Module 1 – What is RFID

Main Objectives:

1. Define RFID technology, what it is and its working principles.

2. Recognize main types of RFID systems based on communication:
   - Passive (no power source but derives its power from the reader's transmission)
   - Battery Assisted or Semi-Passive (tag has a battery to assist with transmitting response to the reader but relies on the reader transmission to initiate action or wake up, does not beacon)
   - Active (tag has a battery and does not rely on reader transmission for any power needs)

3. Know characteristics of these categories and how they impact:

   - Data Transfer Rate
   - Read Range
   - Cost
   - Typical Applications
   - Frequencies normally used
   - Behavior around water based liquids and metals
   - Regulations
   - Modes of operations (inductive/capacitive)
   - Types of antennas used

Passive RFID

The passive RFID tag has no power source but derives its power from the reader's transmission. It often comes in form of a flat inlay or a label and is the simplest type of RFID tag.

- Frequencies normally used
  - Low Frequency (LF) – 120 – 150 kHz
  - High Frequency (HF) – 13.56 MHz
  - Ultra-High Frequency (UHF) – 860 – 960 MHz
  - Microwave Frequency 2.45 GHz

- Data Transfer Rate – depends on frequency and is function of the wave
  - LF – very slow
  - HF – slow
  - UHF – fast
  - Microwave – ultrafast

- Read Range – shortest, up to 30 ft, depends on frequency
  - LF – up to few inches
  - HF – up to 3 feet, most often 3- 5 inches
  - UHF – up to 30 ft
  - Microwave – few inches max.
- Cost – lowest, starting at 5 cents per tag in high volumes

- Typical Applications – inventory tracking, asset tracking, access control, warehouse, hospital, office, events

- Behavior around water based liquids and metals – depends on frequency:

  - LF, HF – can read through aqueous liquids
  - UHF, Microwave – cannot read through aqueous liquids
  - No frequencies can read through metal and tags get detuned when placed on or near metal objects.

- Regulations
  - FCC Part 15.247 – governs UHF allowed transmitted power from the reader/interrogator (maximum 4 W EIRP), frequency hopping channels (50) and the channel width (500 kHz).
    - For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands, the maximum peak conducted output power of intentional radiators is 1 watt.

  - ETSI 302 208 (newer)
    - 865.0 – 868.0 MHz
    - 15 channels – 200 kHz each
    - Three sub-bands
    - Up to 2 W ERP in subband 865.6 – 877.6 MHz (10 channels)
    - Required LBT
  - ETSI 300-220 (older, restrictive)

- Standards (air interface)
  - LF – ISO/IEC 18000-2
  - HF – ISO/IEC 18000-3, ISO/IEC 15693, ISO/IEC 14443
  - UHF – ISO/IEC 18000-6 (A, B, C), EPC Global/GS1 Class 1 Gen 2 (ratified into ISO 18000-6C)
  - Microwave – ISO/IEC 18000-4 for 2.45 GHz, (ISO/IEC 18000-5 for 5.8 GHz (withdrawn due to lack of use)

- Modes of operations – based on frequency
  - LF, HF - Inductive coupling – based on changes in magnetic field
  - UHF, Microwave - Capacitive coupling also called passive backscatter – based on changes in electric field

- Types of antennas used
  - LF, HF – coil antenna
  - UHF, Microwave – dipole antenna

Battery Assisted Passive RFID

The battery assisted passive RFID tag (also called BAP or semi-passive tag) relies on the initial transmission from the reader and then uses a battery to assist with transmitting response to the reader. This allows for longer read ranges. The BAP tags have often integrated sensors.

- Frequencies normally used
  - Ultra-High Frequency (UHF) – 860 – 960 MHz
  - Microwave Frequency 2.45 GHz

- Data Transfer Rate – depends on frequency and is function of the wave
  - UHF – fast
  - Microwave – ultrafast

- Read Range – medium, up to 100 ft, depends on frequency and technology
  - UHF – usually up to 100 ft (depends on technology)
  - Microwave – usually up to 30 ft (depends on technology)

- Cost – high, starting at several dollars per tag

- Typical Applications – applications with sensors – temperature tracking for inventory, transportation, assets; regular and returnable asset tracking where long read ranges are necessary

- Behavior around water based liquids and metals – depends on frequency:
  - UHF, Microwave – cannot read through aqueous liquids
  - No frequencies can read through metal.
  - Tags are encapsulated and can be tuned to perform well on metal.

- Regulations
  - FCC Part 15 – governs UHF allowed transmitted power from the reader/interrogator (maximum 4 W EIRP), frequency hopping channels (50) and the channel width (500 kHz).

- Standards (air interface) – compatible with passive readers if compliant with same standards as below:
  - UHF – ISO/IEC 18000-6 (A, B, C), EPC Global/GS1 Class 1 Gen 2 (ratified into ISO 18000-6C)
  - Microwave – ISO/IEC 18000-4 for 2.45 GHz, (ISO/IEC 18000-5 for 5.8 GHz (withdrawn due to lack of use)

- Modes of operations – based on frequency
  - UHF, Microwave - passive backscatter – based on changes in electric field – aided by the battery

- Types of antennas used
  - UHF, Microwave – dipole antenna

Active RFID

The active RFID tag has a battery and does not rely on reader transmission for any power needs. It can beacon and have integrated sensors.

- Frequencies normally used
  - Ultra-High Frequency (UHF) – 433 MHz
  - Microwave Frequency - 2.45 GHz
  - Ultra Wide Band (UWB) Frequency 3.2 – 10 GHz

- Data Transfer Rate – depends on frequency and is function of the wave
  - UHF – fast
  - Microwave – ultrafast
  - UWB Frequency - fastest

- Read Range – longest
  - UHF up to 1000's of feet (depends on technology and power source)
  - Zigbee – about 30 – 300 ft (10 – 100 m)
  - WiFi IEEE 802.11n – up to 820 ft (250 m)

- Cost – highest, starting around $20 per tag (ballpark price)

- Typical Applications
  - Applications with sensors – temperature tracking for inventory, transportation, assets; tamper sensors;
  - Long range tracking – cars, rail cars, containers for transportation and control in depots, docks, shipyards, military, etc.,
  - Real-time location systems (RTLS) – Both Wi-Fi and UWB technology is often used for RTLS and UWB is one of the most accurate technologies for location.

- Behavior around water based liquids and metals – depends on frequency:

  - Cannot read through aqueous liquids.
  - No frequencies can read through metal.
  - Tags are encapsulated and can be tuned to perform well on/around metal.

    - Due to the tag having a battery and transmitter and therefore stronger signal, the signal can bounce/bend around metal objects, which means that active RFID has usually better performance in metal environments.

- Regulations
    - FCC Part 15 – governs allowed transmitted power from the reader/interrogator (maximum 4 W EIRP), frequency hopping channels (50) and the channel width (500 kHz).

- Standards (air interface):
    - UHF – ISO/IEC 18000-7 for 433 MHz
    - Microwave – ISO/IEC 18000-4 for 2.45 GHz
    - DASH7 (2nd gen of ISO 18000-7) for 433 MHz
    - Wi-Fi IEEE 802.11n – 2.45 GHz
    - Zigbee IEEE 802.15.4 for 868/915 MHz or 2.45 GHz

- Modes of operations
    - Active transmission

- Types of antennas used
    - Dipole or monopole antenna

Study List:

For comprehensive explanation, please read:
Passive vs. Active
RFID Frequencies
Standards and Regulations