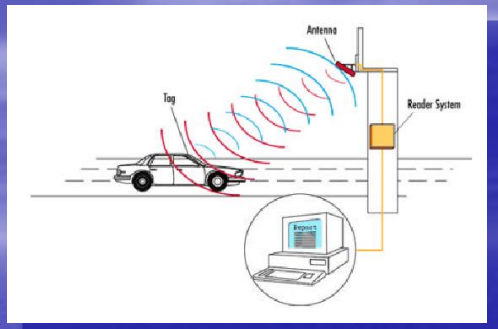
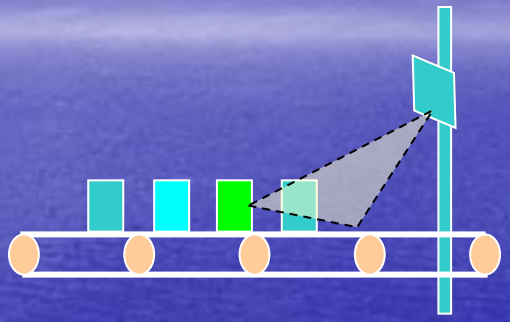
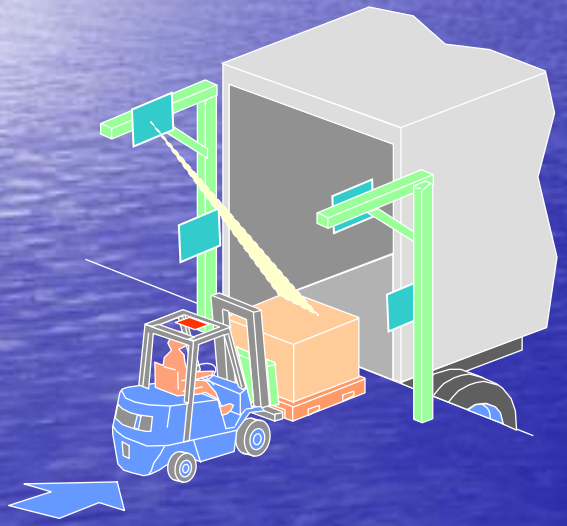
RFID Overview

Radio Frequency IDentification

- Tag wirelessly sends bits of data when it is triggered by a reader
- Power source not required for passive tags… a defining benefit
- Superior capabilities to barcode:
  - Non Line of Sight
  - Hi-speed, multiple reads
  - Can read *and* write to tags
  - Unit specific ID







Focus of this presentation is on UHF

Four main frequencies:

	Frequency	Distance	Example Application
LF	125khz	Few cm	Auto-Immobilizer
HF	13.56Mhz	1m	Building Access
UHF	900Mhz	~7m	Supply Chain
µwave	2.4Ghz	10m	Traffic Toll

Presentation Objectives:

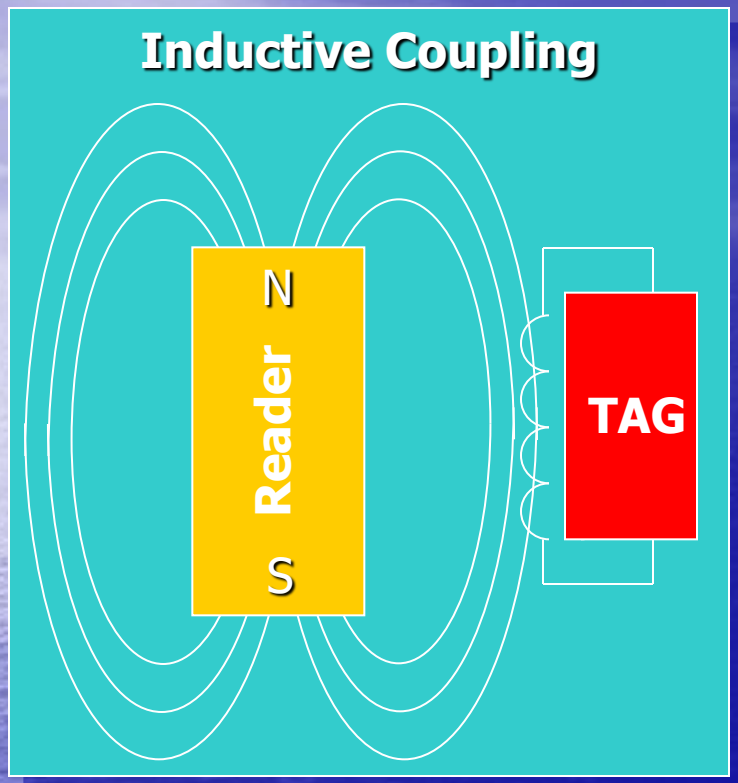
- Explain technical principles behind RFID
- Provide overview of RFID technology
- Discuss:
  - Forces driving the adoption of RFID
  - Challenges RFID deployment must overcome
  - The future

