

# The Physics behind RFID

Edited and Presented by

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## Topics in this section

- Radio Waves – An introduction
- RFID Tags – Active V's Passive V's BAP
- RFID Readers – Fixed V's Handheld
- RFID Communication - Near field V's Far field
- Modulation & Signal Coding
- Frequency choice and performance

# Radio Waves – An introduction

- Radio waves: invisible form of electromagnetic radiation with wavelengths greater than 1 millimeter
- Their frequency causes them to behave differently
  - Important for RFID systems

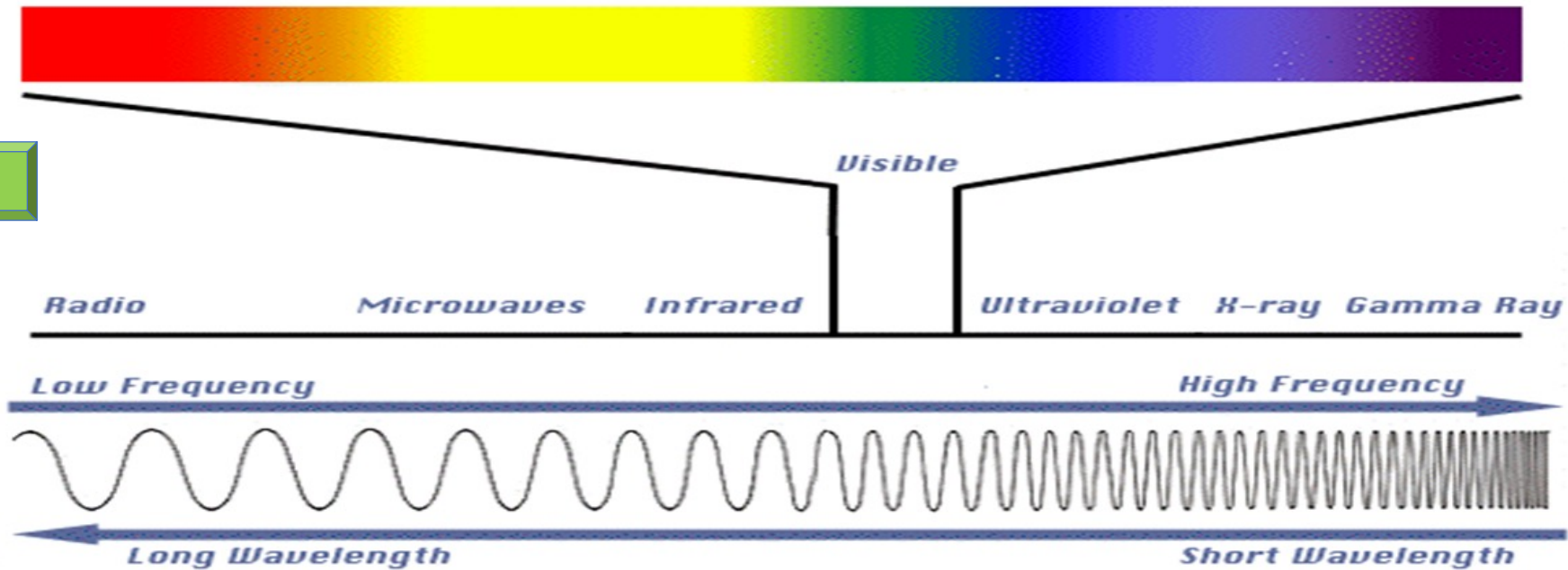
# Lets talk: Frequency

- Frequency: The number of radio wave oscillations per unit time
- Expressed in hertz;
  - 1 hertz is equal to one cycle per second
  - 1 kilohertz (kHz) is 1,000 cycles / sec
  - 1 Megahertz (MHz) is 1,000,000 cycles / sec

.....**This is important for RFID systems**.....
- You will be asked what frequency system you want ????

