Wireless Sensor Node Design Considerations

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Overview

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- Wireless Sensor Network standards
- Block Diagram of Wireless Sensor Node
  - General specifications for Wireless Sensor Node
- Blocks in detail
  - Microcontroller
  - Sensor and Sensor interfaces
  - RFIC(RF Transceiver)
  - Antenna
  - Balun
- Components
- Materials
- Conclusion

Introduction

- A wireless sensor node (WSN) is a node in a wireless network that is able to collect the information from sensors, process it and communicate wirelessly with other nodes in the network

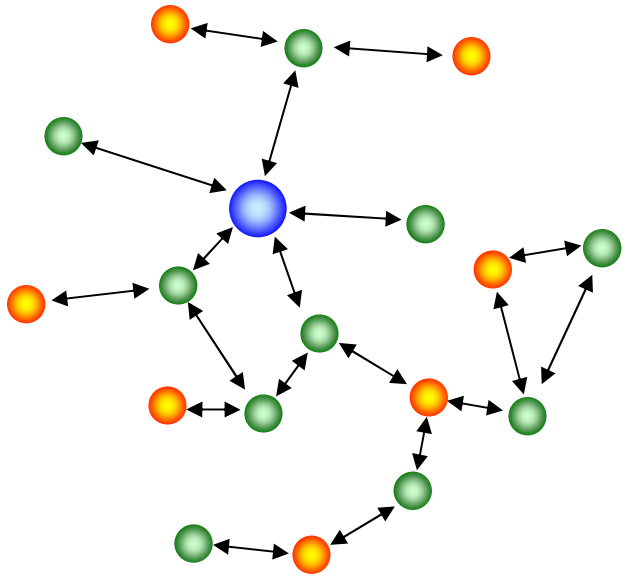
- Applications
  - Industrial automation
  - Home Automation
  - Medical Monitoring
  - Asset tracking
  - Agriculture

Some of the standards for Wireless Sensor Networks

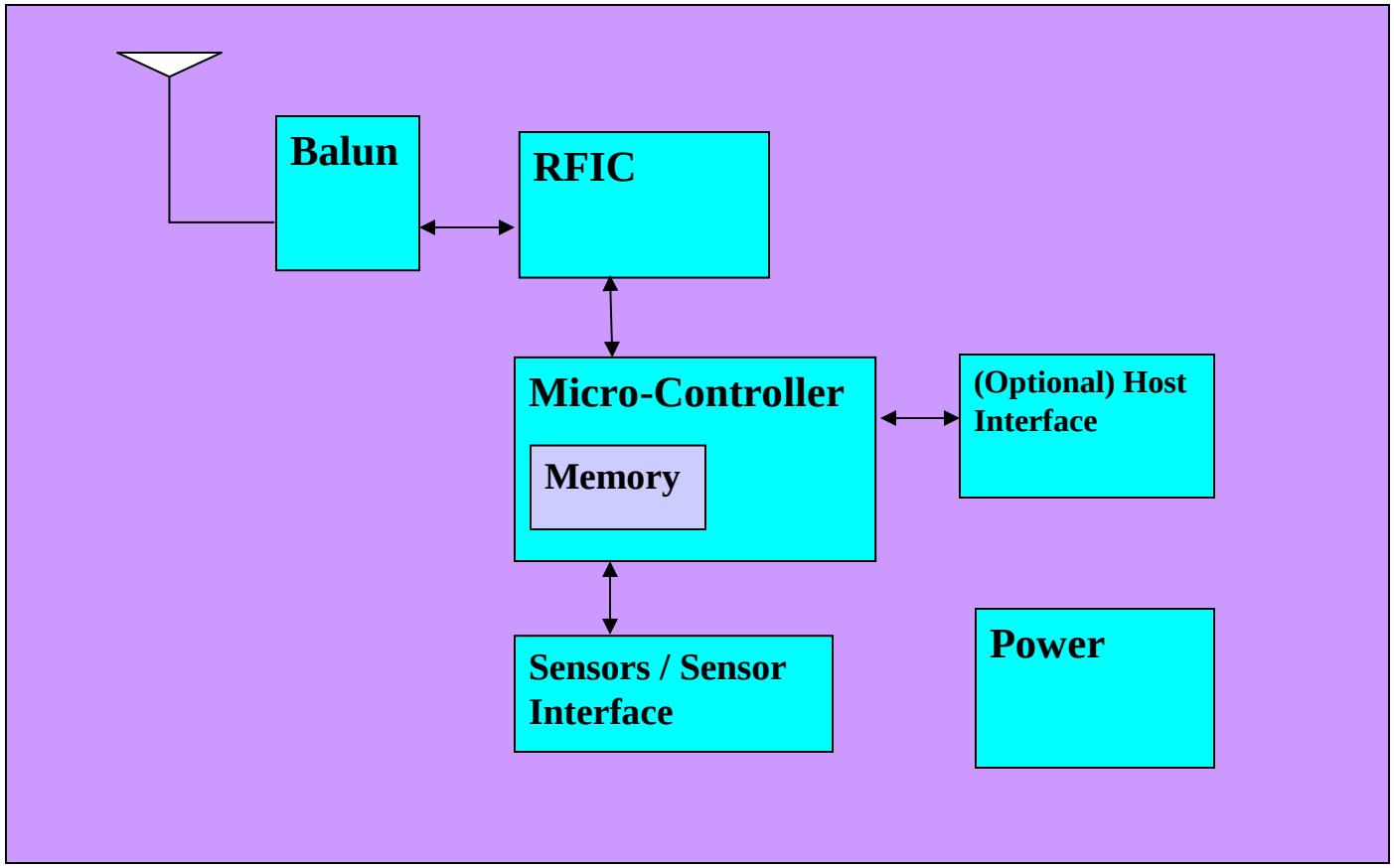
- IEEE 802.15.4/Zigbee
- HomeRF
- UWB
- Or any other proprietary protocols

