RFID in the New Millennium

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Source of RFID Information

Outline

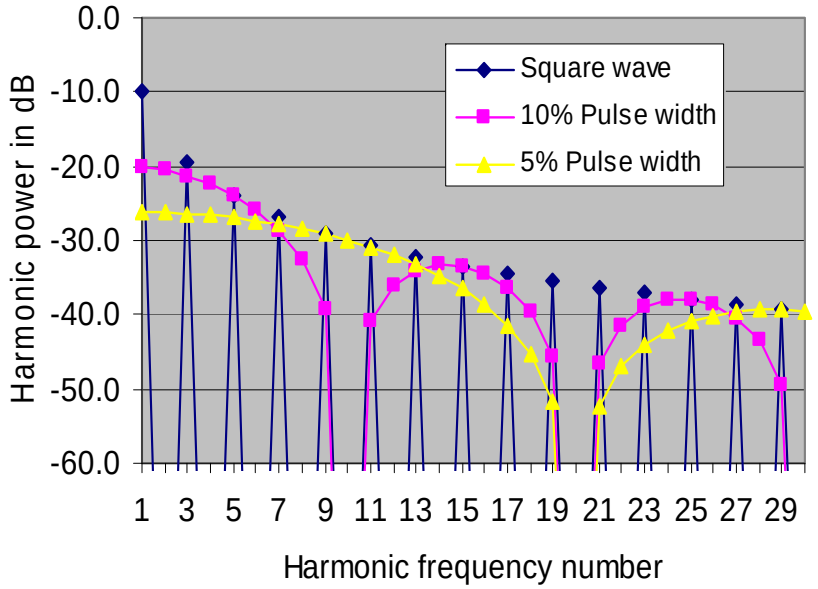
- History
  - Decades of History
  - Recent Decade of History
- Future
  - Context for RFID
  - Sensors
  - Security
  - Spatial Identification

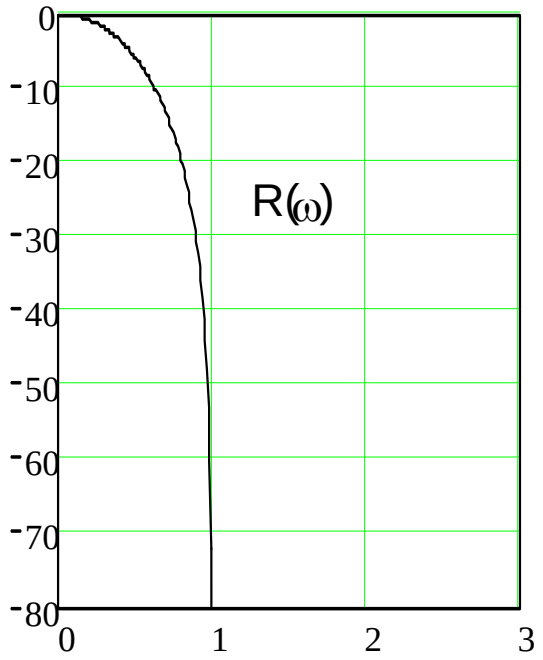
History of “Modulated-backscatter” RFID

- 1940’s
  - Use of modulation backscatter for military
- 1980’s
  - Passive “dumb” UHF RFID tags constructed from discrete semiconductor components
- 1990’s
  - Passive “smart” UHF RFID tags constructed from single integrated circuit

