Advances in SAW Devices for Sensing and RFID Applications

Passive Wireless Sensor Technology Workshop

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www.rfsaw.com

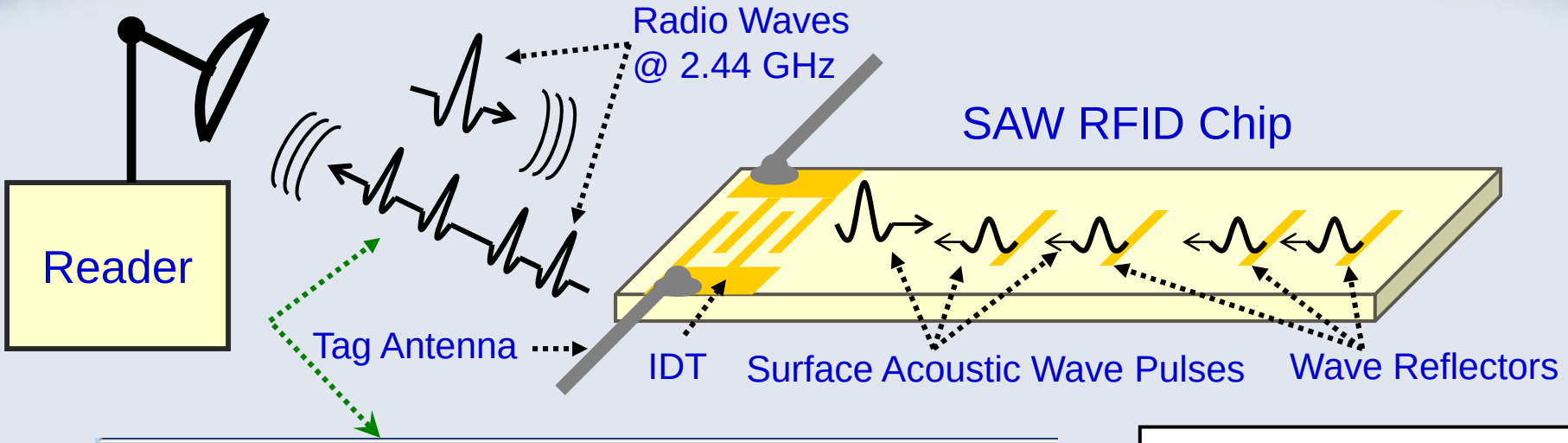
Passive SAW Wireless Sensors

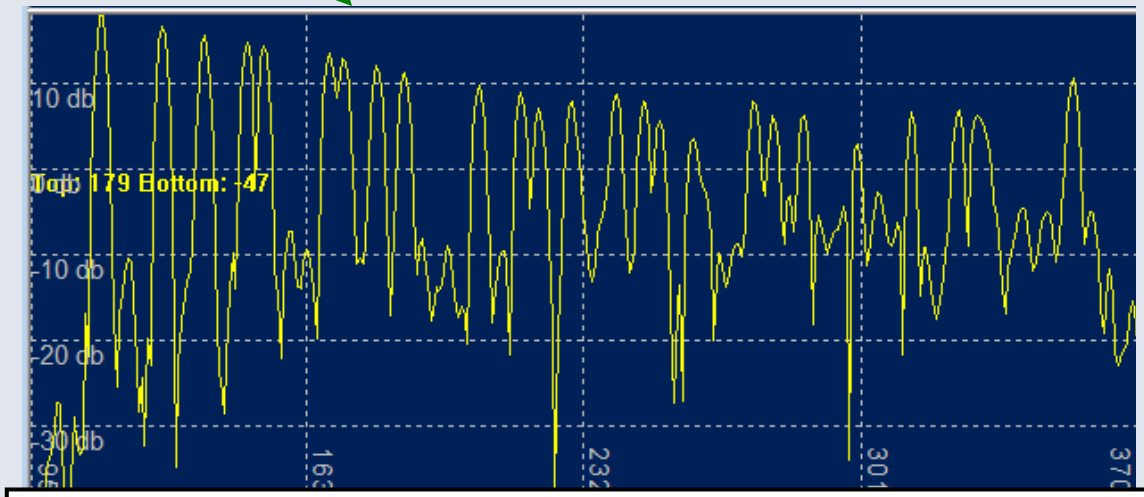
- RF SAW / GST Introduction
- SAW Sensor Advantages
- SAW Sensor Technical Challenges
- Design of High Capacity Sensor Systems
- Summary

RF SAW / GST Introduction

- RF SAW, Inc. provides SAW-based passive RFID and wireless sensing solution based on Global SAW Tag (GST) technology
- GST used on International Space Station
- World leader in SAW tag anti-collision
- World leader in high-data content SAW tags

