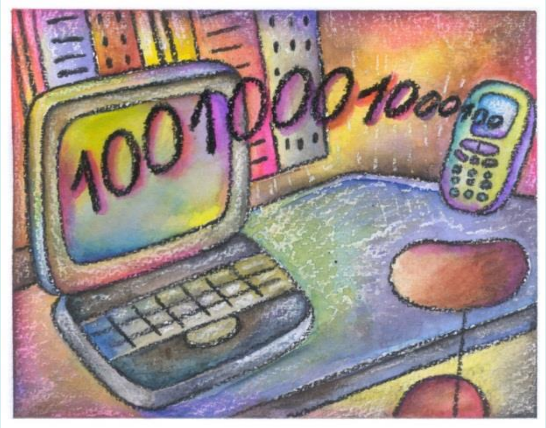
Wireless Technology Applications
RFID Technology
Part I

Melvyn U Myint Oo
T16620
68970688
melvyn_oo@sp.edu.sg



At the end of this lecture, you should be able to:

1. Explain what is an RFID
2. Explain the fundamentals of an RFID system

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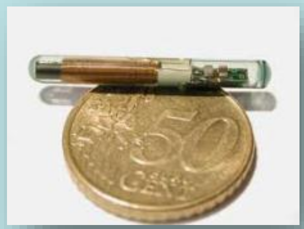
What is RFID technology ?

Radio Frequency Identification

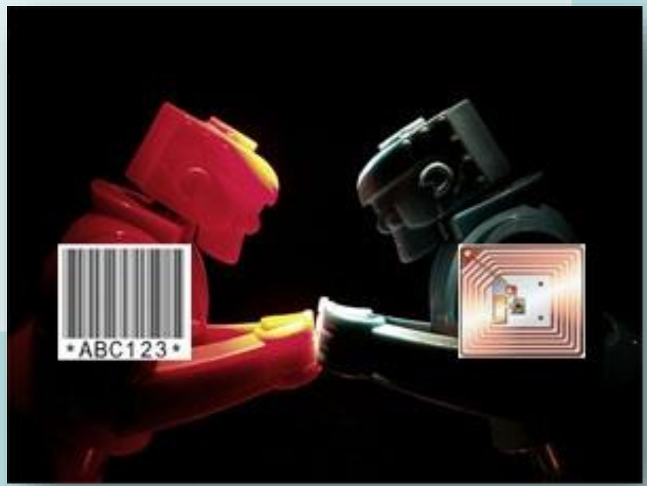
- RFID is a technology that can uniquely identify an object, animal or person using radio waves typically achieved with communication between a scanner or RFID reader and a tag that contains data on a microchip
- Increasingly used in our daily lives



RFID increasingly used

Why?

- No direct contact or line-of-sight scanning required
- Higher data capacity
- Read & write capability
- Data integrity
- Security
- Fast
- Reliable