# Lets talk: Electromagnetic Spectrum

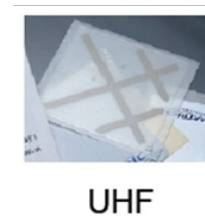
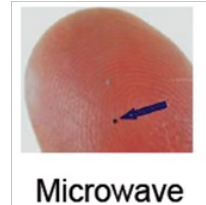
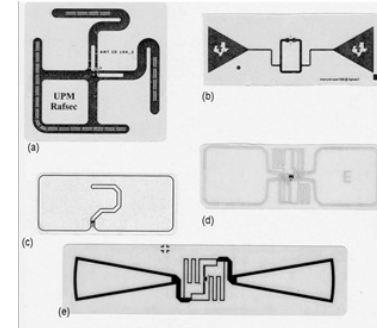
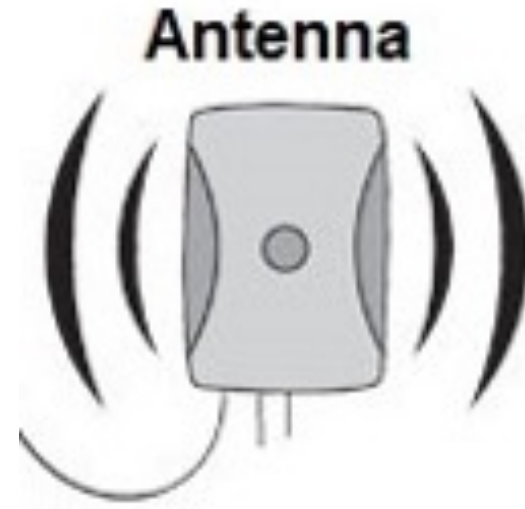
RADIO



# RFID: Systems Components

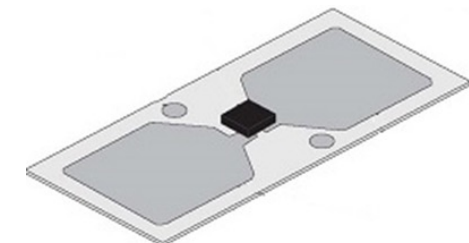
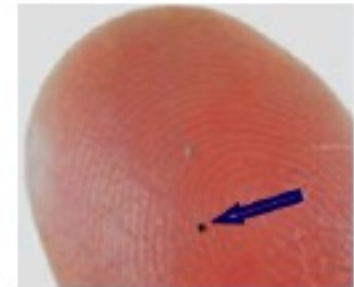
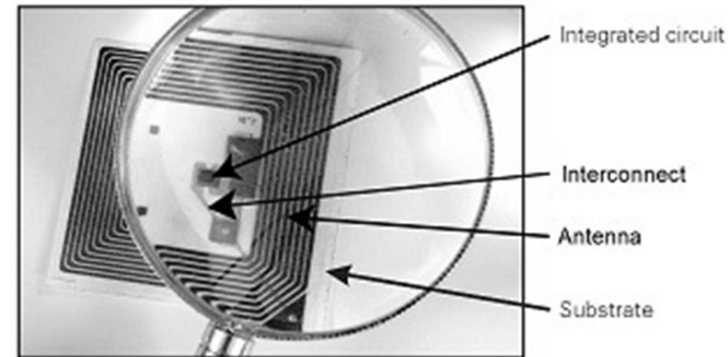
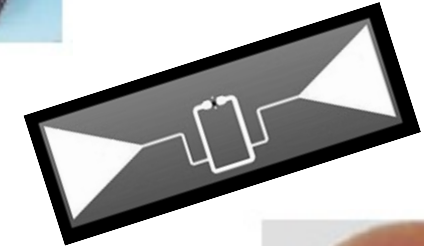
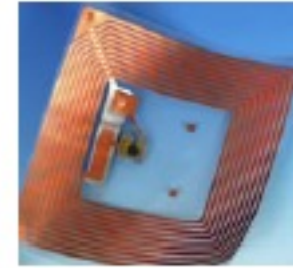
- Hardware
  - **RFID transponders** (tags, smart labels)
    - Made up of chip, antenna, substrate, battery (optional)
  - **RFID reader** (also called interrogator)
    - Antennas (1, 2, 4 or 8), digital signal processor, network port, input/output ports, and power source
- Edge server (runs filtering middleware)
- Network appliances (manages reader/data flow)