RF SAW's Global SAW Tag System





Actual 96-Bit Wireless Tag Waveform

GST Features

- **Trillions of Trillions of ID Numbers**
- **Inherent Temperature Sensing**
- **Inherent Tag Localization**

Advantages of SAW-Based Sensing

- SAW is inherently passive and wireless
- Sensing modalities include temperature, strain/pressure, gas/liquid (surface loading), location, and individual sensor identification
- Longest passive sensor reading range
- Tolerant to high-energy radiation e.g. nuclear
- Globally legal 2.45 GHz operating frequency
- SAW readers can use very low RF power, HERO certified for safe use on munitions

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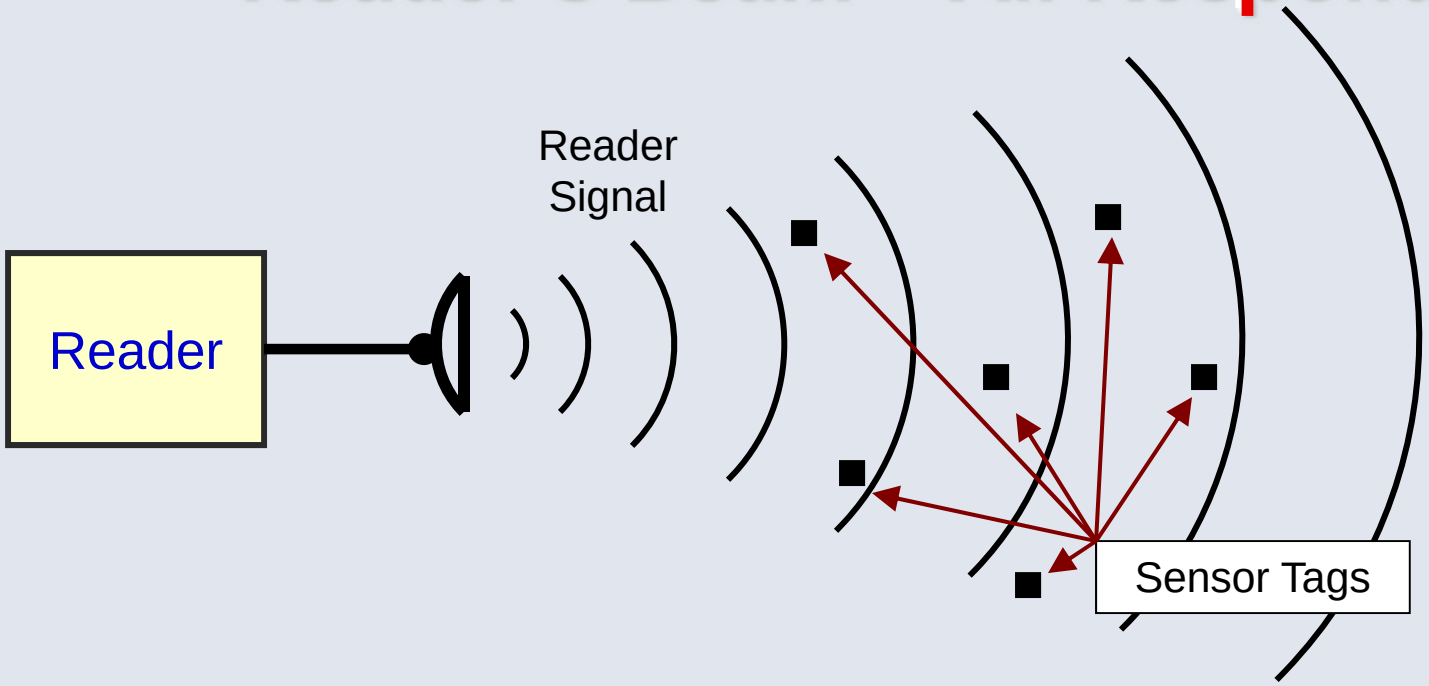
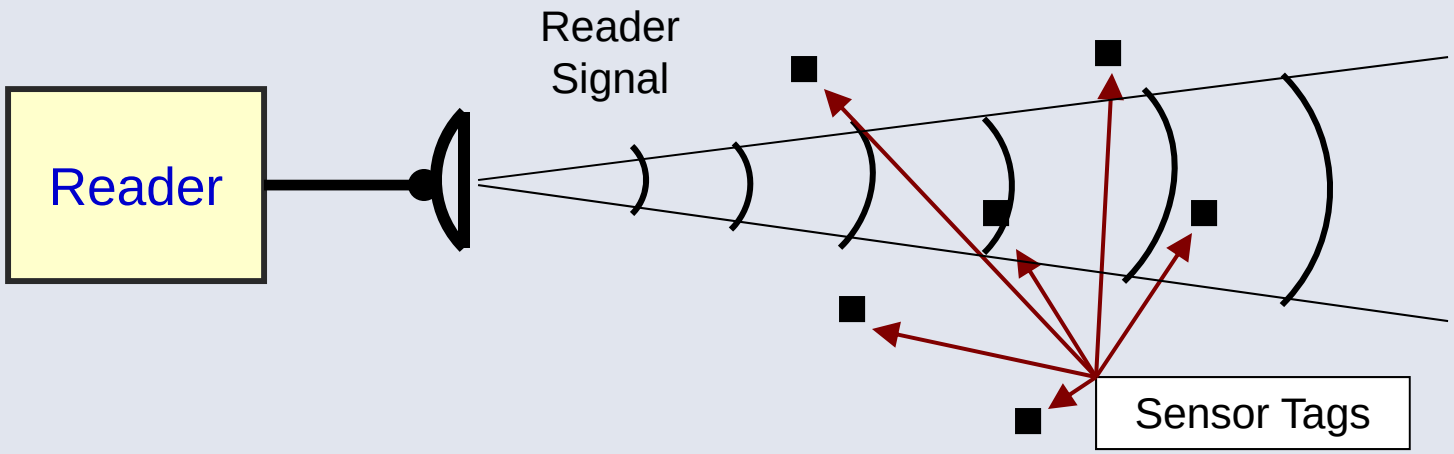
Multi-Sensor Collision: Many Tags in Reader's Beam – All Respond



