Radio Frequency Identification (RFID)

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Some pictures from internet

Introduction

- **Automatic identification procedures (Auto-ID) extract identification information about people, animals and a variety of items.**

- **Barcode system, optical character recognition (OCR), smart cards, RFID, voice and fingerprinting identifications.**

- **Most of the above identification procedures work in short distances (the line of sight, less than 50 cm).**

- **Main advantages of RFID: Maximum data capacity and longer working distance (>1m).**
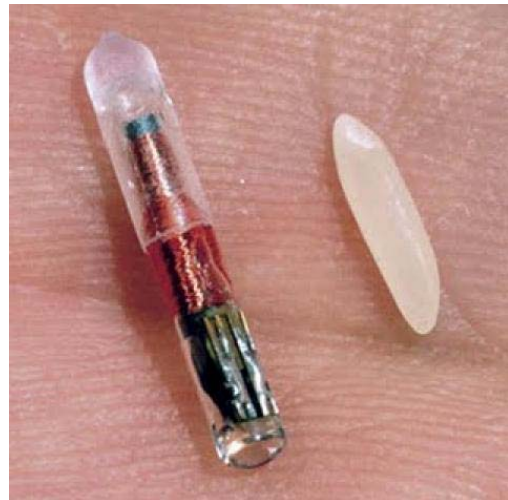
Introduction

- **A simple history of RFID**
  - ⟨ **The predecessor of RFID was invented as an espionage tool by Leon Theremin in 1945.**
  - ⟨ **An early paper by Harry Stockman "Communication by Means of Reflected Power" [Proceedings of the IRE, pp. 1196-1204, Oct. 1948].**
  - ⟨ **With the development of IC design in the 1970s, the development of RFID is accelerated.**
  - ⟨ **The first patent to be associated with the abbreviation RFID was granted to Charles Walton in 1983**
  - ⟨ **In 2014, the world RFID market is worth US$8.89 billion. The market value is expected to rise to US$18.68 billion by 2026**

Basic Principle of RFID

- **Types of RFID**
  - ⟨ **Power supply: Passive or active**
  - ⟨ **Main Frequency:**
    - − **Low frequency (135 kHz)**
    - − **High frequency (13.56 MHz)**
    - − **UHF (433 MHz for defense)**
    - − **UHF (860MHz ~ 915 MHz)**
    - − **Microwave (2450 MHz, 5800 Mhz)**
  - ⟨ **Operating range: near-field capacitive or inductive coupling ($0.62\sqrt{D^3/\lambda} > r > 0$), far field ($r > 2D^2/\lambda$)**
 - ⟨ **Near field communication (NFC)**

Basic Principle of RFID

- Standards
  - ⟨ **Class 0 (Read only, 64 bits)**
  - ⟨ **Class 1 (Write once, read many - WORM, 96 bits minimum)**
  - ⟨ **Class 2 (Read/Write, 96 bits minimum)**
    - Passive read-write tags that can be written to at any point in the supply chain
  - ⟨ **Class 3 (Read/Write)**
    - Read-write with onboard sensors capable of recording parameters; can be semi-passive or active
  - ⟨ **Class 4 (Read/Write)**
    - Read-write active tags with integrated transmitters; can communicate with other tags and readers
  - ⟨ **Class 5 (Read/Write)**
   - Additional functionality
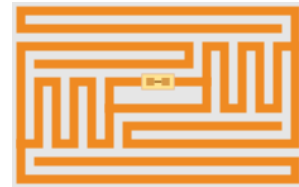
How RFID Works

- **A scanning antenna**
  - It provides a means of communicating with the transponder (the RFID tag) AND
  - It provides the RFID tag with the energy to communicate
- **A transceiver with a decoder to interpret the data**
- **A transponder - the RFID tag that has been programmed with information**
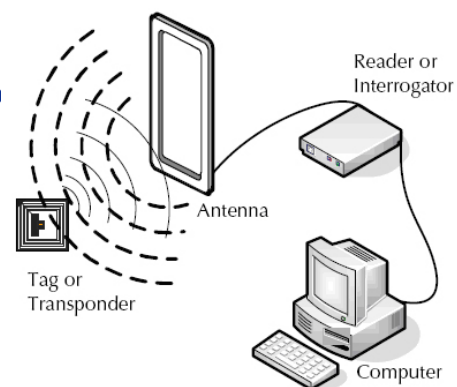
Passive RFID