Fundamentals of an RFID system

Fundamentals of an RFID system

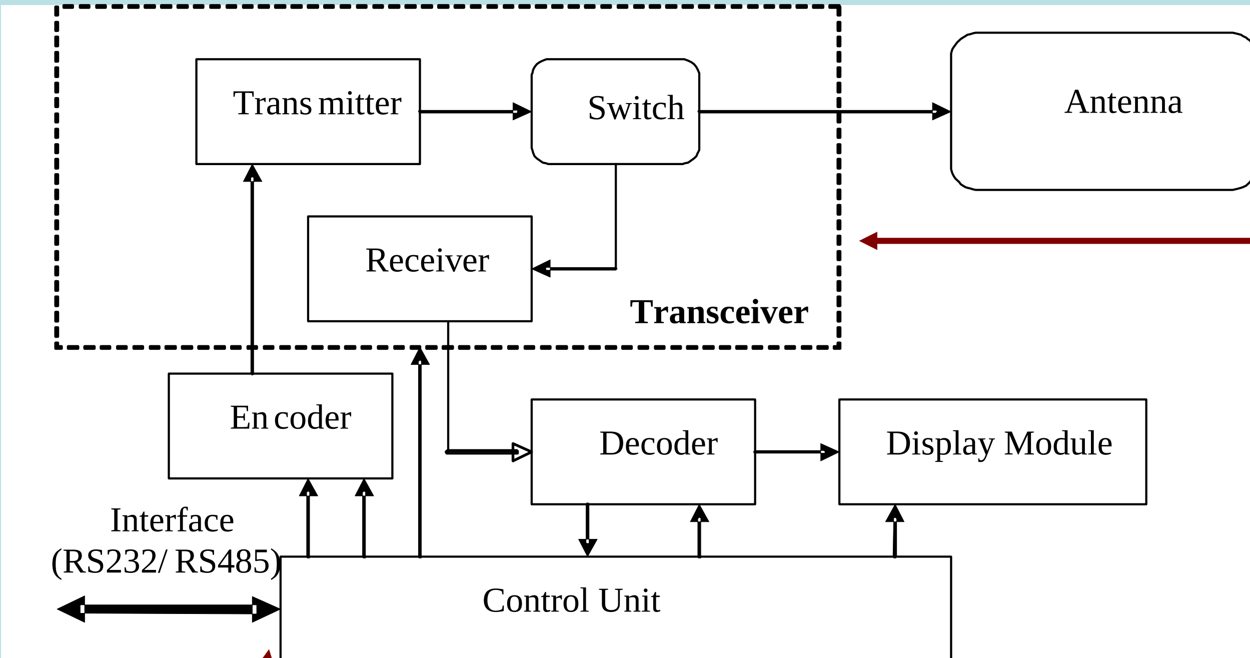
RFID Reader

RFID Tag

Fundamentals of RFID system

- RFID Reader

Antenna



Transceiver

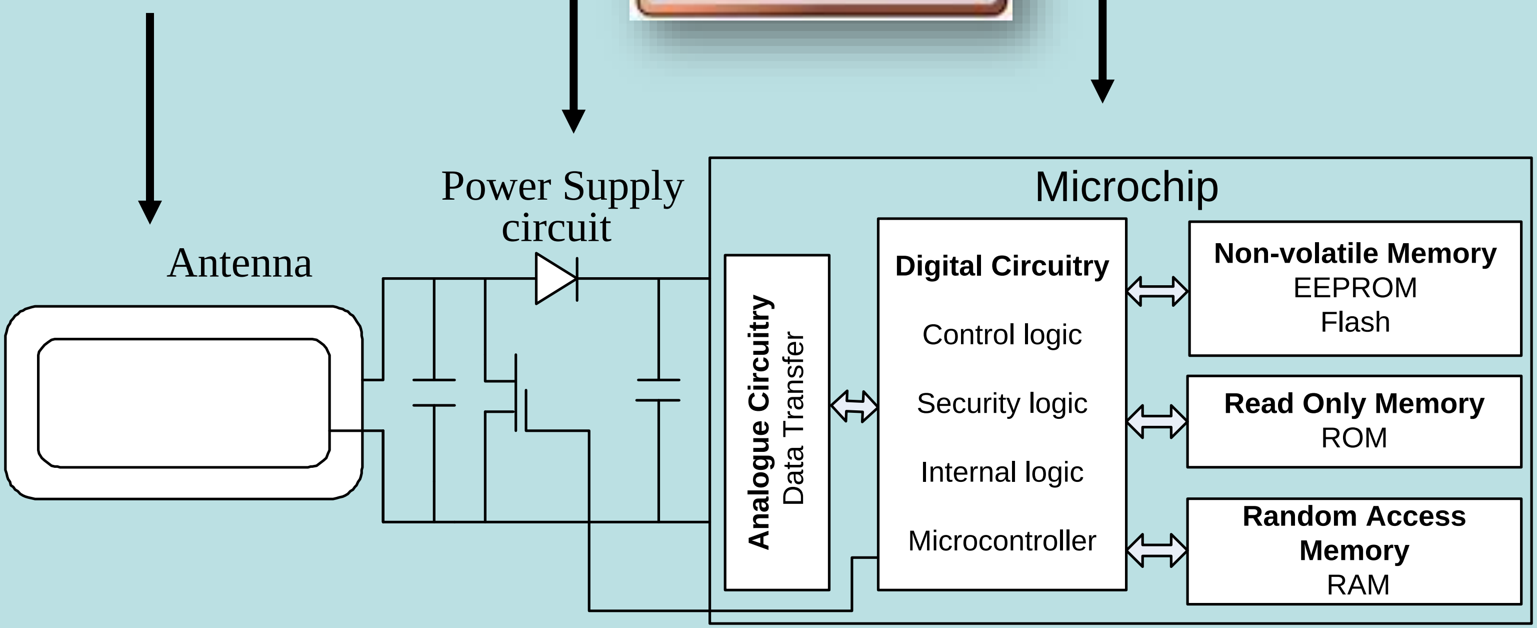
Host Interface

Control Unit

RFID Reader

Fundamentals of RFID system

- RFID Tag



RFID Tag

Fundamentals of an RFID system

Components

- RFID Readers
- RFID Tags

Communication

- Signal coding and modulation in transmitter
- Demodulation and decoding in receiver
- Error detection, error correction and encryption in both transmitter and receiver

Signal Coding

- Process of representing the transmitted message to its voltage representation so that it matches optimally to the characteristics of the transmission channel
- Involves providing the message with some degree of protection against interference or collision and intentional modification

How to represent binary ‘0’ and ‘1’

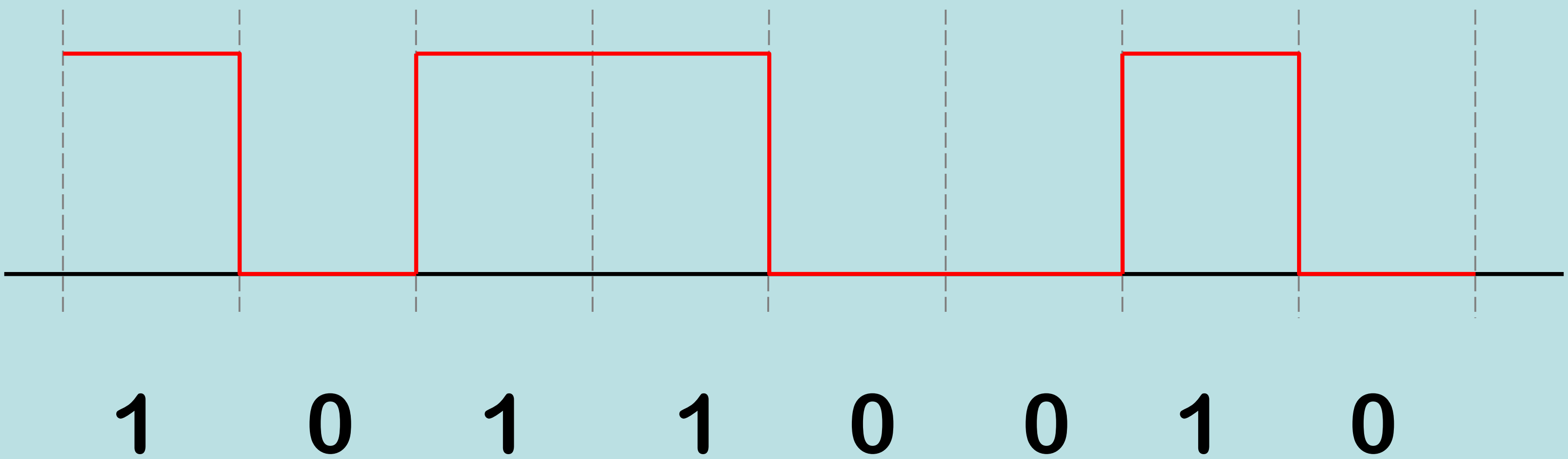
Signal Coding

- NRZ Coding (Non-Return to Zero)