- All SAW tags respond simultaneously
- Collision is inevitable in multi-sensor applications

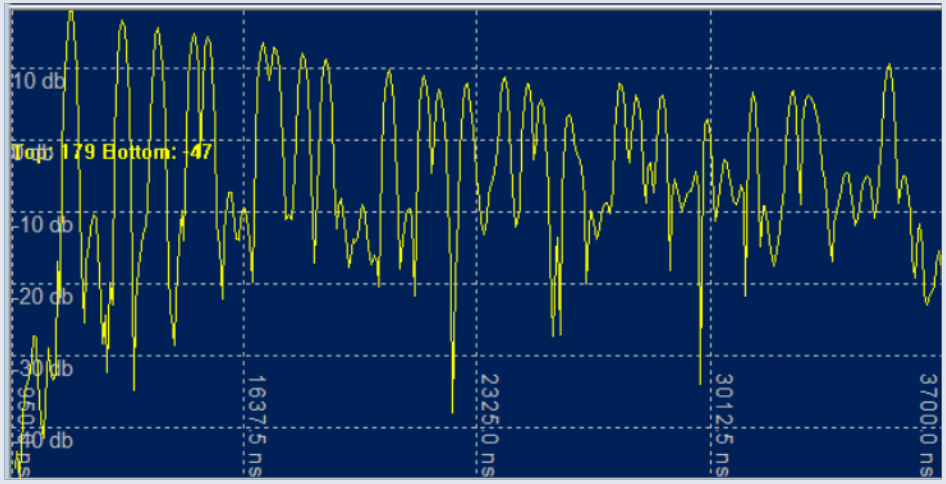
Narrow Reader Antenna Beam Limits Number of Colliding Tags



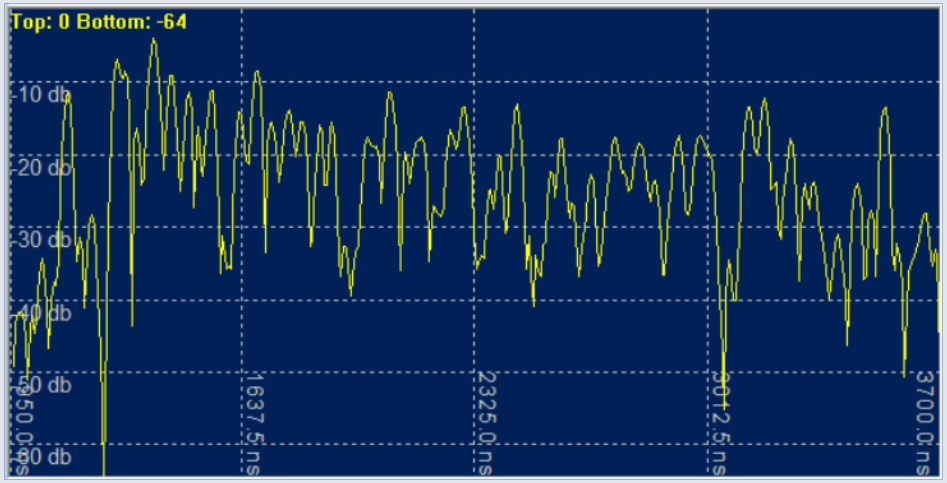
- Narrow antenna beam reduces collision but is not a complete solution
- Remaining collision will be resolved using code division signal separation