# Lets talk: System Components?



# Lets talk: Tags

... Various **shapes** + ...  
Various **casings** .....  
... + Various **sizes**  
.. = Various applications.....



aka.....Transponders

# Lets talk: Tag Classification

- **Power**
  - Active
  - Semi-Passive (Battery Assisted Passive - BAP)
  - Passive
- **Frequency (More on Frequency later)**
  - LF: 125-134 kHz
  - HF: 13.56 MHz
  - UHF: 902-928 MHz (in USA) and
  - MW: 2.4 GHz



# Lets talk: Active tags

- Broadcast a signal (powered by internal battery)
- Performance (read consistency) not usually an issue
- Distances (coupling) can vary depending on frequency



# Lets talk: Active tag types

TYPE	FUNCTIONALITY	PROTOCOL / NAME
<b>ACTIVE (Conventional)</b>	Wake up in reader range	DASH-7
	Broadcast their ID	Active 433 MHz / 900 MHz (proprietary air interface)
		Active 2.45 GHZ (IEEE 802.15.4)
<b>RTLS (real-time location system)</b>	Beacon at Regular Intervals	ZigBee
	Surrounding readers receive signal	Active 433 MHz / 900 MHz
	S/W can determine location	Wi-Fi (2.45 GHZ, IEEE 802.11)
		Ultra-wideband (3 to 10 GHz)

# Lets talk: Active tag types

TYPE	FUNCTIONALITY	PROTOCOL / NAME
HYBRID	Active tags with a variety of added functionality	433MHz active tags + infrared
		900MHz active tags + infrared
		2.45GHz Wi-Fi active tags + infrared
		433MHz active tags + GPS
		433MHz active tags + GPS and GPRS

# Lets talk: Semi-Passive

- Also called Semi-Passive Tag / Battery Assisted Passive (BAP).
- Uses on board battery to power internal IC (Active)
- Uses backscatter to couple (Passive)

# Lets talk: Semi-Passive

- Use energy from the reader.
- Internal power source (Battery)
- Radio waves from the reader are on the same frequency as waves being reflected by the tag
  - Tx significantly stronger than Rx (Backscatter)
  - Performance varies with surrounds... more later

# Lets talk: Semi-Passive

- There are a variety of battery-assisted RFID transponders
- High-frequency (13.56MHz)
  - Usually used for recording temperature
- Ultrahigh-frequency (856 to 960MHz, ISO 18000-6C air interface protocol)
  - Used for recording temperature / RH and other environmental conditions

# Lets talk: Passive tags

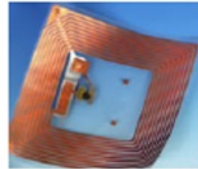
- Use energy from the reader.
- No internal power source (Battery)
- Radio waves from the reader are on the same frequency as waves being reflected by the tag
  - Tx significantly stronger than Rx (Backscatter)
  - Performance varies with surrounds... more later

# Passive Systems include

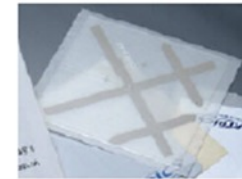
- Low Frequency (125 KHz or 134 KHz)
- High frequency (13.56 MHz)
- Ultra High Frequency (860 to 960 MHz)
- Microwave (2.45 GHz)
- Ultra Wideband (gaining in popularity)



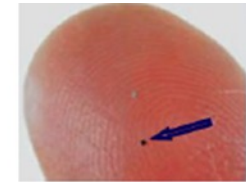
LF



HF



UHF



Microwave

# Lets talk: Readers

- Reader Types:

- ✓ Handheld
- ✓ Headphone jack
- ✓ Fixed
- ✓ Desktop

✓ There is no limit for form factor



# Lets talk: Antenna

- Both tags and readers have antenna
- Facilitate air interface communication for system “coupling” (more on this soon)
- Vary in shape size and material depending on application

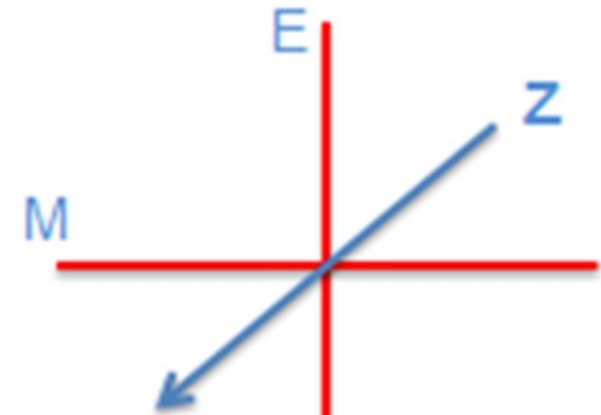
# Lets talk: Antenna

- Generate an Electromagnetic (**Interrogation**) wave:

## Antenna types

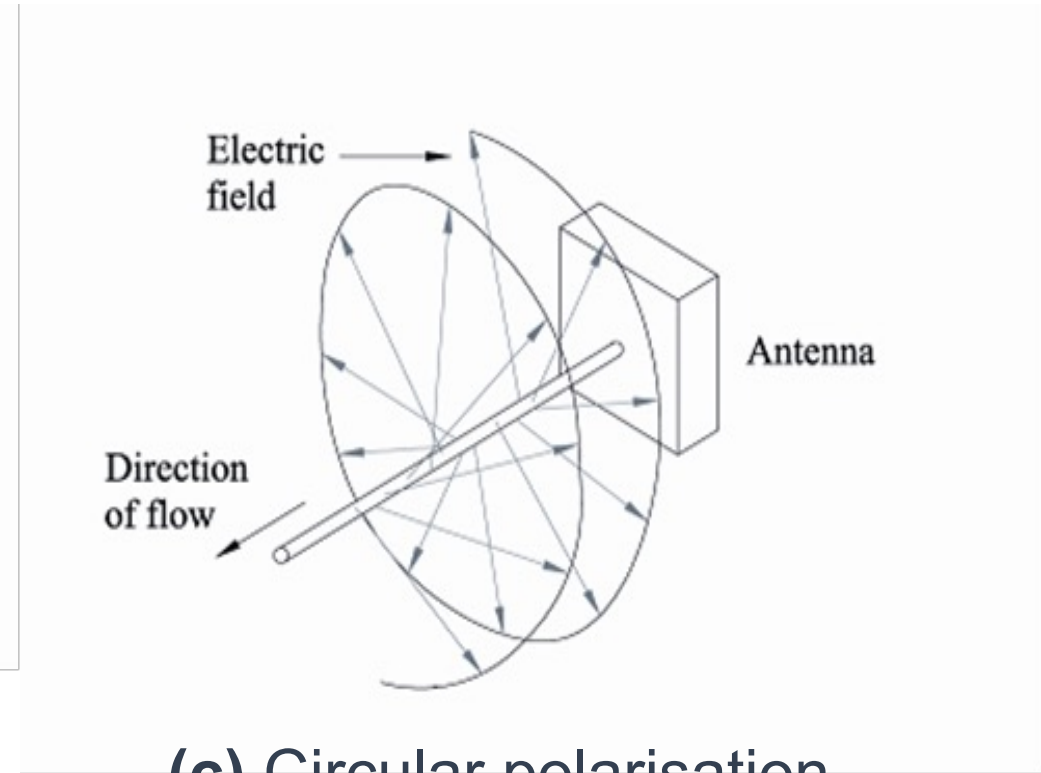
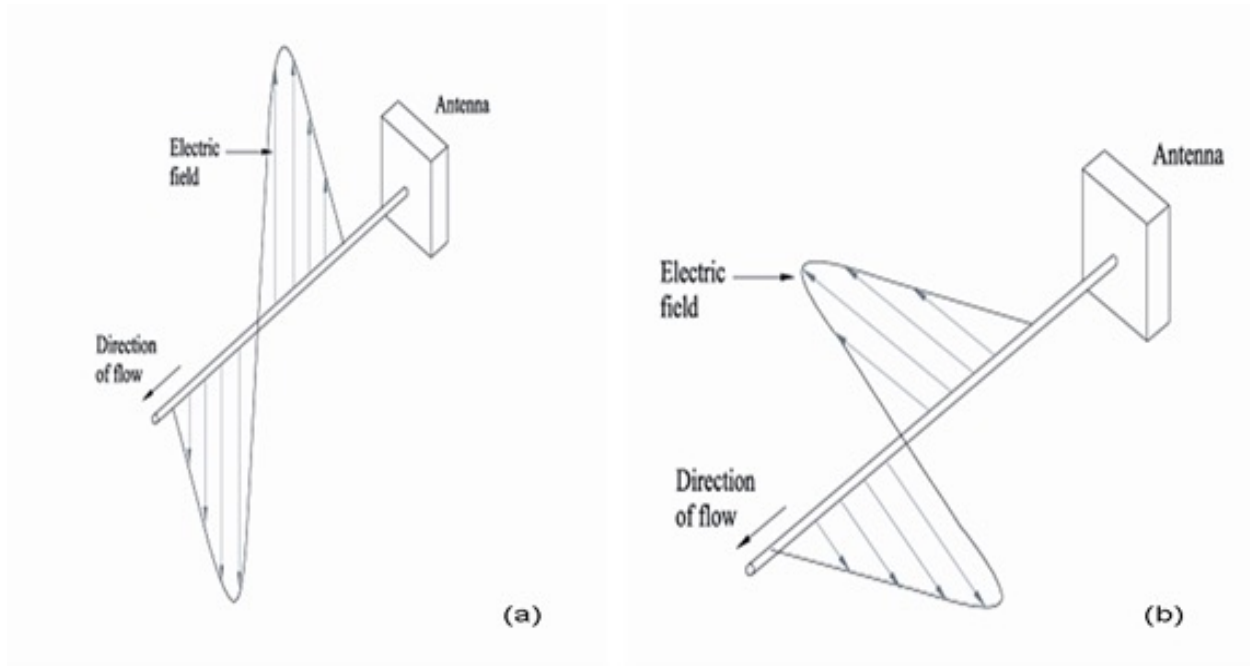
- ✓ Linear polarized
- ✓ Circular polarized