Recent Decade of Bandwidth Improvements

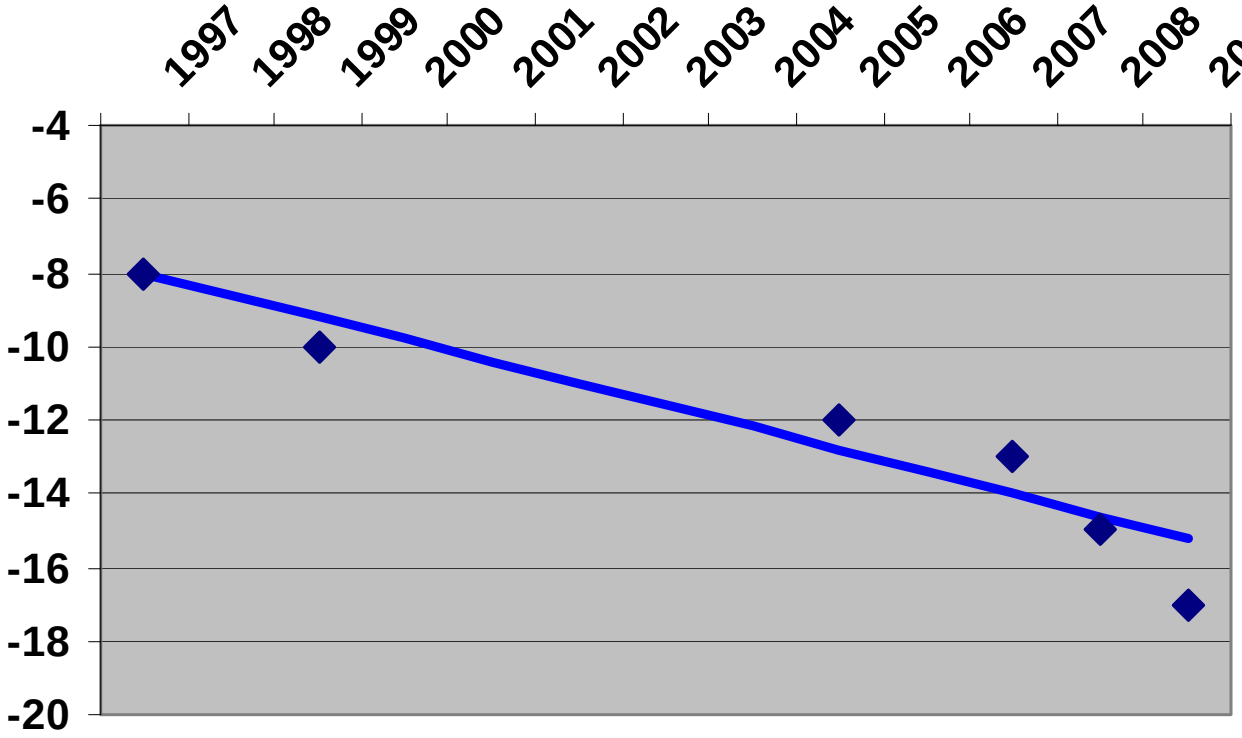
- Old reader modulation used on/off keying
- Using digital filtering (e.g. raised cosine), reader modulation bandwidth (50dB) decreased by x10-x100





Recent Decade of Range Improvements

- Range doubles every decade (avg of 0.6dB/yr improvement)