  1 – ‘high’ signal

  0 – ‘low’ signal

  Used almost exclusively with **FSK** or **PSK** modulation



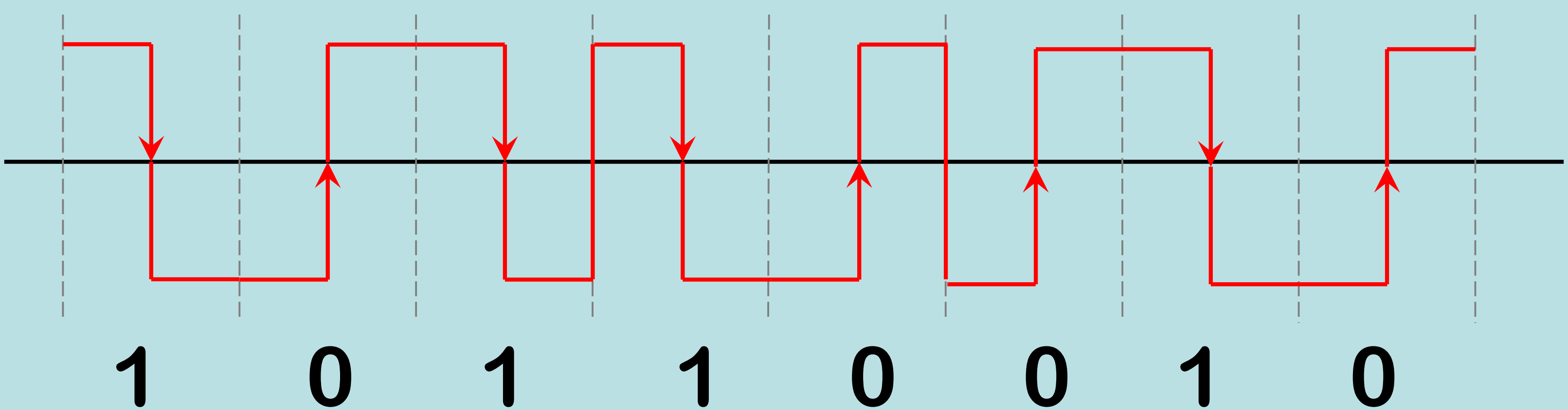
Signal Coding

- Manchester Code

1 – negative transition

0 – positive transition

Often used for data transmission from **transponder to reader** based upon load modulation using a subcarrier



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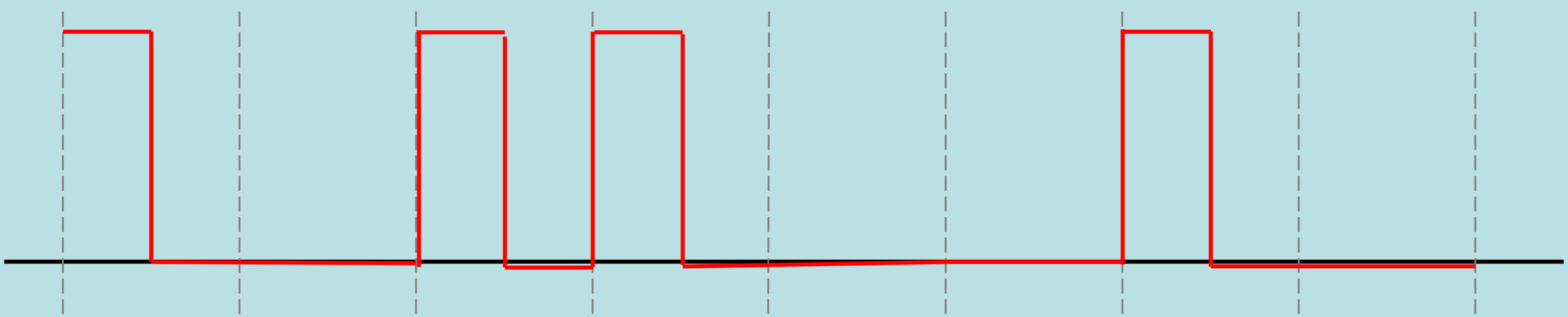
Signal Coding