- EM Wave – in direction Z



**E – Field – M - Field**

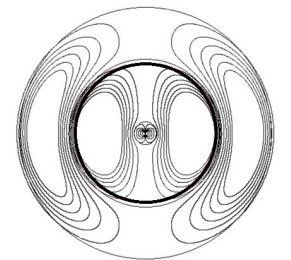
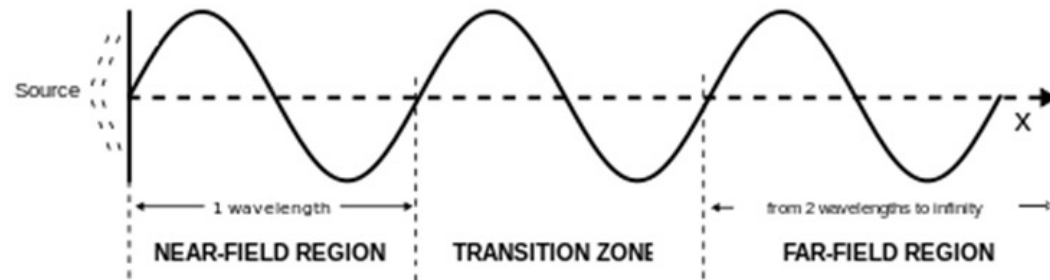
# RFID Antenna: Linear and Circular Polarization