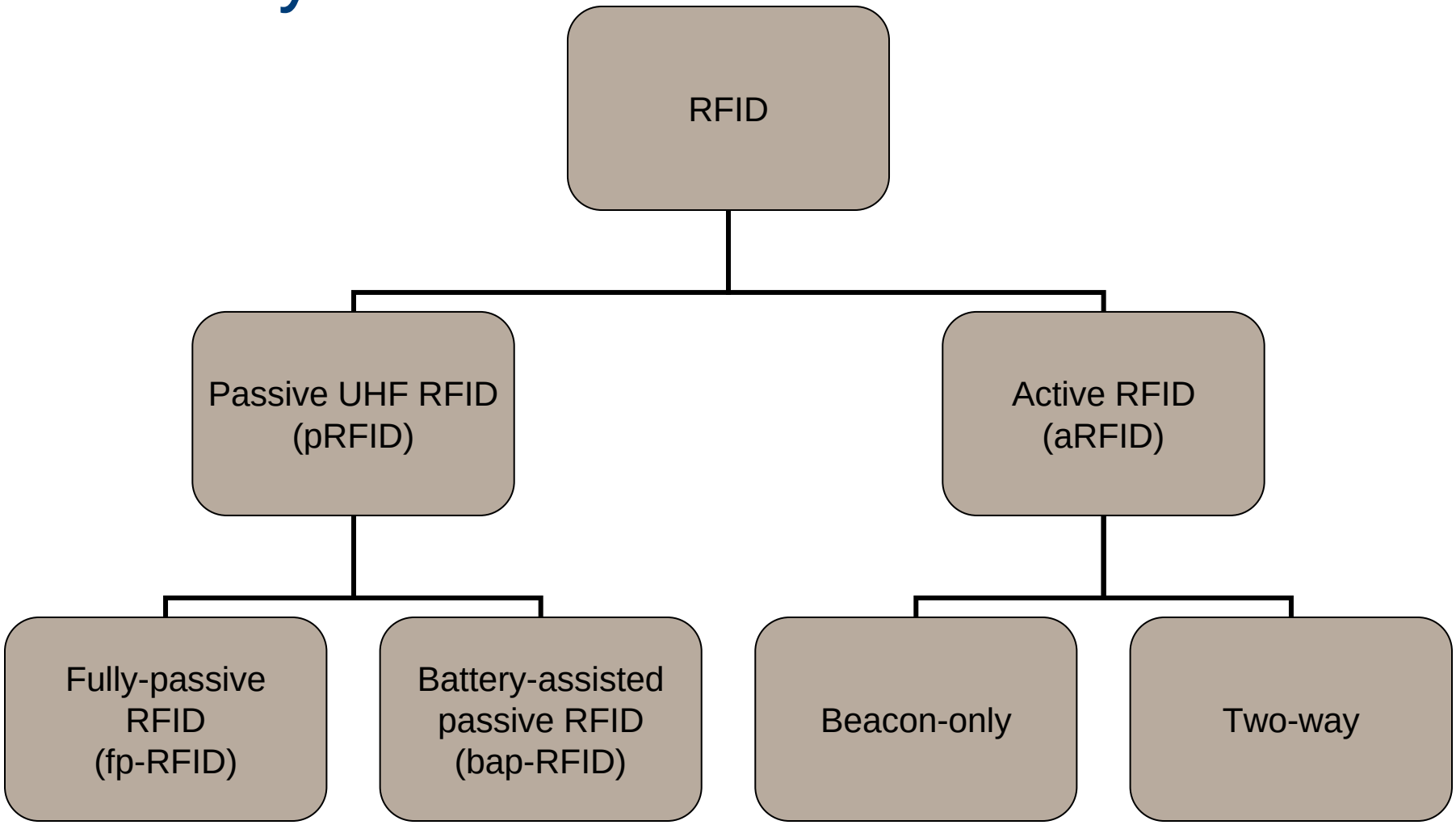


- In the future, range ultimately limited by powers

$$P_{dc} = V_{chip}\, I_{chip} \qquad P_{rcv} = G_{tag}\, EIRP \left(\frac{\lambda}{4\pi r} \right)^2$$

Future of RFID

Hierarchy of RFID



Characteristics of RFID Tags

Tag type	Internal battery	Intentional RF (internal xtal)
fp-RFID	X	X
bap-RFID	√	X
aRFID	√	√

Characteristics of RFID readers

Reader category	Tags	Emitted RF power	Antenna size	DC power
Low-power reader	fp,bap, & act.	≤250mW	≤3x3 cm	≤1 Watt
High-power reader	fp & bap	≥1 Watt	≥ 15x15 cm	≥5 Watt

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Range of RFID Systems

Reader	fp-RFID tag	bap-RFID tag	aRFID tag
Low-power reader	proximity ≤1m	vicinity ≤10m	facility ≤100m
High-power reader	vicinity ≤10m	facility ≤100m	

Sensor Characteristics of RFID Tags

Tag type	Internal battery	Intentional RF emissions	Sensing & monitoring
fp-RFID	X	X	Snapshot
bap-RFID	√	X	Continuous
aRFID	√	√	Continuous

Examples of RFID Sensors

- fpRFID Snapshot Sensors
  - TOUCHLESS™ configuration
  - Environmental status of object (e.g. tamper detection)
  - Update displays with eInk
- bapRFID and aRFID Continuous Sensors
  - Environmental exposure at item level of object
  - Human indicators (eInk, flashing lights, & sound)

RFID Security

- RFID Security implemented at close ranges and slow speeds:
  - Confidentiality
  - Authentication
  - Integrity
- UHF RFID provides long ranges and higher speeds
  - High speed & low power security needed
- Key management Issues
  - Secret Key vs. Private/Public Key

Spatial Identification / RTLS

- pRFID Technologies
  - Eliminate “False Positives” using RSSI, carrier phase, phased arrays, business logic
- aRFID Technologies
  - Impulse UWB at 3-5GHz
  - TDOA with CDMA at 2.45GHz
  - SDS-TWR with CSS at 2.45GHz
  - NFER at 1MHz
  - Ultrasound and Infrared
  - Combination of pRFID as a side channel

Summary of Existing and *Future* R&D for RFID

- What
  - Identify the object
- *Where*
  - Locate the object
- *How*
  - Obtain object status
- *Protect*
  - Secure the object status, identity, and location

Thank you

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