- Unipolar RZ (Return Zero) Code

1 – ‘high’ to ‘low’ 0 – ‘low’ signal



1 0 1 1 0 0 1 0

Signal Coding

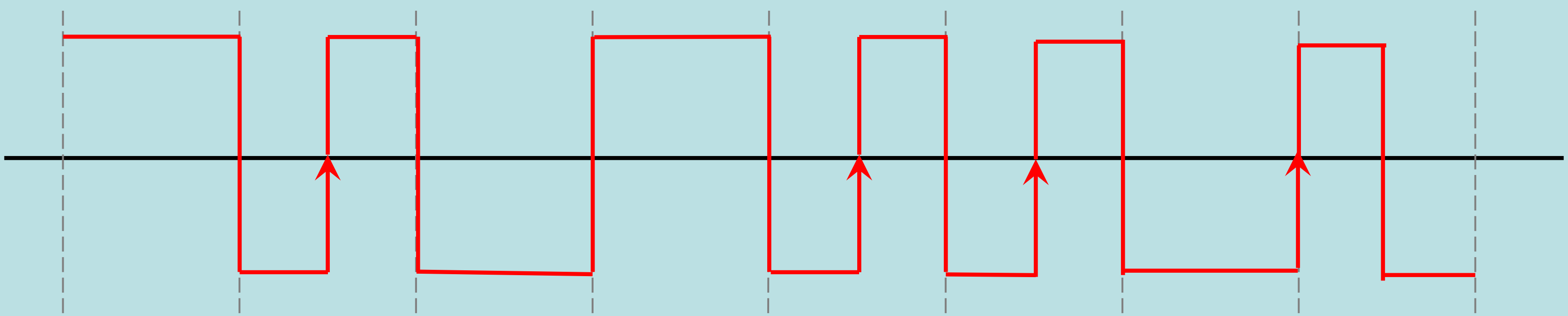
- DBP (Differential Bi-Phase) Code

1 – no transition in half bit

0 – transition in half bit

Level always start inverted

Thefore, bit pulse can be more easily reconstructed in the receiver



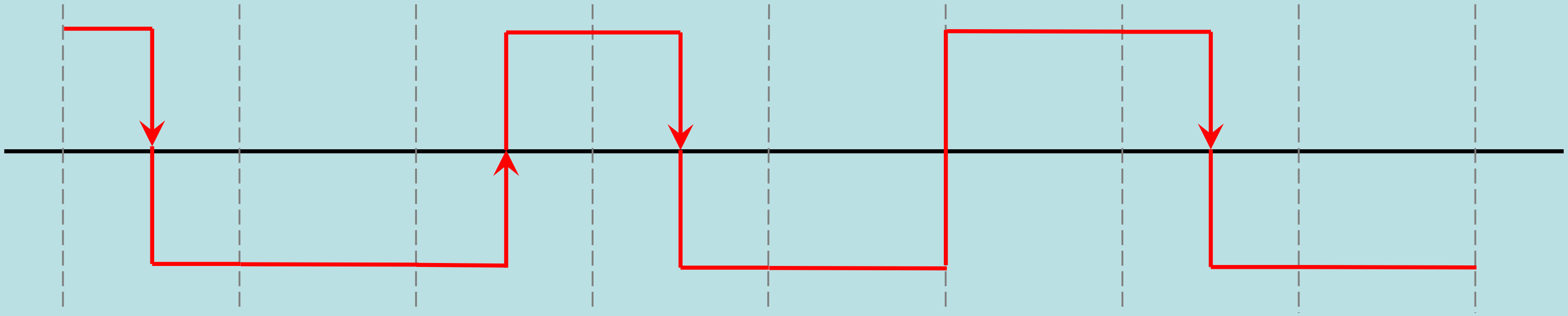
1 0 1 1 0 0 1 0

Signal Coding

- Miller code

1 – continue from previous level, transition in half bit

0 – If ‘1’ in the last bit period, continue level; if ‘0’ in the last bit period, transition. No half bit transition



1 0 1 1 0 0 1 0

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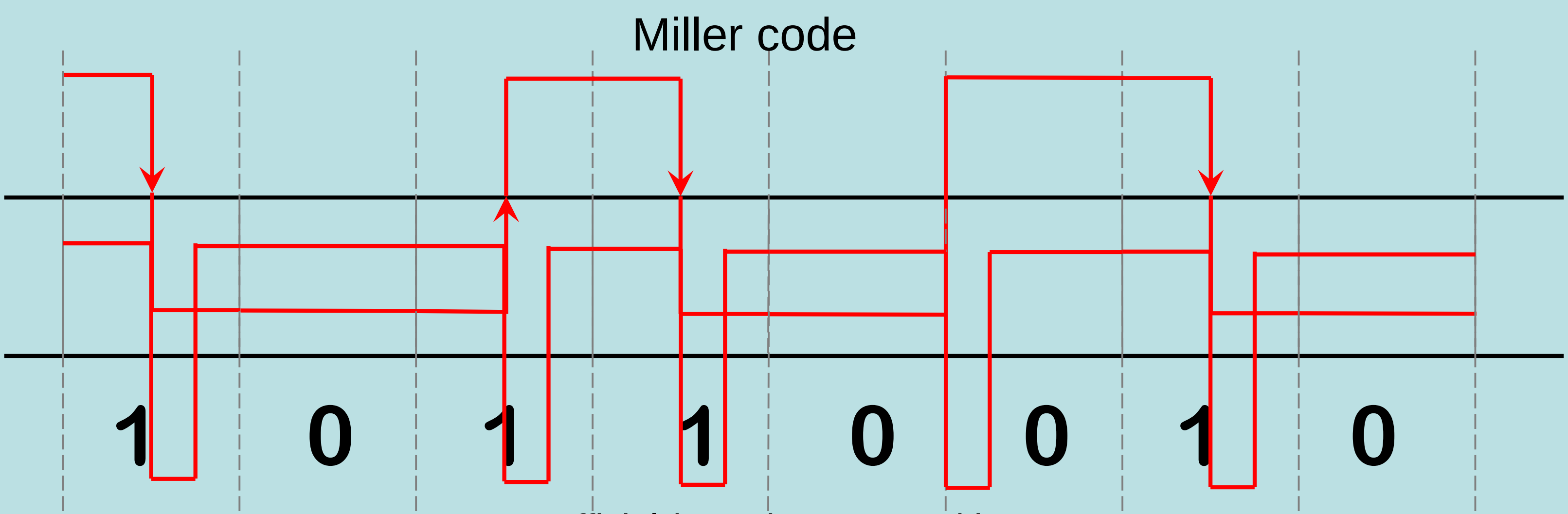
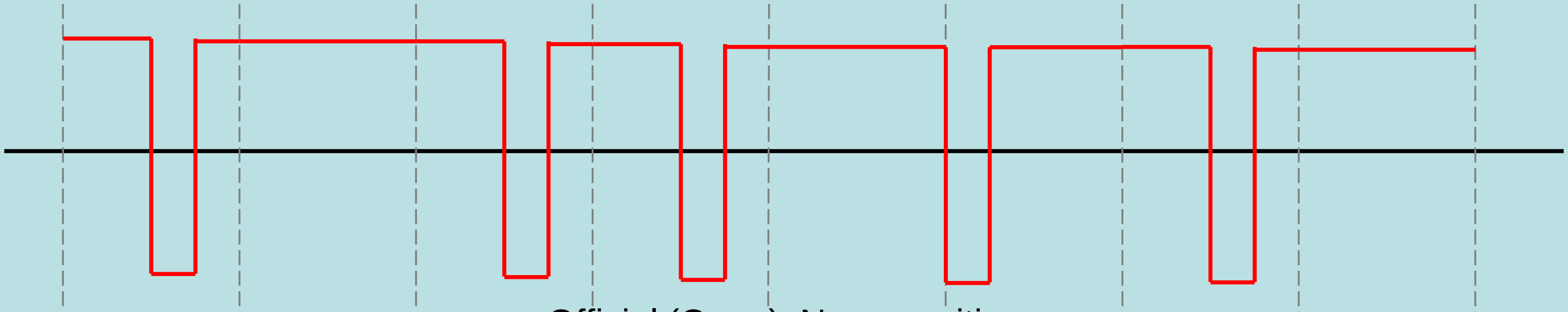
Signal Coding

- Modified Miller code



Signal Coding

- Modified Miller code
  - Each transition is replaced by a ‘negative’ pulse
  - Suitable for inductively coupled RFID systems for data transfer from reader to transponder
  - Very short pulse durations ($t_{pulse} << T_{bit}$) – ensure a constant power supply to the transponder from the HF field of the reader even during data transfer