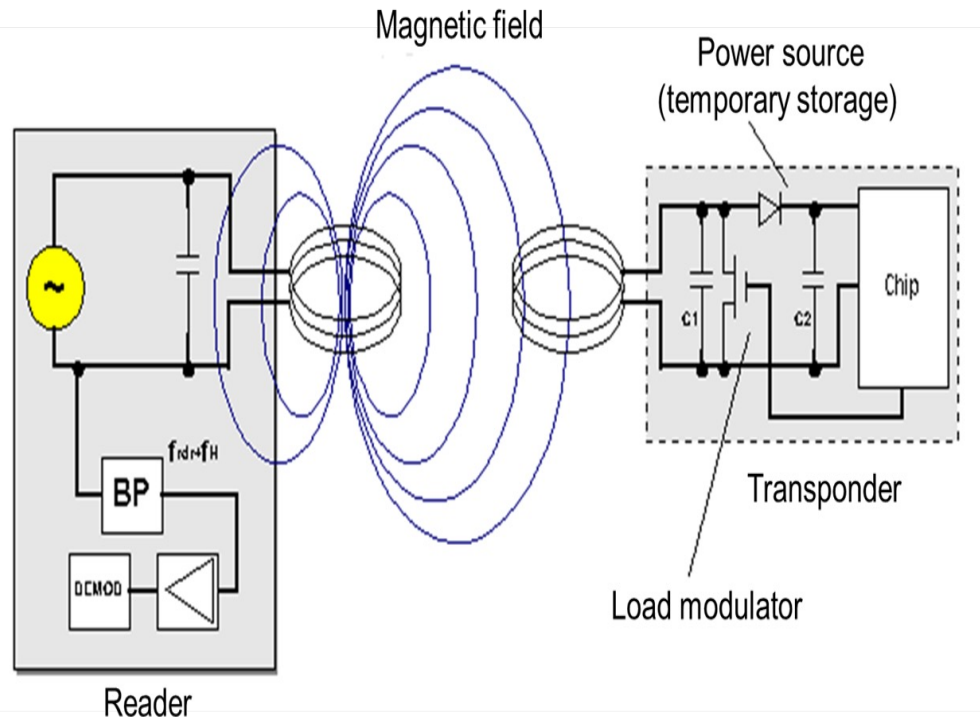


# RFID: Communication

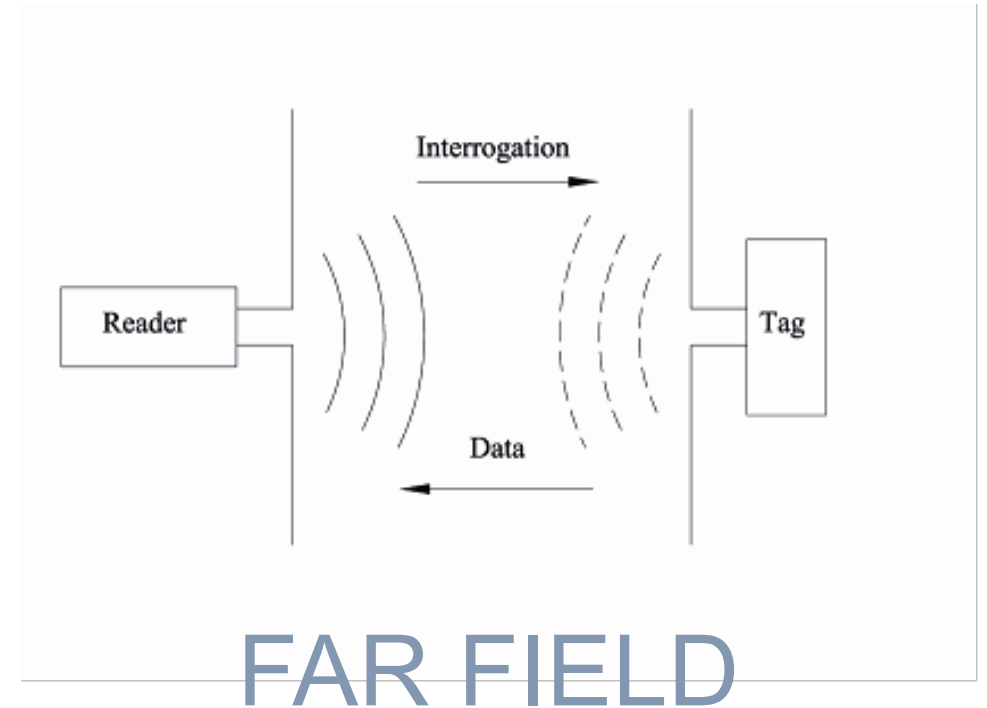
- There are very different types of communication
  - **Magnetic** near field is an energy storage field (LF, HF)
  - **Electromagnetic** far field is an energy propagating field (UHF)