Code Division SAW Tag Signal Separation

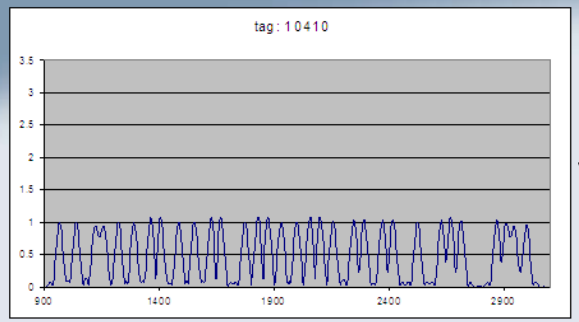
- Single Tag

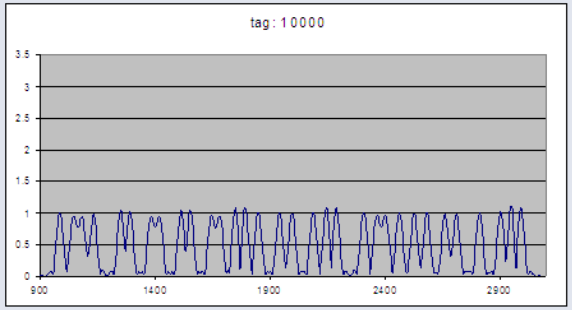


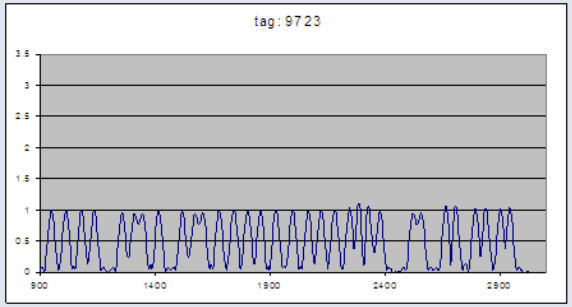
- 14 Tags in Collision

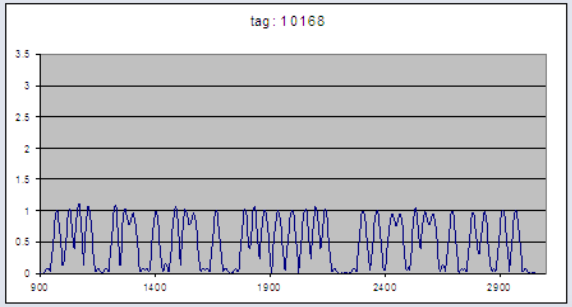


Anti-Collision Matched Filter Processing

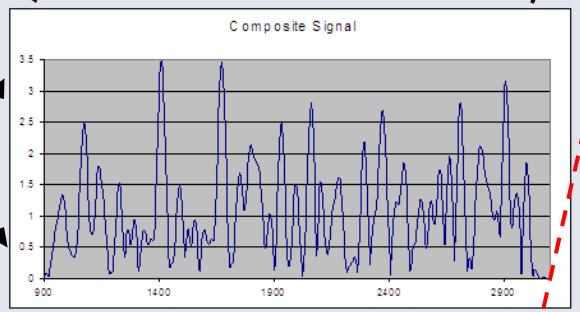






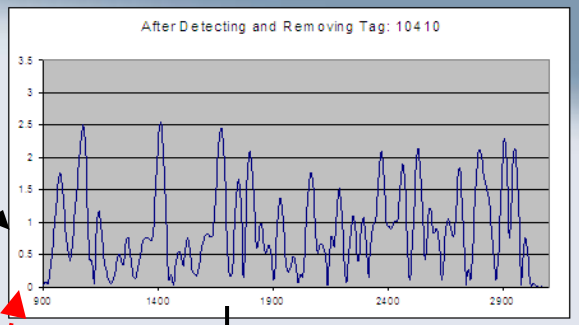


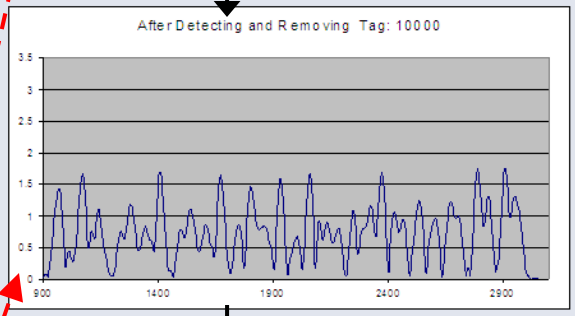
Sum of Tag Signals

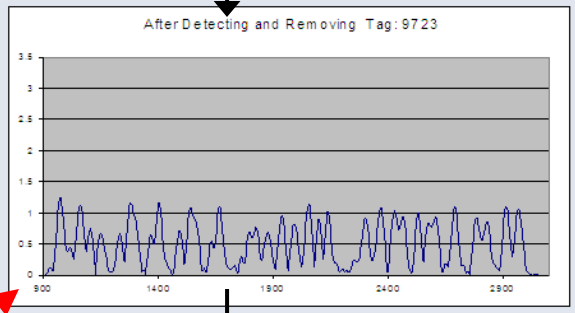


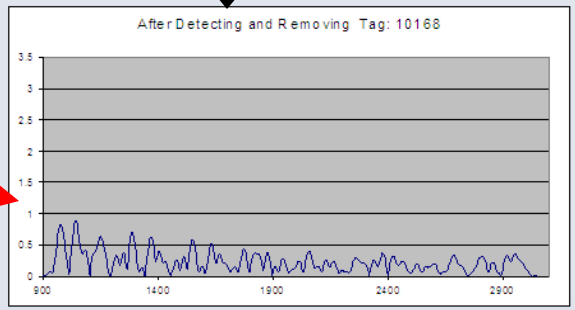
Matched filtering & signal subtraction

Signal after Subtraction of Signal 1, 2, 3 & 4









Passive SAW Wireless Sensors

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Resolving SAW Sensor Collisions Using Code Division Signal Separation

- Technique is well known in digital cellular phones
- Code division requires use of code families with good cross-correlation properties
- For temperature sensing, detection is based on code changes caused by temperature changes
- Temperature induced code changes destroy the good cross-correlation properties of known codes
- Temperature tolerant codes have been discovered

Temperature Tolerant Code Families

- These new codes have good cross-correlation (i.e. anti-collision) properties for all code pairs for arbitrary device temperatures
- Cross-correlation properties are mathematically provable for all code pairs in a single family
- Code properties have not yet been mathematically proven when all codes in a family are present
- Good cross-correlation has been proven by brute force search over all temperature combinations and all tag ranges for a 5-member code family