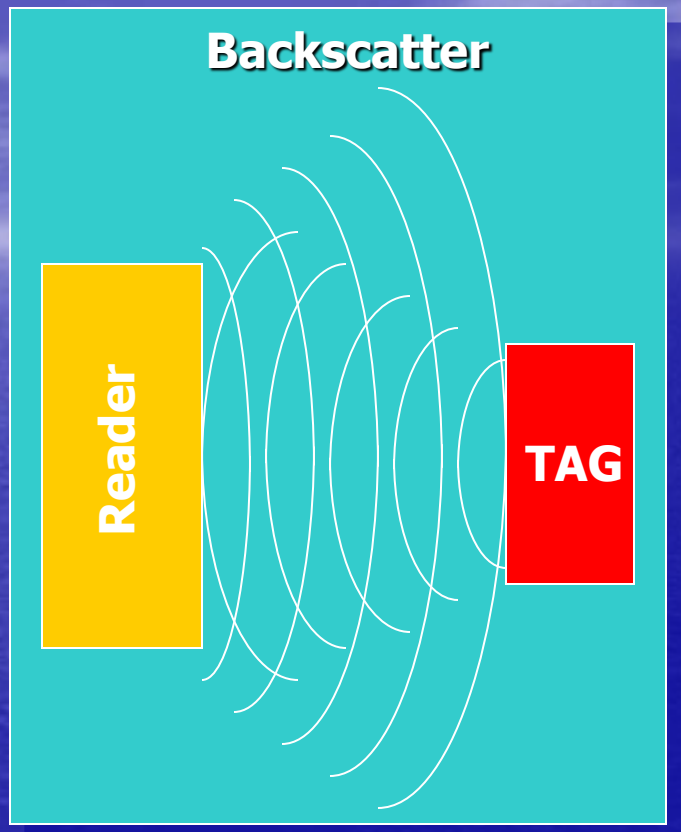
RFID History

- First Bar code patents – 1930s
- First use of RFID device – 2nd world war – Brittan used RFID-like technology for Identify- Friend or Foe
- Harry Stockman October 1948 Paper – Communication by means of reflected power (The proceedings of the Institute of Radio Engineers)
- First RFID Patent - 1973
- Auto-ID center founded at MIT – 1999
  - Standardization effort taken over by EPC Global (Electronic Product Code)
- Current thrust primarily driven by Wal-Mart and DoD
  - Automate Distribution:
    - Reduce cost (man power, shipping mistakes)
    - Increase sales (keep shelves full)
    - DoD Total Asset Visibility Initiative

Source of data: EDN – October 2004 - "Reading Between the Lines" Brian Dipert

Basic Tag Operational Principles





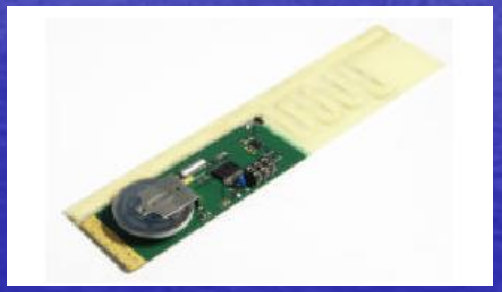
- Near field (LF, HF): inductive coupling of tag to magnetic field circulating around antenna (like a transformer)
  - Varying magnetic flux induces current in tag. Modulate tag load to communicate with reader
  - field energy decreases proportionally to $1/R^3$ (to first order)
- Far field (UHF, microwave): backscatter.
  - Modulate back scatter by changing antenna impedance
  - Field energy decreases proportionally to 1/R
- Boundry between near and far field: R = wavelength/2 pi so, once have reached far field, lower frequencies will have lost significantly more energy than high frequencies
- Absorption by non-conductive materials significant problem for microwave frequencies

