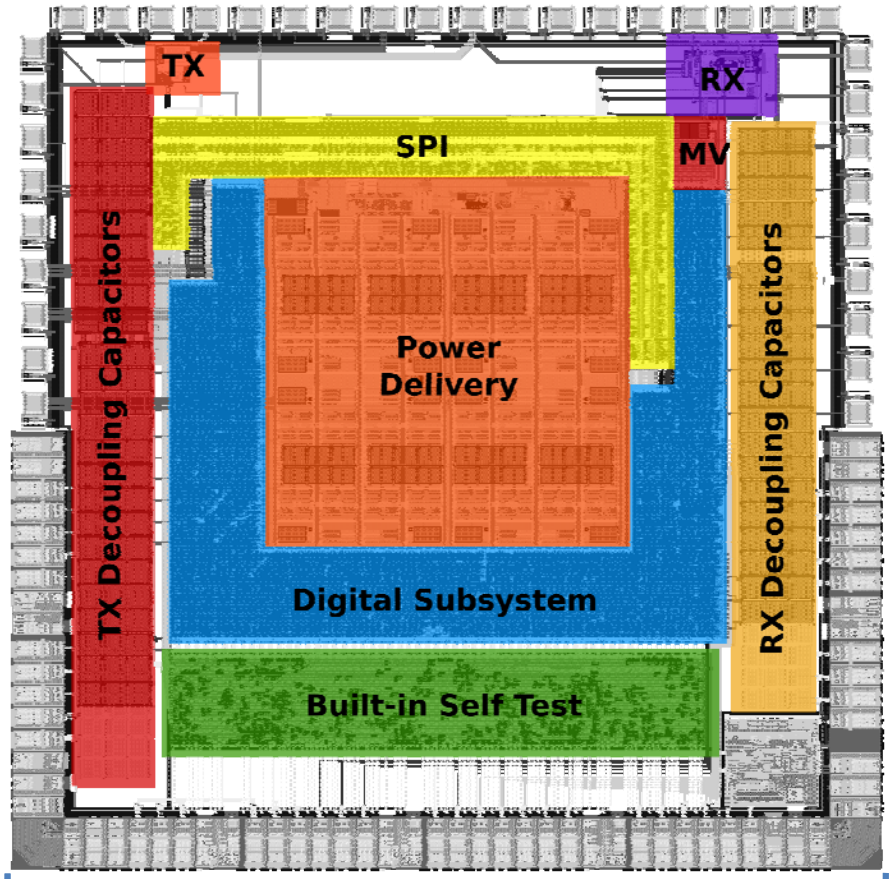
Multi-Mode Operation

- Blocks turned off to reduce leakage/ standby current
- Wide output loads (3uA->100uA->10mA)

Analog Blocks

- Voltage & Current references
- Low-dropout regulator for finer regulation

Chip Layout and Floorplan

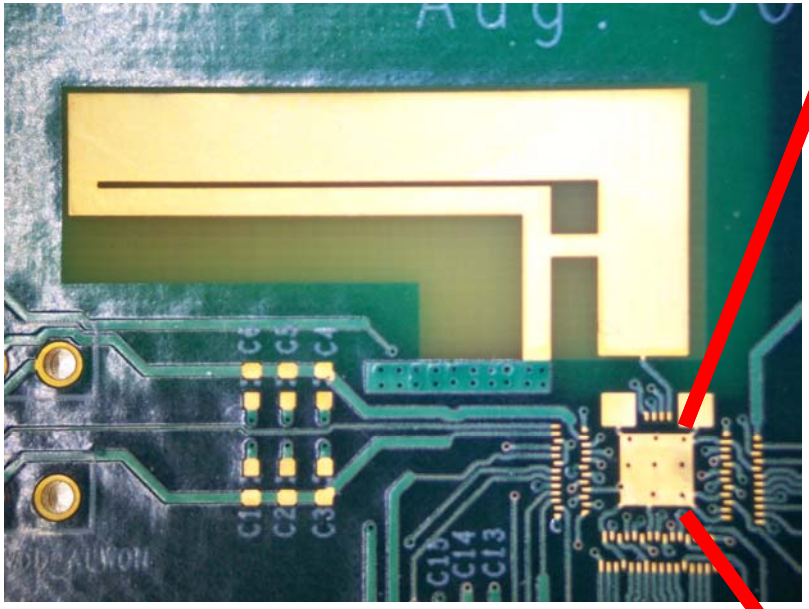


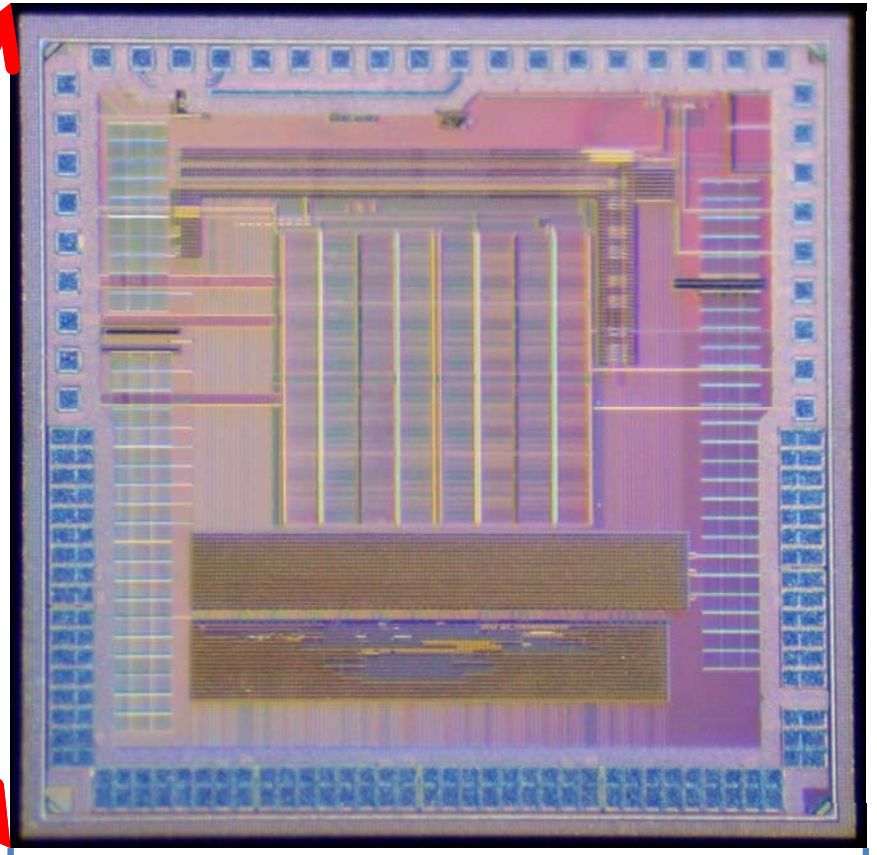
Chip size: 2mm x 2mm

Utilizes full-custom layout and design for the radios and power, generated standard cells for digital.

Sent to Fab: May 2010
Return from Fab: Sept 2010

Hot off the Press: Chip Die Photo





2 mm

We have developed a ActiveRFID Platform

- Enables small active RFID nodes powered purely by energy scavenging with less 10 uW of average power
- Are easy to deploy and can use existing infrastructure
- Can communicate over more than 10 m indoors
- Fully integrated design contains all power management and communication circuits
- Testing underway

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