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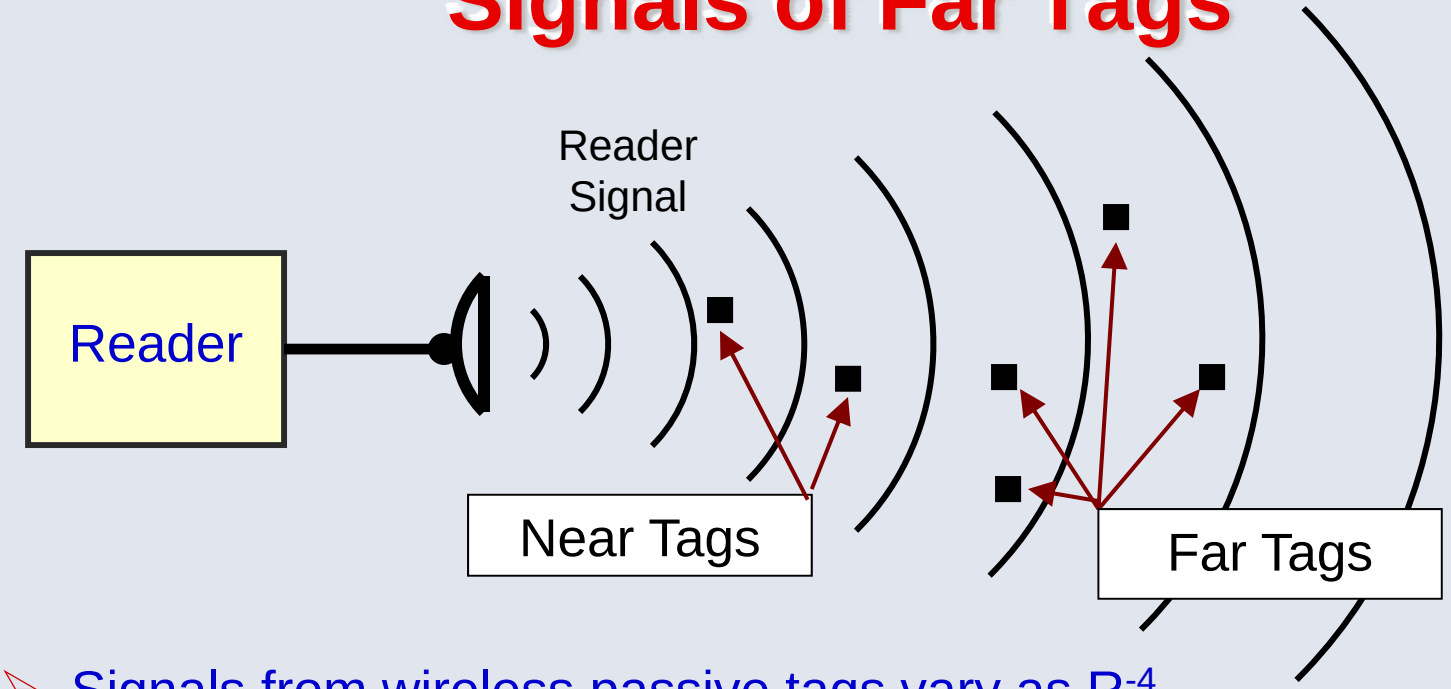