- **A passive RFID tag will use the interrogator's radio wave energy to relay its stored information back to the interrogator**
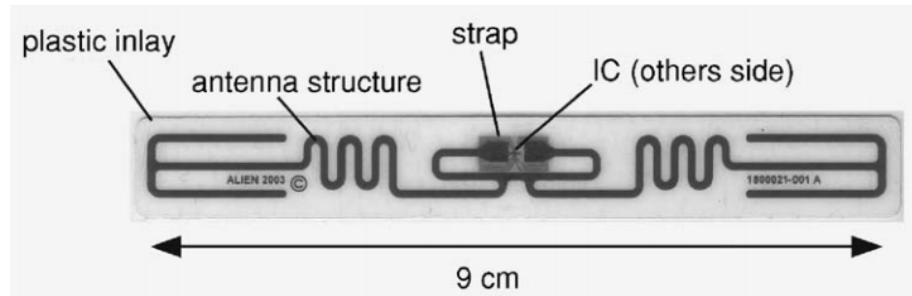
Typical Commercial Passive UHF Tag (Alien Technology Model 9238 'Squiggle')

Modulation

- **ASK (OOK)**
  - ⟨ **The magnitude of the reflection coefficient is modulated.**
  - ⟨ **Easy to be implemented but lost RF input at impedance mismatched state.**
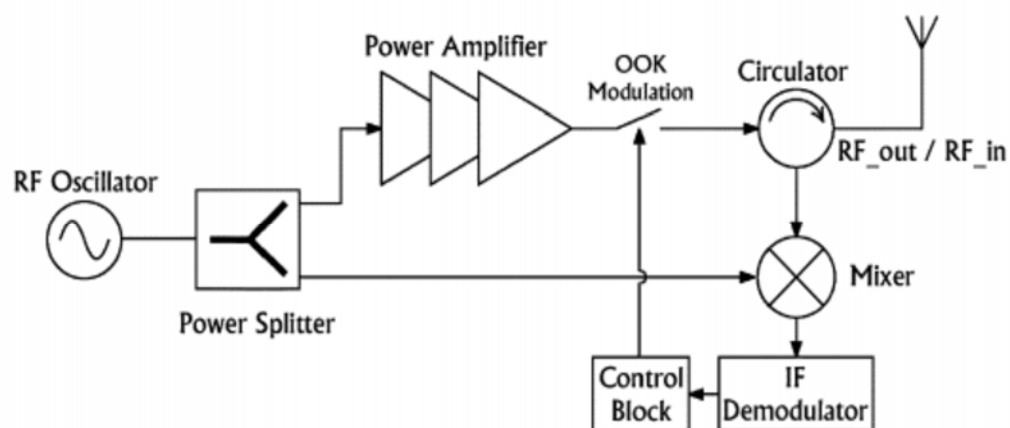
- **PSK**
  - ⟨ **The phase of the reflection coefficient is modulated by varying the value of capacitance.**
  - ⟨ **Better bit error rate (BER), better for power supply but more complicated structure.**
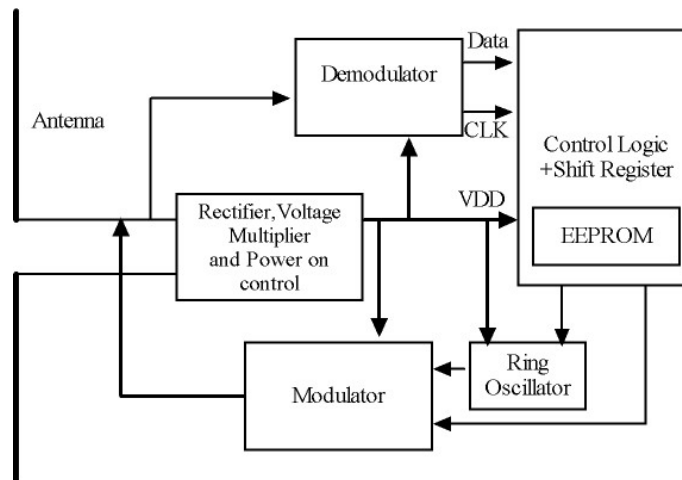
# Basic Principle of RFID
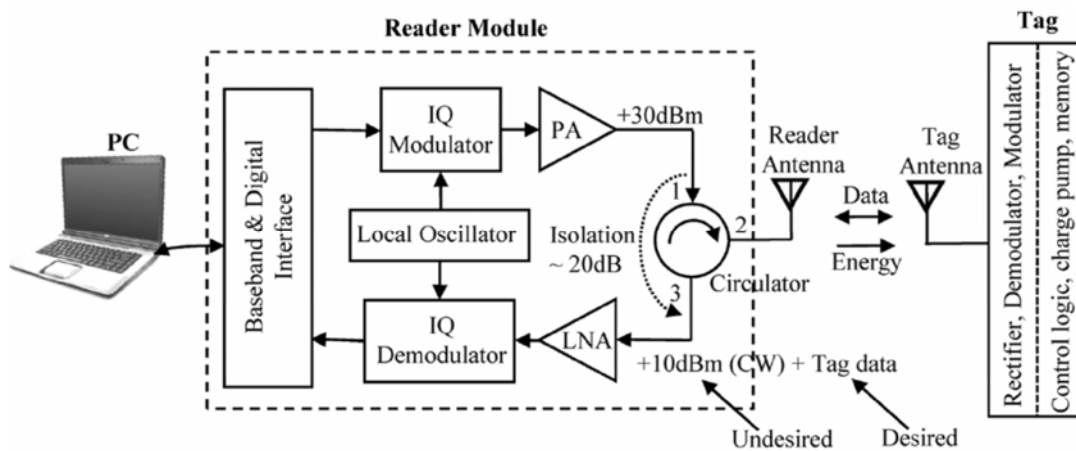
A RFID reader