Types of Devices in a typical Wireless Sensor Network

- Gateway
  - Interfaces wired and wireless domains
- Router
- End Device



Block diagram of a Wireless Sensor Node (WSN)



- Blocks
  - Microcontroller
  - Sensor & Sensor Interface
  - Radio Transceiver
  - Power
  - Host Interface (optional)

General specifications of WSN

- Operating Frequency
- Power output
- Range
- RF data rate
- Receiver sensitivity
- Interface data rate

Factors in Design of Wireless Sensor Nodes

- Power Management
  - Battery life
  - Power Consumption in sleep mode
- RF Power and Range
  - Power Amplifier Stage 1mw / 100 mw depending on operating range of 10m to 100m
- Cost
- Size/ weight
- S/W Foot print
  - Network Stack
- Functionality/ application
- Sensor Interface
  - Sensors / Actuators/ / MEMS / Vibration

Microcontroller

- Desired Features
  - Low Power
  - Small Profile
  - Built in peripherals
  - On chip RAM and Flash memory
- Typical Examples of WSN Microcontrollers
  - MSP430
  - ATMega
  - Any 8051 based low power microcontrollers …

Sensor and Sensor Interface

- Onboard sensors
  - MEMS based sensors like
    - Temperature sensors
    - Voltage sensors
    - Photo sensors
    - Humidity sensors
    - Vibration sensors
    - Accelerometer…
- External sensors
  - Requires the node to have a sensor interface.
    - SPI
    - I2C
    - Serial
    - Analog