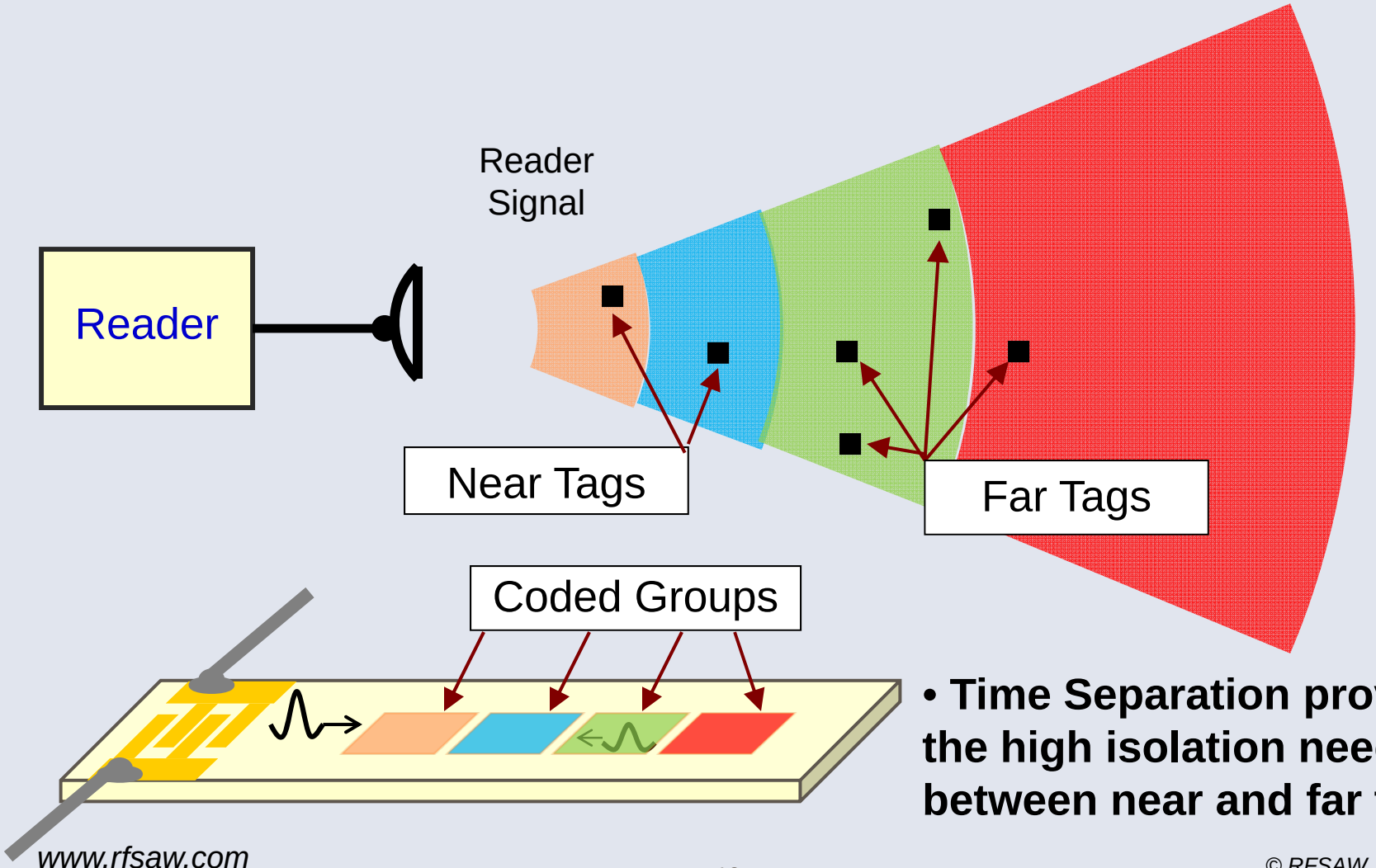
Near/Far Effect: Strong Signals from Near Tags Overwhelm the Weak Signals of Far Tags