Source of data: "Introduction to RFID" CAENRFID an IIT Corporation

Types of Tags

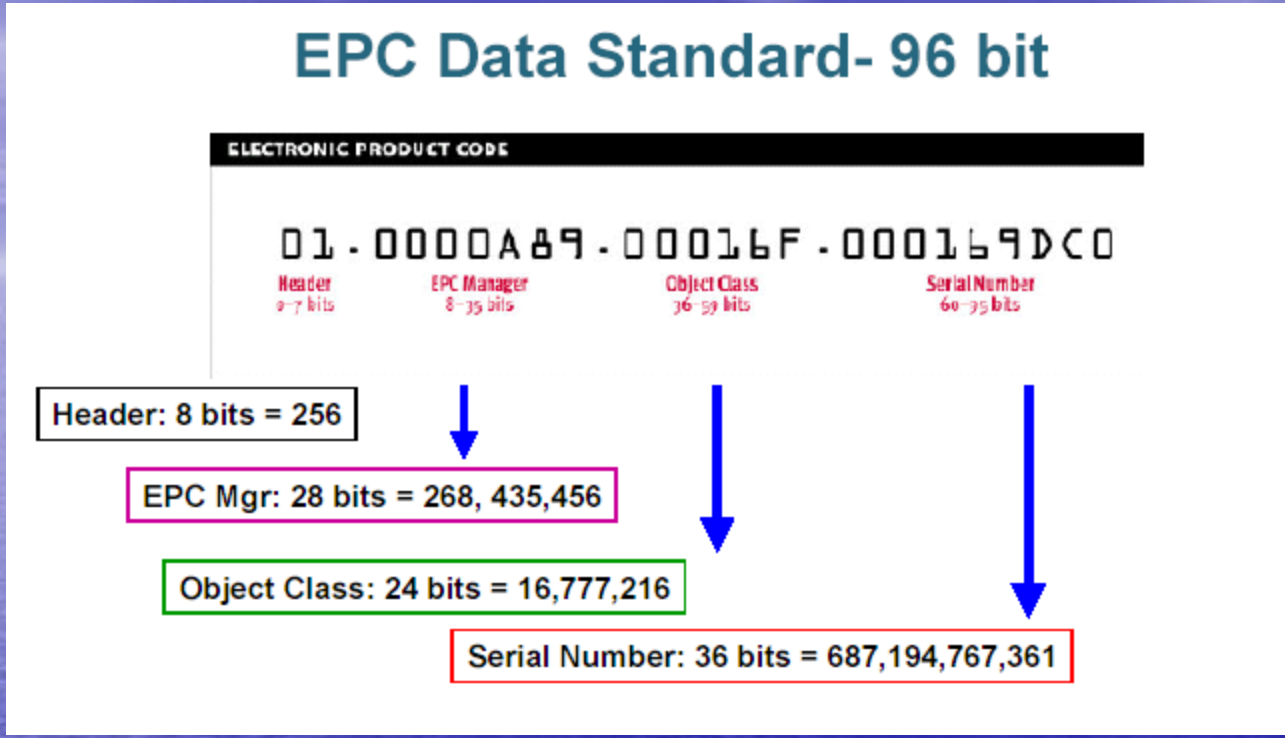
- **Passive**
  - Operational power scavenged from reader radiated power

- **Semi-passive**
  - Operational power provided by battery



- **Active**
  - Operational power provided by battery - transmitter built into tag