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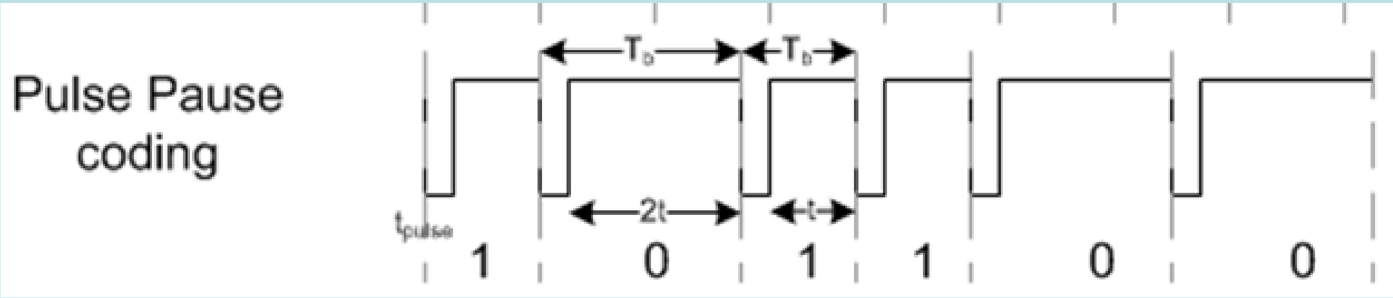
Signal Coding

- Pulse Pause Coding (PPC)

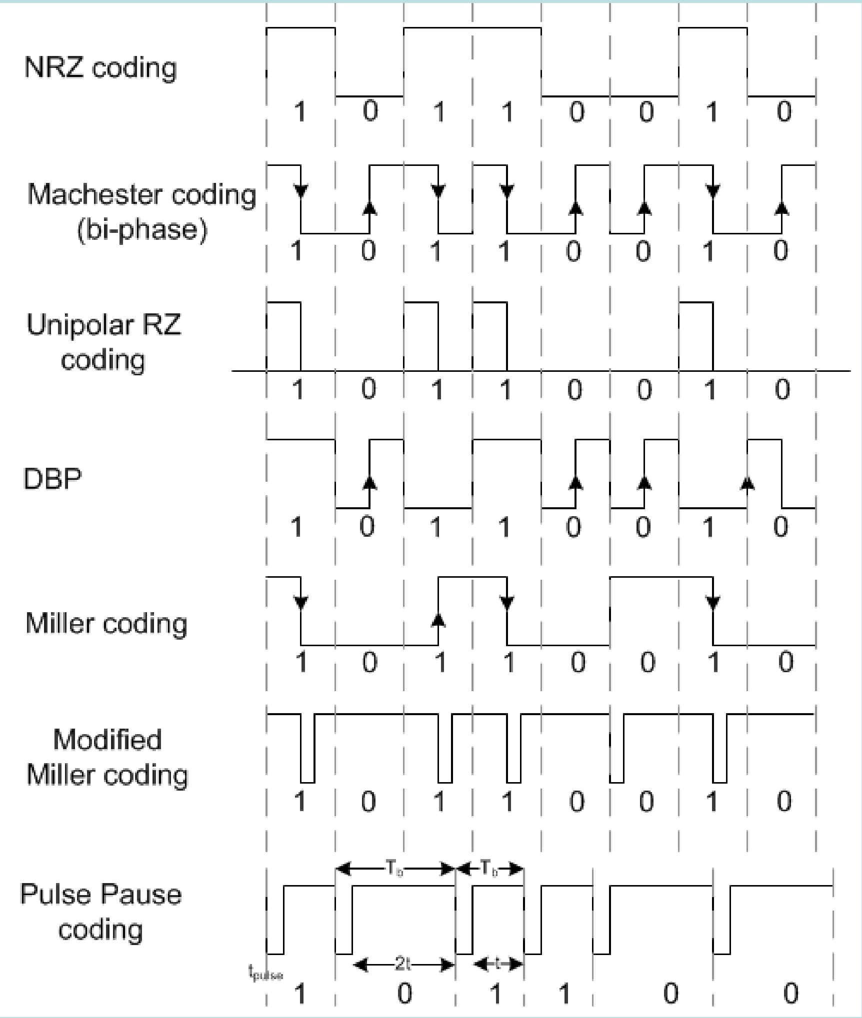
1 – pause of duration *t* before next pulse

0 – pulse of duration *2t* before next pulse

  - Popular in inductively coupled RFID for data transfer from the reader to transponder
  - Very short pulse durations ($t_{pulse} << T_{bit}$) ----- ensure a continuous power supply to the transponder from the RF field of the reader even during data transfer.



Signal Coding

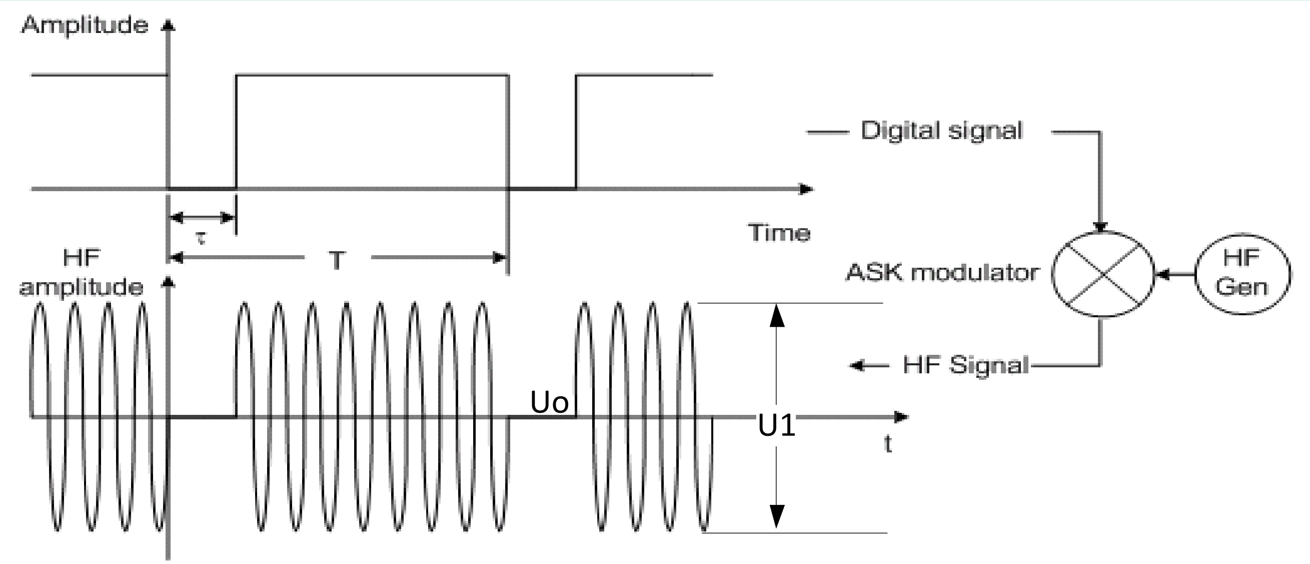


Digital Modulation

3 basic digital modulation

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)