J.P. Curty, N. Joehl, C. Dehollain, and M.J. Declercq, "Remotely powered addressable UHF RFID integrated system", *IEEE J. Solid-State Circuits*, Vol. 40, No.11, pp. 2193-2202, Nov, 2005.

A Transponder IC

U. Karthaus and M. Fischer, "Fully integrated passive UHF RFID transponder IC with 16.7-uW minimum RF input power", *IEEE J. Solid-State Circuits*, Vol.38, No.10, pp. 1602-1608, Oct 2003.
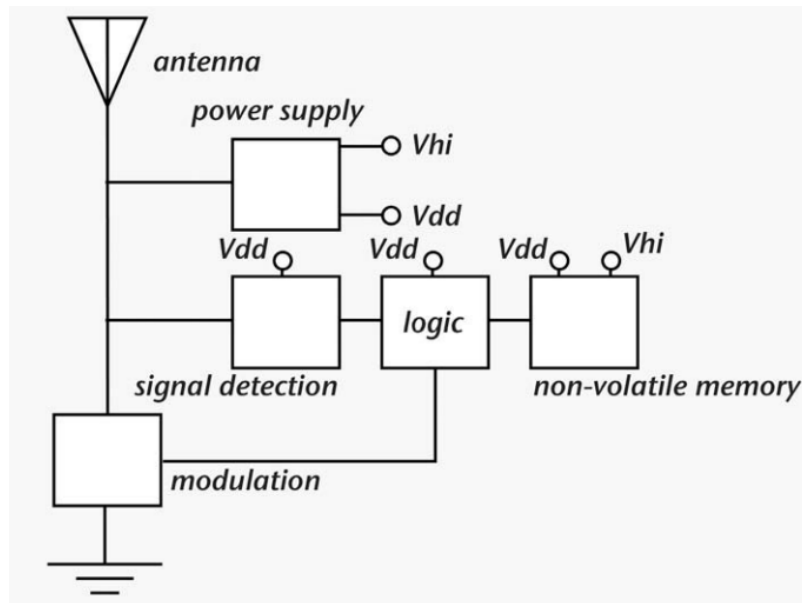
A Transponder IC
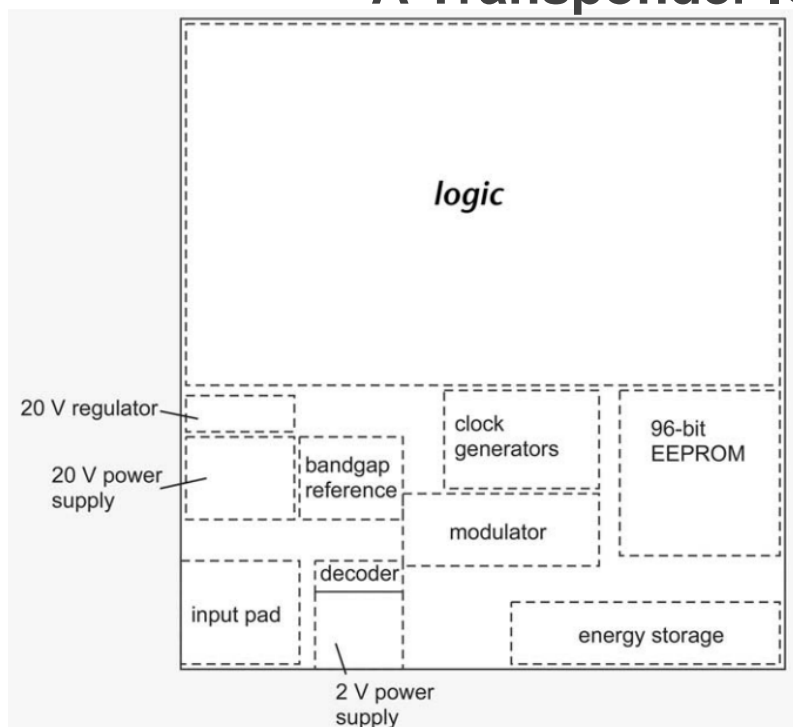
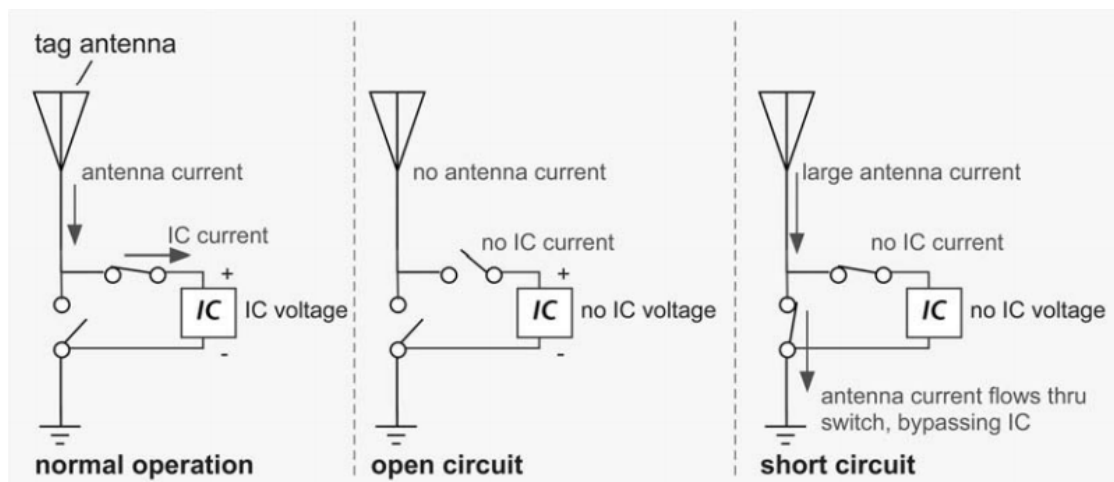

Functional Layout of a Tag IC (After Stewart)