Electronic Product Code



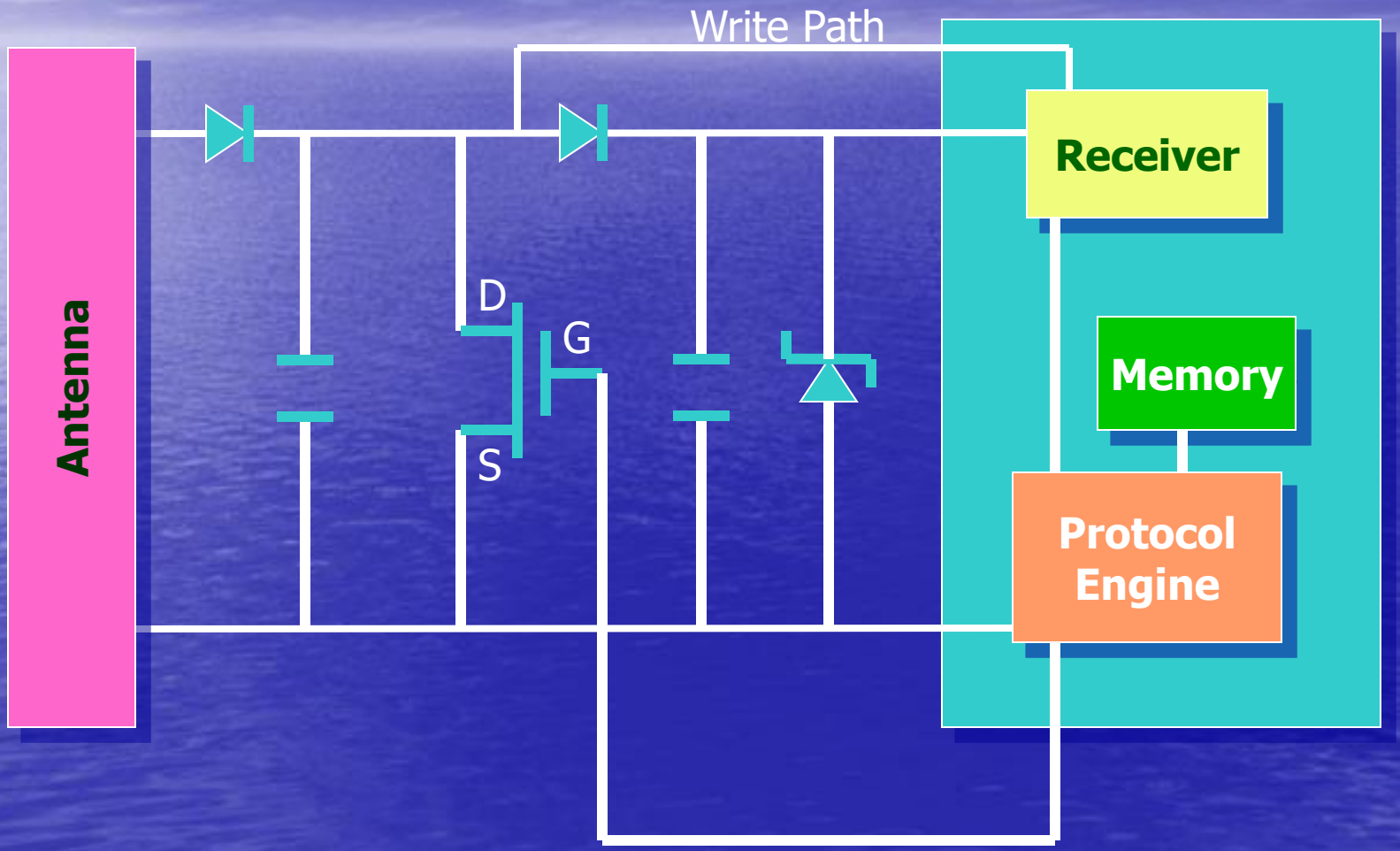
Header - Tag version number
EPC Manager - Manufacturer ID
Object class - Manufacturer's product ID
Serial Number - Unit ID

With 96 bit code, 268 million companies can each categorize 16 million different products where each product category contains up to 687 billion individual units

Note: 64 bit versions also defined, 256 bit version under definition

Generic Tag Architecture

(Highly Simplified)