# RFID: Near / Far Field Communication



NEAR FIELD



FAR FIELD

# RFID: Signal Coding

- The bi-directional communication link (coupling) requires data to be embedded (**coded**) in the radio waves.
- Information is encoded by tag in a particular coding scheme in synchronisation with a particular data transfer rate
- Reader then to **decodes** the incoming data stream (i.e. reads the tag)

# RFID: Modulation

- The alteration or modification of the carrier wave in accordance with the message signal
- Determines how the communication bits are transferred according to the message between tag and reader.

# RFID: Modulation

- Tag chip uses energy from the reader antenna to modulate the signal, changing the wave reflected back
- Process of altering the signal parameters in relation to tag ID (the data)
- Different ways to modulate:
  - Analog modulation: AM, FM
  - Digital modulation: ASK, FSK, PSK

# RFID: Frequency V's Performance

- Frequency and performance are critical system considerations
- Remember the question

*“What frequency system would you like to buy ??”*



Answer: If you don't know what frequency you would like, you should know at least what you want to tag – then seek help

# RFID: Frequency V's Performance

- Here are some general rules of thumb
- As the frequency increases . . .
  - the amount of data that can be transferred per second increases
  - radio waves are “disturbed” by environmental factors
  - ability to penetrate materials diminishes

# RFID: Frequency and Performance

- Low-frequency (LF) tags
  - 125 kHz or 134.2 kHz
  - Short read range (1 cm to 3 - 4 inches)
  - Works well around water
  - Can be used near metal
  - Used for access control, animal tracking, asset tracking
  - ISO 14223, and ISO/IEC 18000-2

# RFID: Frequency and Performance

- High-frequency (HF) tags
  - 13.56 MHz
  - Short read range (around 1-3 feet)
  - Works well around water and near metal
  - Well-defined read field
  - Well-established standards
  - Where medium data rate and read ranges are acceptable, mainly access control / financial transactions

# RFID: Frequency and Performance

- High-frequency (HF) tags (continued)
  - ECMA-340 and ISO/IEC 18092 standards for Near Field Communication (NFC)
  - ISO/IEC 14443 A and ISO/IEC 14443 standards for MIFARE technology - smart cards and proximity cards
  - JIS X 6319-4 for FeliCa - electronic money cards

# RFID: Frequency and Performance

- Ultrahigh-frequency (UHF) tags
  - 860 MHz to 960 MHz (902-928 in USA)
  - Longer read range (up to 20 feet) and faster data transmission
  - Signal bounces off metal and is absorbed by water

# RFID: Frequency and Performance

- Ultrahigh-frequency (UHF) tags
  - Read field dependent on environmental factors and antenna configuration
- Global standard (ISO 18000-6)
- Recommend looking at RFID RAIN Alliance
  - EPC Gen2v2 UHF or ISO/IEC 18000-63

# In Conclusion

- LF, HF and UHF perform differently due to the physics of different radio waves / material properties
- Important to choose the RFID system that works best for their application(s)
- Seek help in selecting a system to ensure goals are achieved

# Questions ?

Thank you

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