Amplitude Shift Keying (ASK)

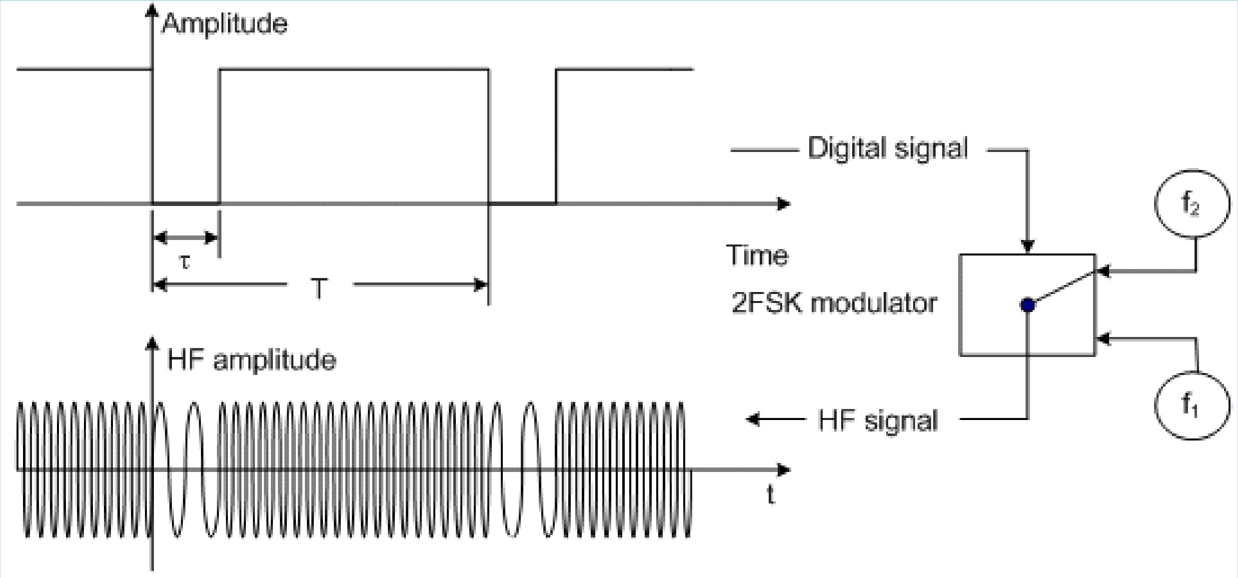


- Amplitude of a carrier oscillation is switched between u_0 and u_1 (keying) by a binary code signal.

Percent Modulation:

$$m = \left(1 - \frac{u_0}{u_1}\right) x100$$

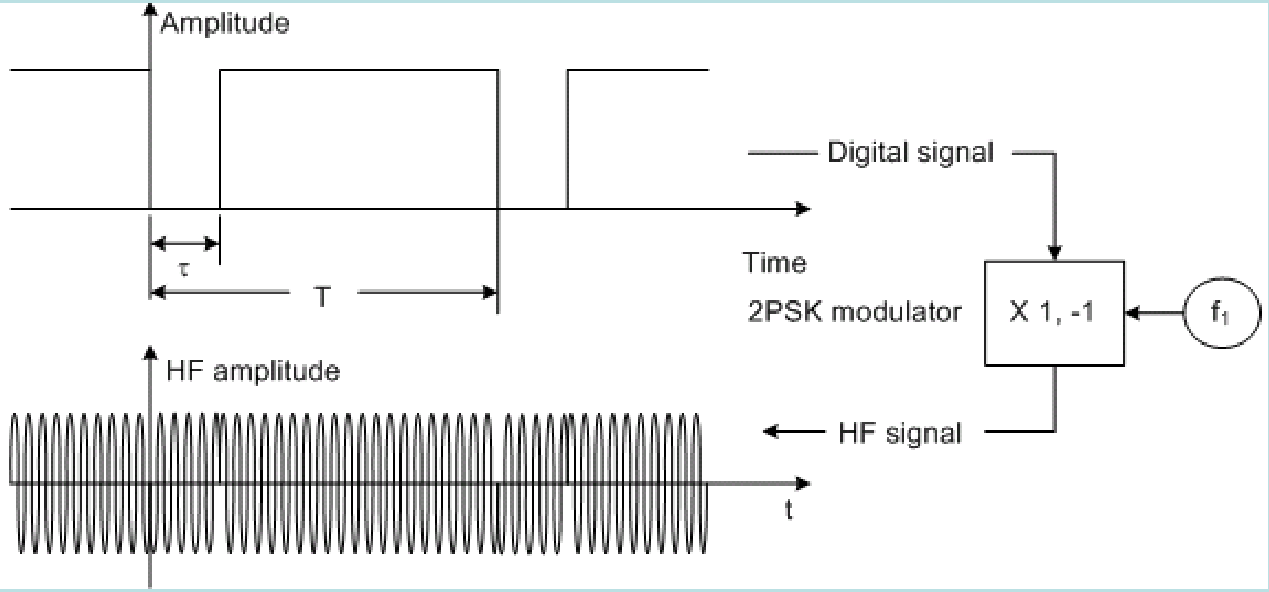
Frequency Shift Keying (FSK)



- Frequency Shift Keying (FSK)

  Frequency of a carrier oscillation is switched between f_1 and f_2 by a binary code signal.
- $f_c=(f_1+f_2)/2$.
- $\Delta f=(|f_1-f_2|)/2$.