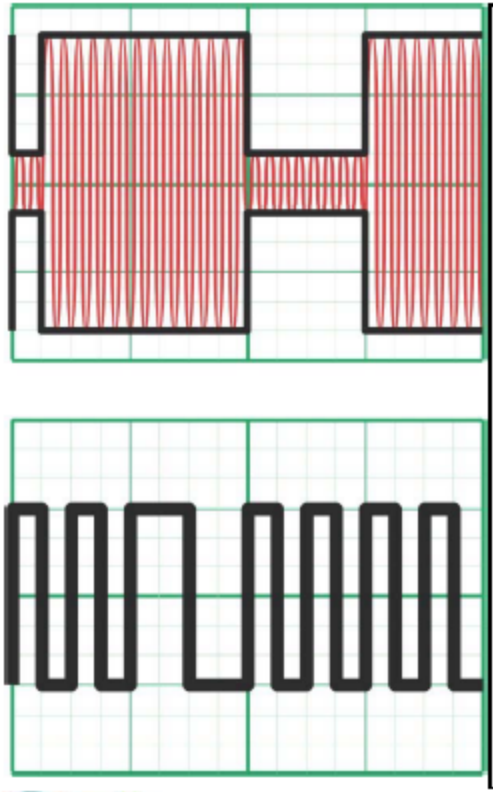


Tag Details

	LF	HF	UHF	Microwave
Freq. Range	125 - 134KHz	13.56 MHz	866 - 915MHz	2.45 - 5.8 GHz
Read Range	10 cm	1M	2-7 M	1M
Market share	74%	17%	6%	3%
Coupling	Magnetic	Magnetic	Electro magnetic	Electro magnetic
Existing standards	11784/85, 14223	18000-3.1, 15693,14443 A, B, and C	EPC C0, C1, C1G2, 18000-6	18000-4
Application	Smart Card, Ticketing, animal tagging, Access, Laundry	Small item management, supply chain, Anti-theft, library, transportation	Transportation vehicle ID, Access/Security, large item management, supply chain	Transportation vehicle ID (road toll), Access/Security, large item management, supply chain

Class 0 Signaling

EPC : Reader-tag Communication



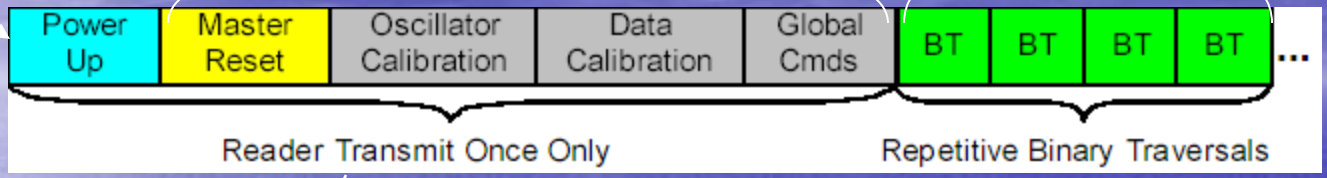
- Reader to tag communication (AM)
  - Output RF power is modulated between full and fractional power
  - 50% duty cycle is binary ‘1’
  - 88% duty cycle is binary ‘0’
    - Picture at left shows ’01’ Tag to reader communication
- Tag responds by FM
  - 2 cycles of modulation in one data bin is a binary ‘1’
  - 1 cycle of modulation is a binary ‘0’
    - Picture at left shows ‘1011’