- Signals from wireless passive tags vary as R^{-4}
- Nearest tag is often more than 40 db stronger than furthest tag
- Near tags can negate large reading range
- Use different time slots for different tag ranges

Overcoming Near/Far Effect Using Coded Groups in Multiple Time Slots



- **Time Separation provides the high isolation needed between near and far tags**

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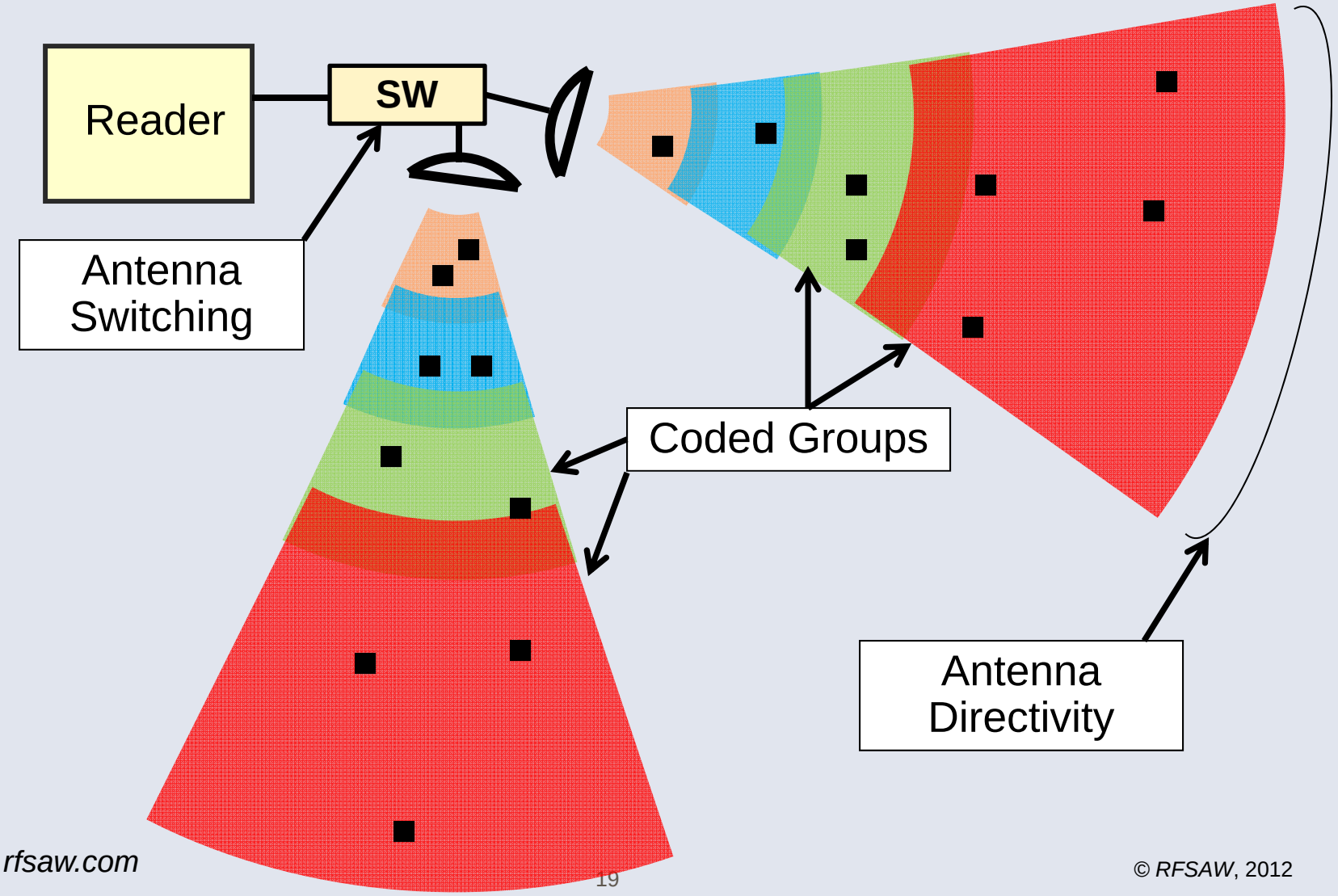
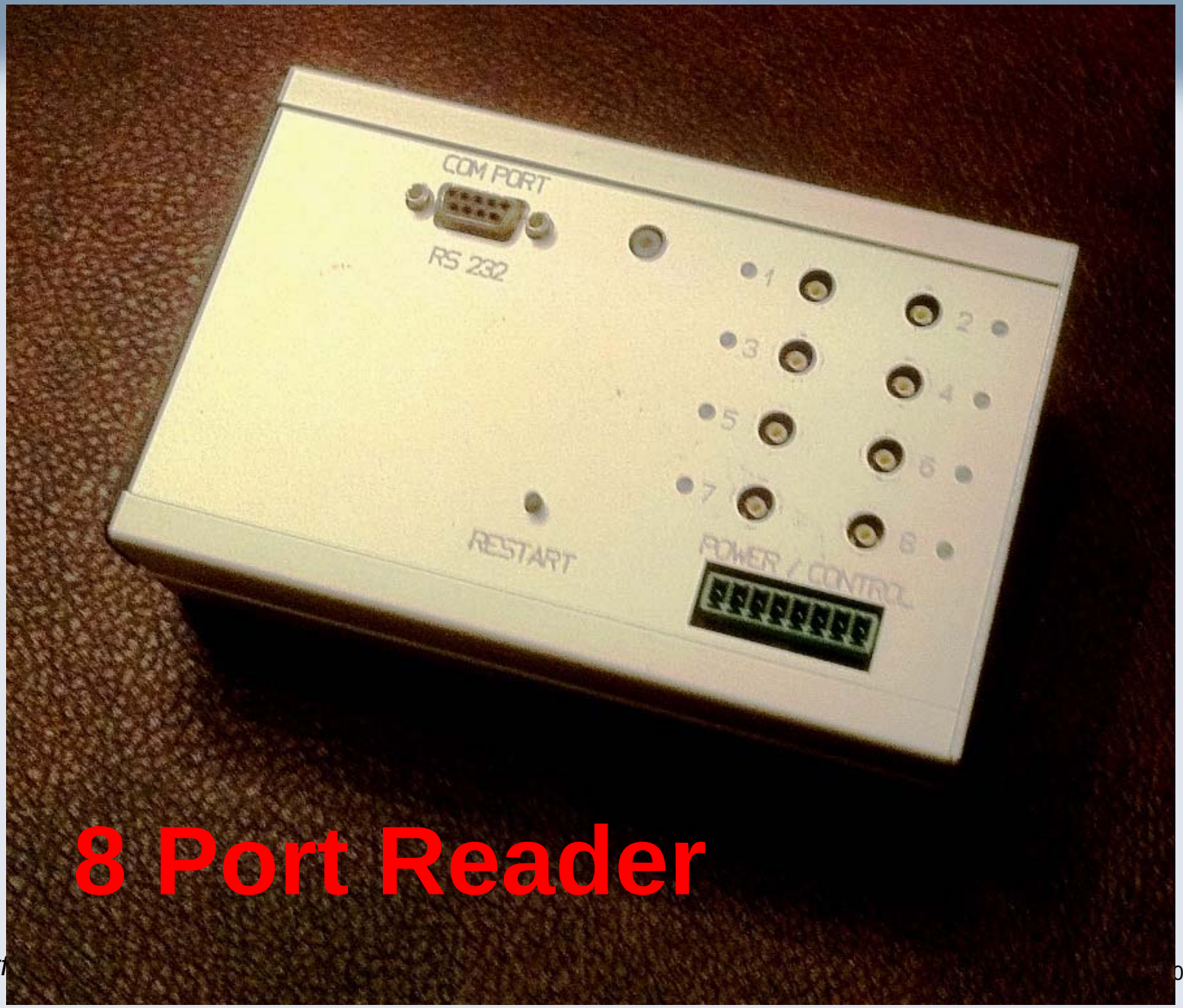
Design of High Capacity Sensor Systems

- System utilizes tag family with 30 codes comprised of
  - Six separate time slots for different ranges
  - A 5-member temperature tolerant code family in each slot
- Up to 8 narrow beam-width 2.45 GHz antennas oriented in different directions
- Interrogator with 8 separate antenna ports
- Enables > 100 sensors per interrogator with theoretical capability of 240 sensors (30 x 8 = 240)

High Capacity Sensing System





8 Port Reader

Summary

- A SAW-based passive wireless temperature sensing system that features:
  - Large number of sensors with a single reader
  - Large sensor reading range
  - Solution for near/far simultaneous reading challenge
  - Wide temperature range
  - Cost effectiveness