Phase Shift Keying (PSK)

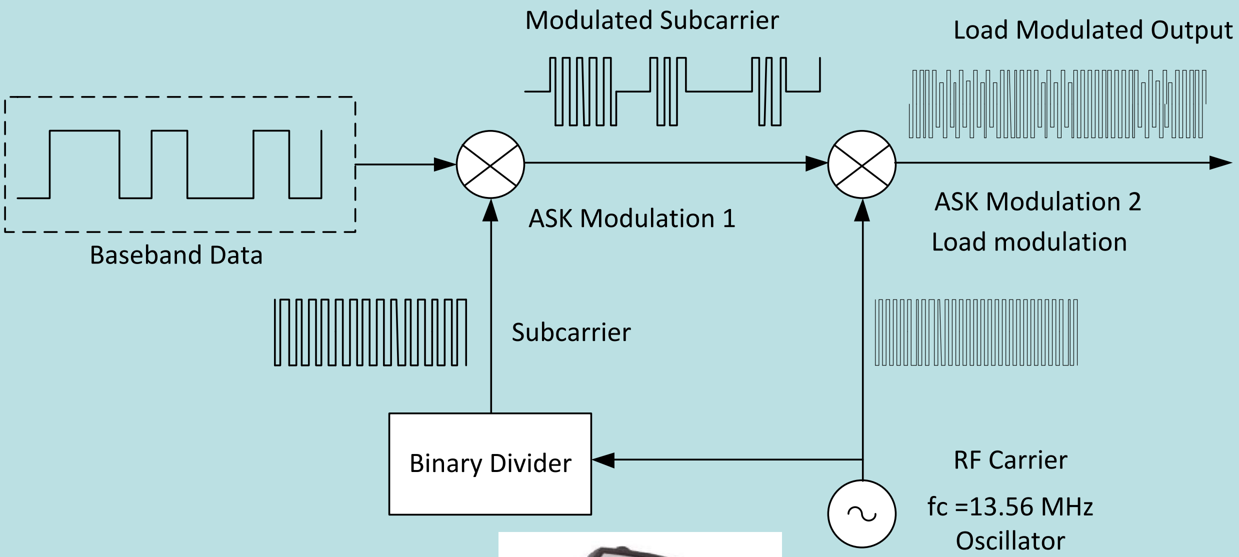


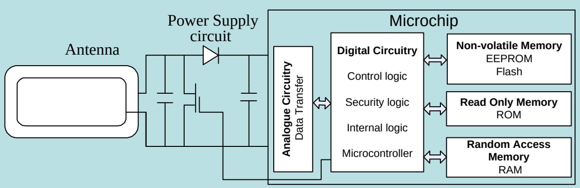
- Phase Shift Keying (PSK)

  Binary states '0' and '1' of a code signal are converted into corresponding phase states of the carrier, in relation to a reference phase.

  In BPSK, the signal is switched between 0º and 180º. This corresponds with the multiplication of the carrier by 1 and -1 respectively.

Modulation with Subcarrier

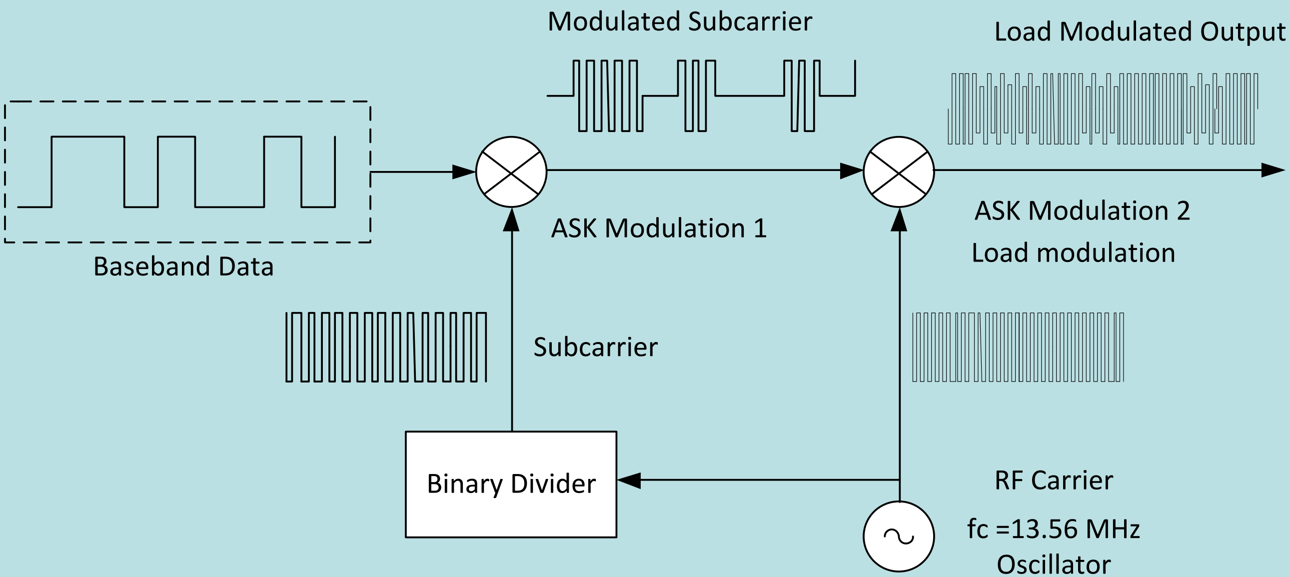




1) The baseband signal is modulated onto a subcarrier.

2) The modulated subcarrier signal will switch the load resistor of the antenna on and off resulting in the load modulated signal with subcarrier.