Power

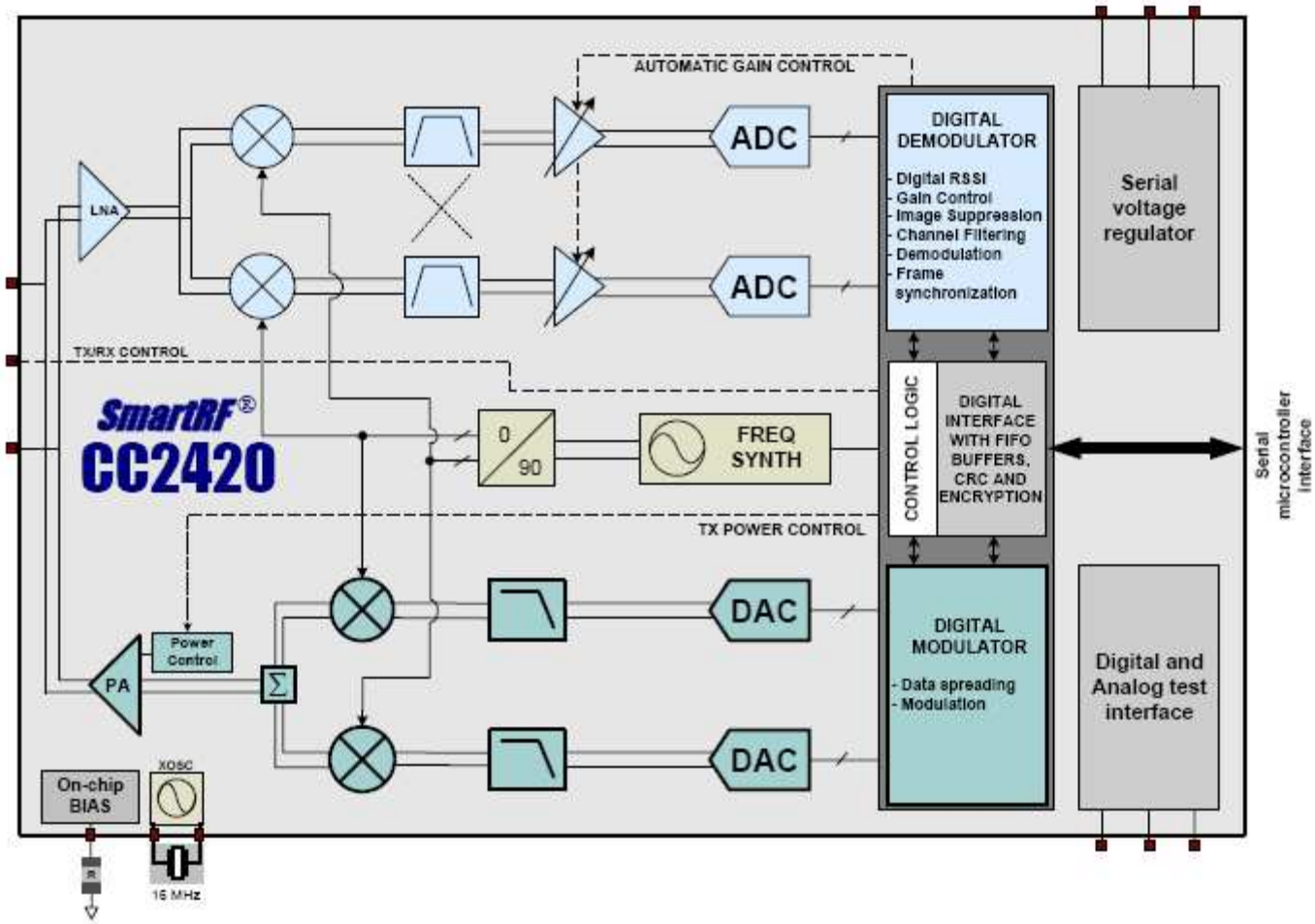
- The power in a WSN is mainly dissipated by
  - Sensors
  - Transceivers (RFIC) while either transmitting or receiving

- Power Options
  - Battery operated
  - Solar power
  - DC power

RF Blocks

- RF Transceiver
  - Can be interfaced to Microcontroller using SPI, I2C, or UART interfaces
  - Low Noise Amplifier (LNA), Mixer, Variable Gain Amplifier (VGA), ADC, Demodulator,
  - Modulator, DAC, Filters, Mixer, Power Amplifier (PA),
- Balun
- Antenna

RFIC or RF Transceiver



UbiComp

Antenna

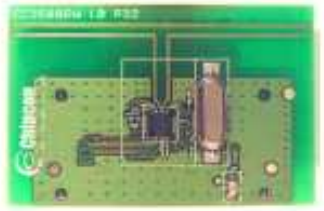
- Key parameters
  - Radiation pattern
  - Antenna gain

- Proper impedance (50ohm) match has to be maintained while feeding the antenna to minimize the return losses

Antenna

- External Antenna
  - Provides good gain and radiation pattern
  - Long ranges possible
  - monopoles

- PCB Antenna
  - Designing the PCB antenna is challenging
  - Requires good simulation while designing
  - Cost effective
  - Dipole, monopole, inverted F antenna…



PCB Antenna

- Chip Antenna
  - Small Range
  - Small profile

Chip Antenna

Balun

- A typical RFIC has a Differential output for antenna
- External antennas and monopoles are single ended
- Balancing and Unbalancing Network (Balun) will be needed when single ended antenna has to interface with differential drive of RFIC
  - Its a network of RLC which can also provide good matching in addition to from providing balancing
  - Can be also implemented using transmission lines on a PCB
  - Chip baluns can also be used with minimum external components

Passive components

- Resistor
  - Precision resistors with very low tolerances
  - Chip resistors
- Capacitor
  - NPO capacitors
- Inductor
  - (Self Resonance Frequency) SRF must be above the circuit operating range
  - Monolithic or Multilayer chip Inductors

Materials

- Parameters of the materials that has to be considered for RF
  - Dielectric Constant
  - Loss Tangent
  - Tg (Glass Transition Temperature)
- Some Materials
  - PTFE
  - Rogers
  - Nelco
  - FR4

Thank You