D. M. Dobkin, *The RF in RFID Passive UHF RFID in Practice*, Elsevier, 2008

Elements of a Passive UHF Tag

D. M. Dobkin, *The RF in RFID Passive UHF RFID in Practice*, Elsevier, 2008
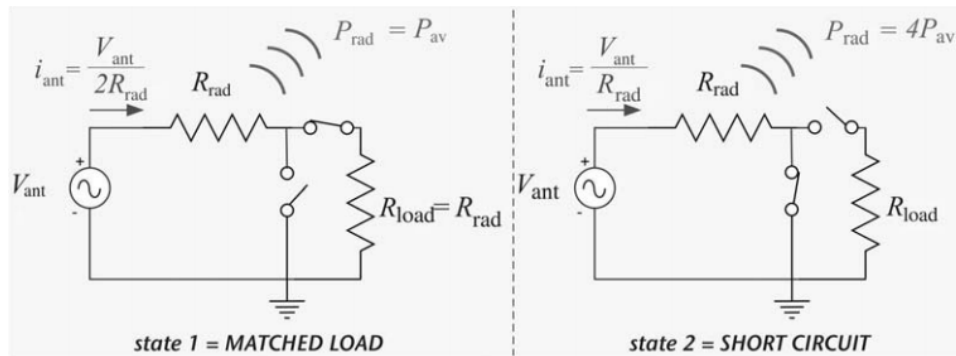

A Passive UHF Tag

Elements of Simple Backscatter Modulation Schemes. Single-ended Antenna Connections are Shown for Simplicity

D. M. Dobkin, *The RF in RFID Passive UHF RFID in Practice*, Elsevier, 2008
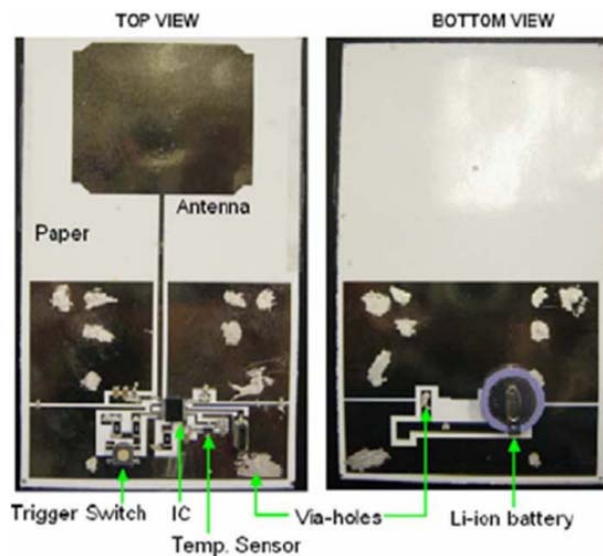
Modulation Approaches

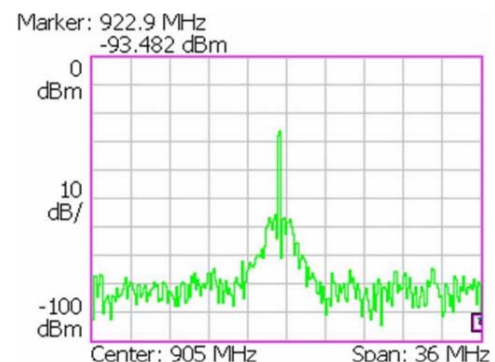| Approach	Backscattered Power	IC Power
Match <=> Open	$P_{av}/2$	$P_{av}/2$
Match <=> Short	$P_{av}/2$	$P_{av}/2$
Resistive ASK	$0.22\ P_{av}$	$0.55\ P_{av}$
Reactive PSK	$0.32\ P_{av}$	$0.8\ P_{av}$

Modulating the Backscattered Signal by Switching Between a Matched Load and a Short Circuit

D. M. Dobkin, *The RF in RFID Passive UHF RFID in Practice*, Elsevier, 2008

Passive RFID-Enabled Sensor

RTSA measured ASK modulated signal strength for the monopole based module

Monopole based wireless sensor module.

Yang, Rida, and Tentzeris, "Design and Development of Radio Frequency Identification (RFID) and RFID-Enabled Sensors on Flexible Low Cost Substrates," in *Synthesis Lectures on RF/Microwaves*, 2009

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