RFID JOURNAL LIVE!

APR. 14-16 • ORANGE COUNTY CONVENTION CENTER • ORLANDO
Physics of RFID

Understanding the behavior of radio waves and how that affects RFID system performance

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Agenda

• Radio Waves
• Active vs. Passive
• Near Field vs. Far Field
• Behavior of HF Fields
• Behavior of UHF Fields
• Addressing UHF Physics Issues
Radio Waves

• What is Frequency?
  – Refers to the property of radio waves used to transmit data
  – Roughly speaking, it is the intensity of
Electromagnetic Spectrum
Radio Waves

• Frequency Allocations
  – RF waves are regulated by FCC. FCC and its associates specify the frequencies, communication means, amplitudes and uses that are permitted over the whole frequency spectrum through a spectrum licensing process
Radio Waves

• Frequency Allocations
  – Four primary frequency bands are being used for RFID applications:
    • Low Frequency (125/134KHz): Most commonly used for access control, animal tracking, asset tracking and most importantly when there is close proximity to water or non-conductive materials
    • High-Frequency (13.56 MHz): Used where medium data rate and read ranges are acceptable. It has the advantage of not being susceptible to interference from water or metals.
    • Ultra High-Frequency (850 MHz to 950 MHz): It offers the long read ranges and high reading speeds.
    • Microwave Frequency (2.4 GHz): Highest penetration in metals and lowest in water surroundings
Radio Waves

• Range & Power Levels
  – The range that can be achieved in an RFID system is determined by
    • The power available at the reader
    • The power available within the tag
    • The environmental conditions and structures
    • More important at higher frequencies than at lower frequencies
## Radio Waves

<table>
<thead>
<tr>
<th>Material Composition</th>
<th>Its Effect on RF Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrugated Cardboard</td>
<td>Absorption from moisture</td>
</tr>
<tr>
<td>Conductive Liquids</td>
<td>Absorption</td>
</tr>
<tr>
<td>Glass</td>
<td>Attenuation</td>
</tr>
<tr>
<td>Groups of Cans</td>
<td>Multiple propagation effects; reflection</td>
</tr>
<tr>
<td>Humans/Animals</td>
<td>Absorption; detuning; reflection</td>
</tr>
<tr>
<td>Metals</td>
<td>Reflection</td>
</tr>
<tr>
<td>Plastics</td>
<td>Detuning (dielectric effect)</td>
</tr>
</tbody>
</table>
Active Tags

• Broadcast a signal
• Performance not usually an issue
  – Think of your cell phone
• With some lower-frequency systems, rain might affect performance
Passive Tags

- Use energy from the reader
- Radio waves from the reader are on the same frequency as waves being reflected by the tag
  - Reader emissions 1,000 times as strong as the tag reflecting back
  - Depending on environmental conditions, reading tags can be difficult
Passive Tags

- HF tag
- LF tags
- UHF tag
- UHF item tag
- Reusable UHF tag
- Metal mount tag
- Cattle tag
- Button tag
Passive Tags

- Key is to get enough energy to the tag
- Metal reflects radio waves
- Water absorbs UHF radio waves
- Other materials have varying effects on radio waves
RF Behavior

- Behavior of RF depends on Frequency
  - Low frequency is like your FM radio
    - Waves pass through walls easily
  - UHF and microwave frequencies behave more like light
    - Light bounces off objects, doesn’t penetrate
    - Light travels quickly
    - Light can carry more information
      - Think fiber optic cable
Near Field vs. Far Field

• Near field is within one wave length
• Far field is beyond one wave length
• These are very different types of communication
• Near field is magnetic
• Far field is electromagnetic
Near Field Communication

- LF and HF systems work with near-field communication
- A coil in the reader emits energy that creates a magnetic field with the coil in the tag
- The tag modulates and demodulates its antenna, changing the field
- The reader picks up changes in the field and turns them into binary data
Near Field Communication

Magnetic field

Power source (temporary storage)

Transponder

Load modulator

Reader
Near Field Communications

- Characteristics of near-field RFID systems
  - Short read range
  - Well-defined read zone
  - Consistent reads
  - Good penetration through materials
  - Not highly affected by water
Far Field Communications

- UHF systems work with far-field communication
- A plate or patch antenna radiates energy
- An antenna attached to the chip receives the radio waves and converts them to energy to power the chip
- UHF tags usually have large antennas
UHF Tag Examples
Behavior of UHF Tags

• The tag converts energy from the reader into energy to run the chip

• Antenna is designed to capture most energy

• The reader antenna can be circular-polarized
  – Energy emitted in a circular pattern to reduce orientation sensitivity

• The reader antenna can be linear-polarized
  – Energy is channeled into a narrow band to increase read range
Behavior of UHF Tags

• The chip uses energy from the reader antenna to modulate and demodulate the antenna, changing the wave reflected back

• There are different ways to modulate the antenna
  – Frequency modulation (FM)
  – Amplitude modulation (AM)
  – Frequency shift-keying (FSK)
  – Phase shift-keying (PSK)
Coding & Modulation

- **Signal Coding:**
  - It takes the message to transmitted and codes it in a way that will be optimal for the transmission channel.
  - It provide protection against interference or/and collisions.
  - Examples: NRZ code, RZ code, Differential coding, pulse-pause coding, ..etc

- **Modulation**
  - It is the process of altering the signal parameters of a high frequency carrier in relation to the signal to be transmitted (the data).
  - Examples: ASK, FSK & 2 PSK
UHF Near Field Tags

• Some companies are developing UHF tags that work in the near field
  – Short read range
  – More defined read zone
  – More consistent reads
  – Good penetration through materials
  – Less affected by water
Conclusion

- LF, HF and UHF perform differently because of the physics of different radio waves
- Companies must choose the RFID system that works best for their application(s)
- Companies must overcome the limitations of UHF tags to achieve consistent reads
Thank you