Default Class 0 Reader Communication Sequence

Tag power up, reset, and calibration process

Tag Singulation Process

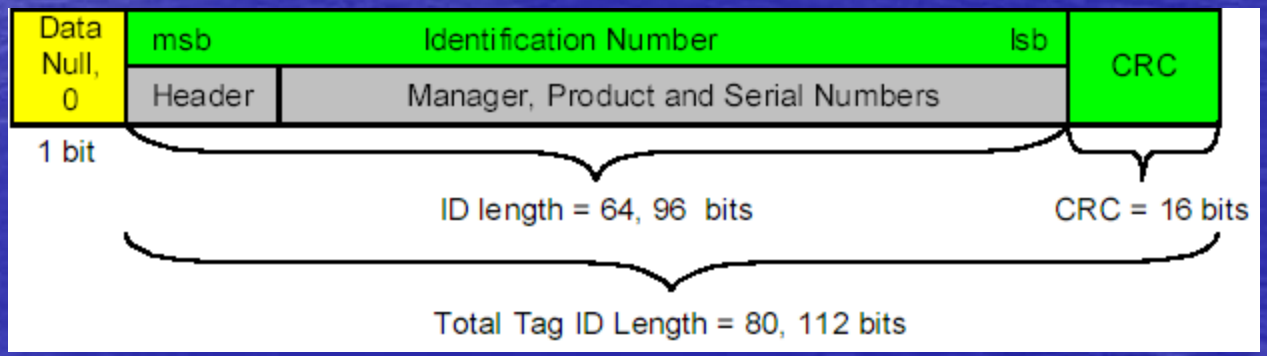
Reader power up



Repeated after each frequency hop

Reset: 800 micro sec uninterrupted continuous wave
Oscillator calibration: 8 116 micro sec pulses
Data calibration: 3 pulses (data "0", data "1", data "null")

Single Binary Transversal



Once tag has been singulated, reader can send commands to it or begin next BT cycle

Tag Singulation Process

read individual tag from group of all tags in range of reader

Basic process:

1. All tags within range of reader backscatter their MSB to the reader.
2. Reader responds with either a 1 or a 0.
3. If tag bit equals reader bit, tag backscatters the next bit in it's code . If instead, tag bit does not equal reader bit, tag goes mute for remainder of singulation.
4. Process continues until reader has completely read a single tag.
5. Reader conducts consecutive singulations until all tags in its range are read.
6. Reader can interrupt the singulation process to send commands to a single tag, a subset of all tags in range, or globally to all tags in range.

UHF Reader Standards

GEO / Country	Frequency Band
North America	900 – 930 MHz
EMEA	866 – 868 MHz
Korea	908.5 – 914 MHz
Australia	918 – 926 MHz
China (PRC)	TBD
Japan	TBD

