1. **RFID Review**

![Diagram of RFID system]

**RF Tag**
- passive
- or active

**RFID Reader**

**Data Processing Subsystem**

- **Carrier Frequency**: typically $125 \text{kHz} \leq f \leq 2.45 \text{GHz}$

- **Tag Reader Protocol**
  - Reader sends out carrier signal and waits for a return.
  - Tag receives carrier signal and powers up (if passive) or turns on (if active).
  - Once the Tag is "on", it clocks out its data by shorting all or a portion of the antenna circuit:
    1. Changing the load if low freq.
    2. Changing the effective RCS if high freq.

2. **Typical Tag Design**

![Diagram of RFID tag]

- Tag
- IC chip
- Antenna
a. Antennas
   → often printed onto the tag
1. Loop Antennas
   → used for lower frequency tags
     ex: 13.56 MHz or 125 kHz
   → parallel resonant LC loop antenna coupled to the carrier frequency
   → acts similar to a transformer → for magnetically coupling
2. UHF Antennas
   → various designs used
3. Fractal Antennas
   → wide bandwidth
b. IC chip
   serves all other functions (typically)
   → Antenna matching network
   → Voltage regulation
   → Clock circuits
   → Memory
   → Logic / microcontroller functions
   → Interface to battery (active tags)
   → Interface to sensors (if used)
   → Data readout
1. Matching Network
   - High Q at carrier frequency to effectively couple RF energy

2. Voltage Regulation
   - Charge Pump often used to provide DC power

   ![Diagram](attachment:diagram.png)

   D → Schottky diodes with low turn on voltage $V_D \approx 200\text{mV}$ at 7μA

   $V_{DD} = n (V_{RF} - V_0)$

   $n = \text{number of diodes}$

   How it works:
   - $C_1$ charges up to $V_{RF} - V_0$ every $1/2$ cycle
   - $C_2$ eventually charges up to $2(V_{RF} - V_0)$
   - $C_3$ then charges up to $3(V_{RF} - V_0)$
   - $C_n$ charges up to $n(V_{RF} - V_0)$

   → Load needs to be low current.
3. Digital Subcircuits
   → Clocks generated and used to read stored data out of the memory

4. Data Readout
   → Transistor used to change antenna impedance, affecting carrier amplitude at the reader

c. Active Tags
   → include a battery
   → power for added functions / longer interrogation range than with passive tags
   → need small, long lasting battery
   → limits useful life of the tag

0. Semipassive Tag
   → battery power for added tag functions, but not for RF communications