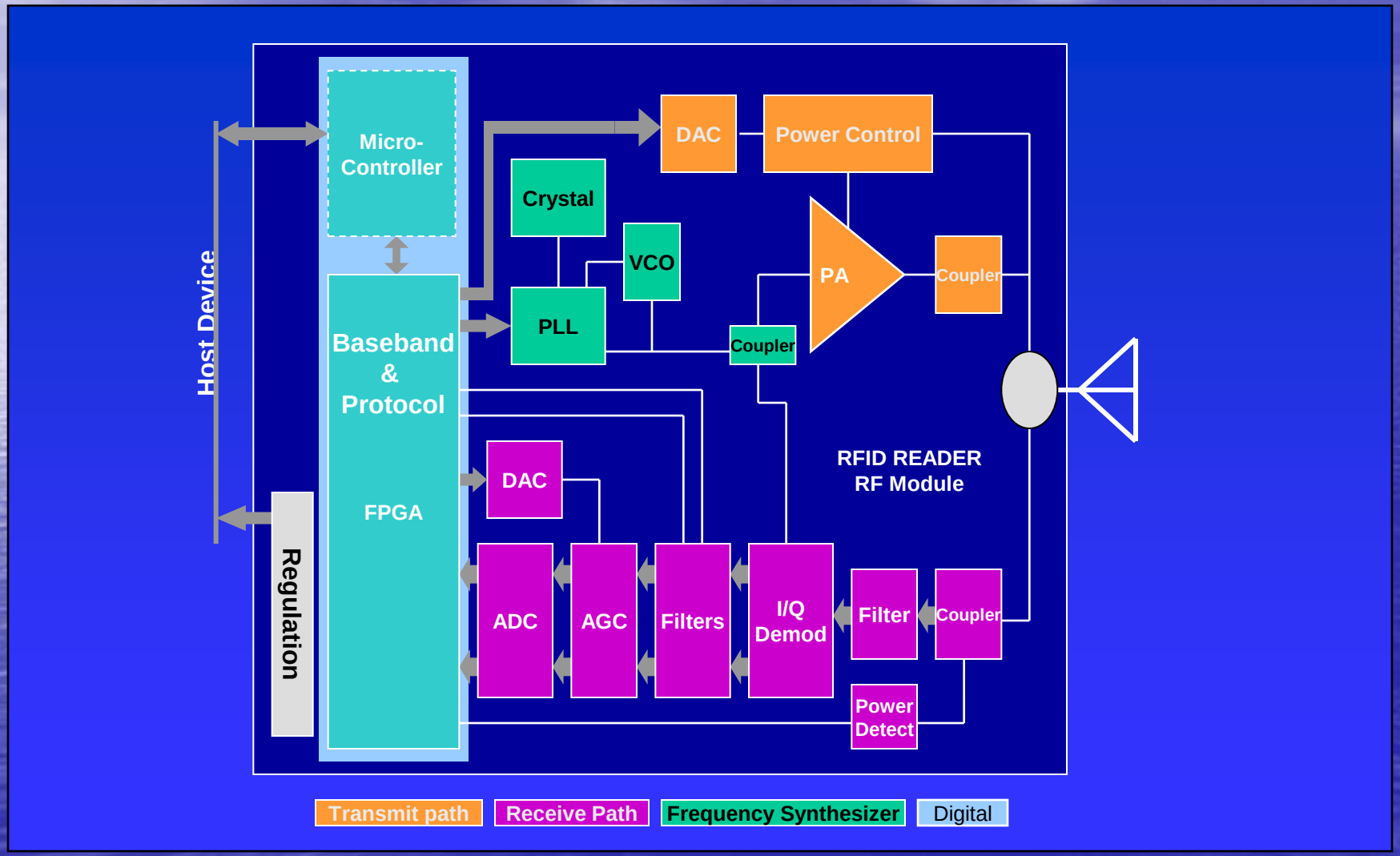
Transmitter	North America
Output Freq. Band	902 – 928 Mhz
Output Power	4 watts EIRP
TX Channel step	500Khz
Hop frequency	2.5 to 20 times per second
TX Channels	902.75, 903.25, …, 927.25Mhz
Modulation	Typically ASK –- 20% to 100% modulation depth

Note: EIRP = 1.64X ERP (Effective Radiated Power)

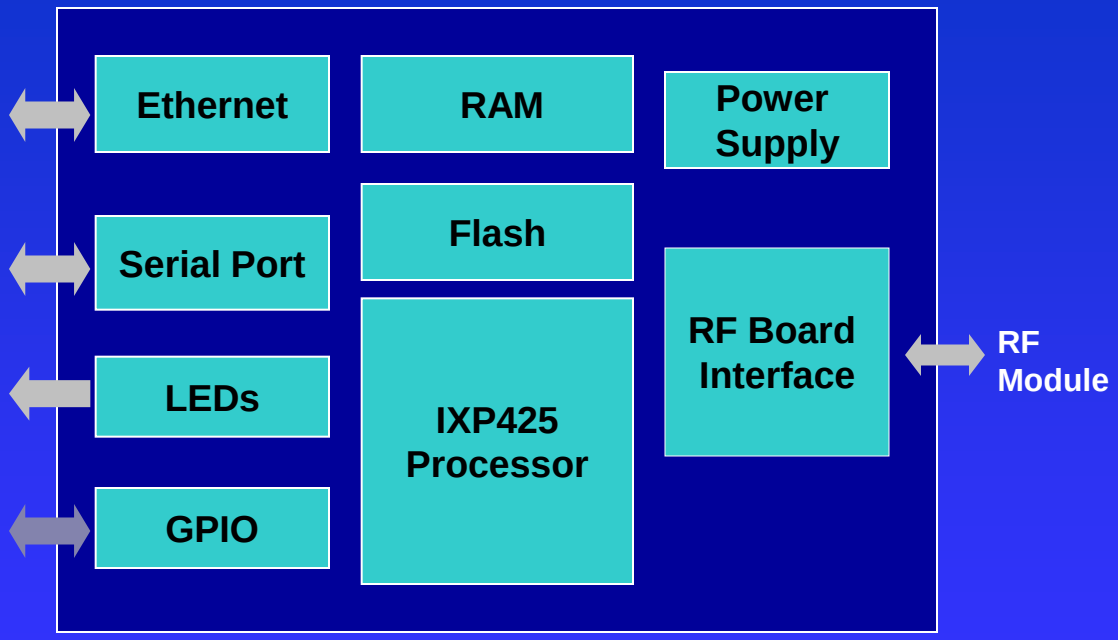
Reader Implementation Challenges

- Reader must deliver enough power from RF field to power the tag
- Reader must discriminate backscatter modulation in presence of carrier at same frequency
- 70db magnitude difference between transmitted and received signals
- Interference between readers
- Hugh volume of tag data – readers need to filter data before releasing to enterprise network

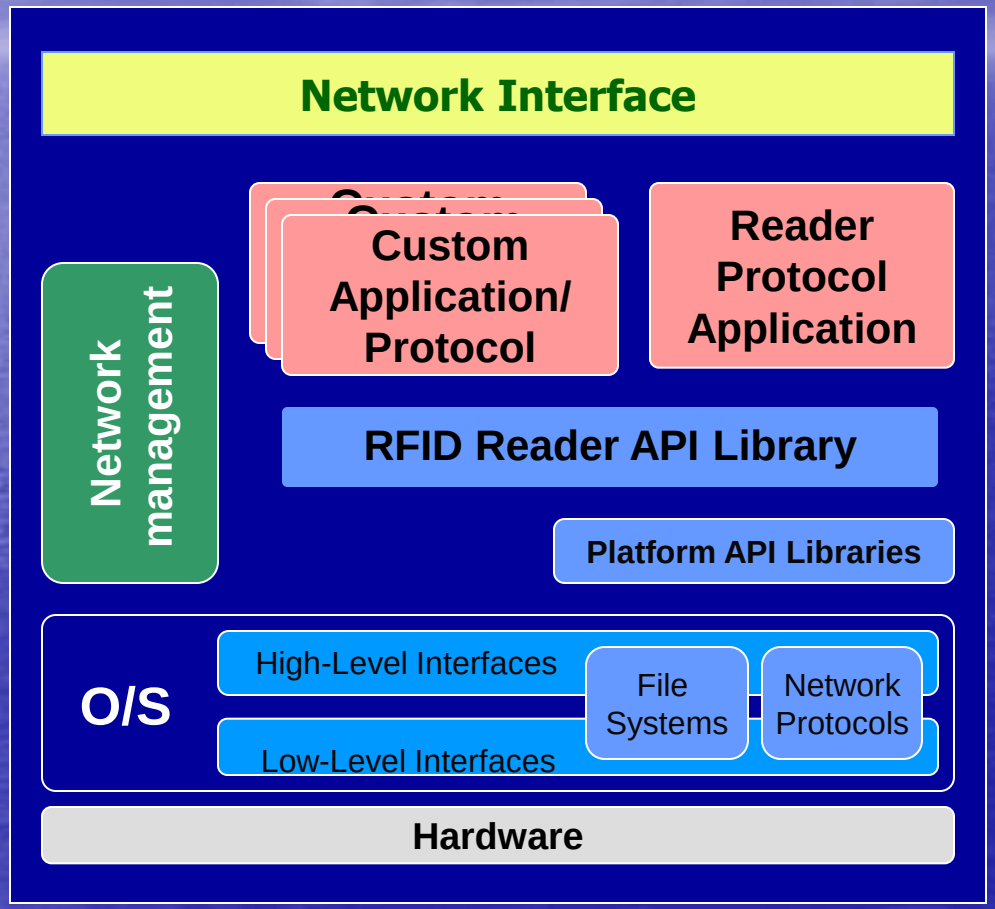
Possible UHF Reader RF Processor



Possible Digital Back End



Possible Reader Software Stack



Traditional RFID Market Segments

Auto Immobilizers

Automated Vehicle Id

- *Isolated systems*
- *Simple reads*
- *Slow growth*

Access Control

Animal Tracking