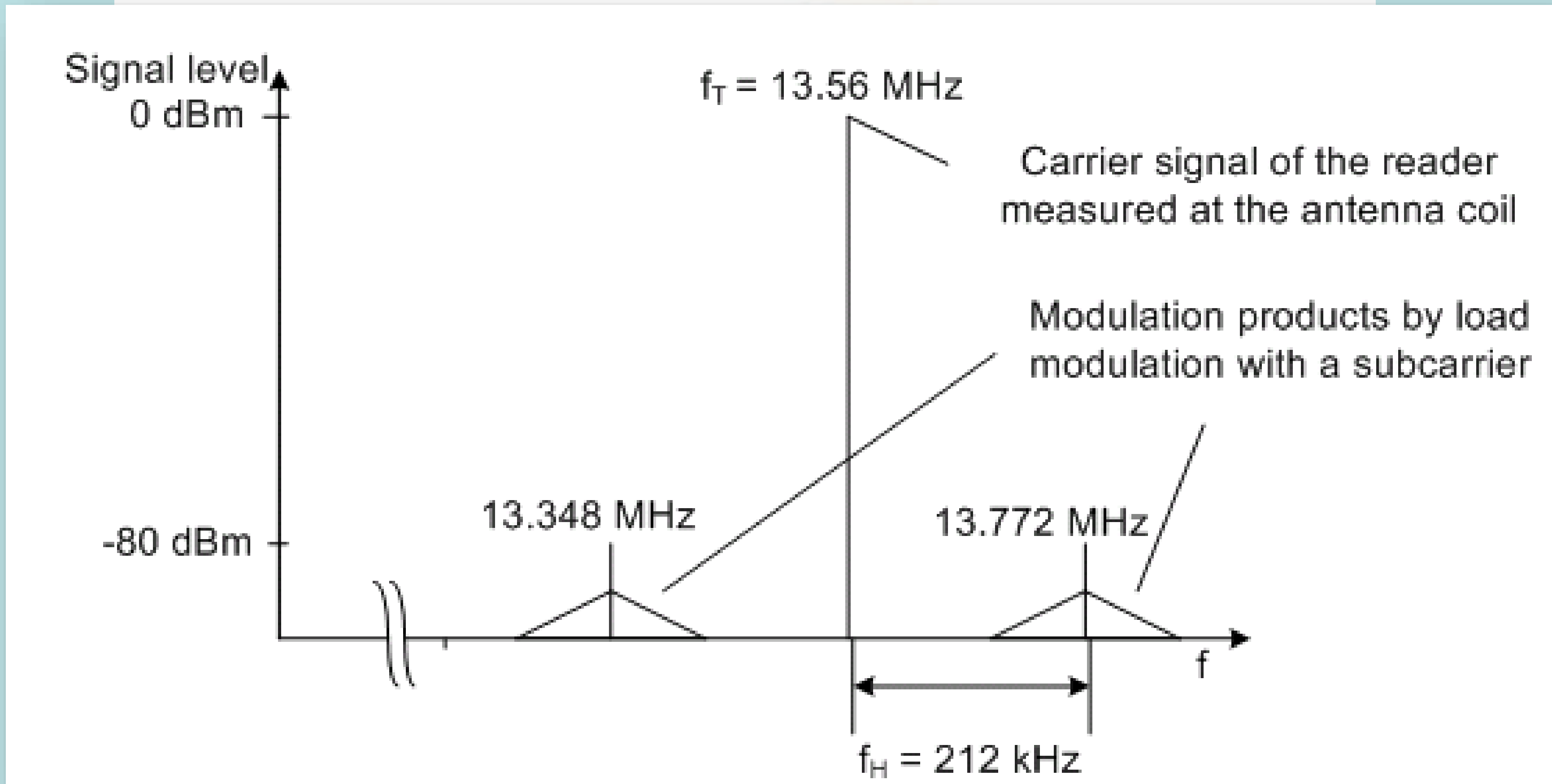
Modulation with Subcarrier



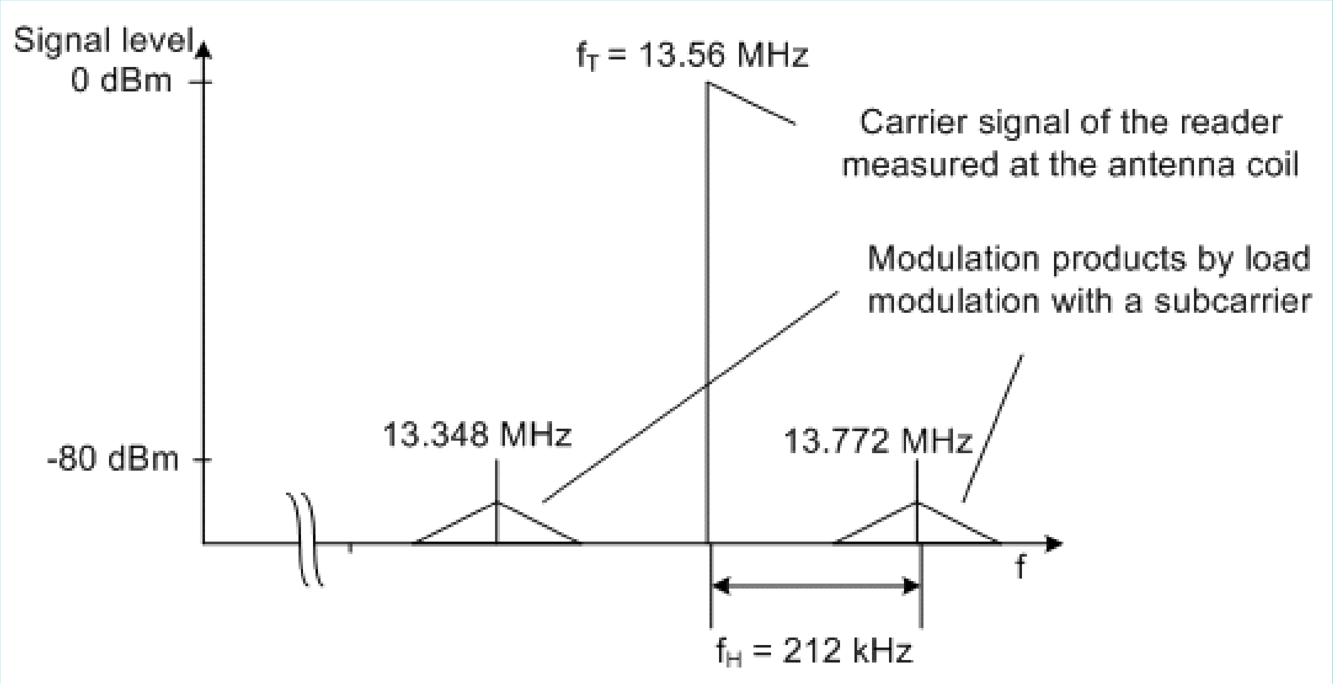
Used in:

- Inductively coupled systems in the frequency ranges of 6.78MHz, 13.56MHz or 17.125MHz
- Load modulation for data transfer from the transponder to the reader

Why use subcarrier modulation?

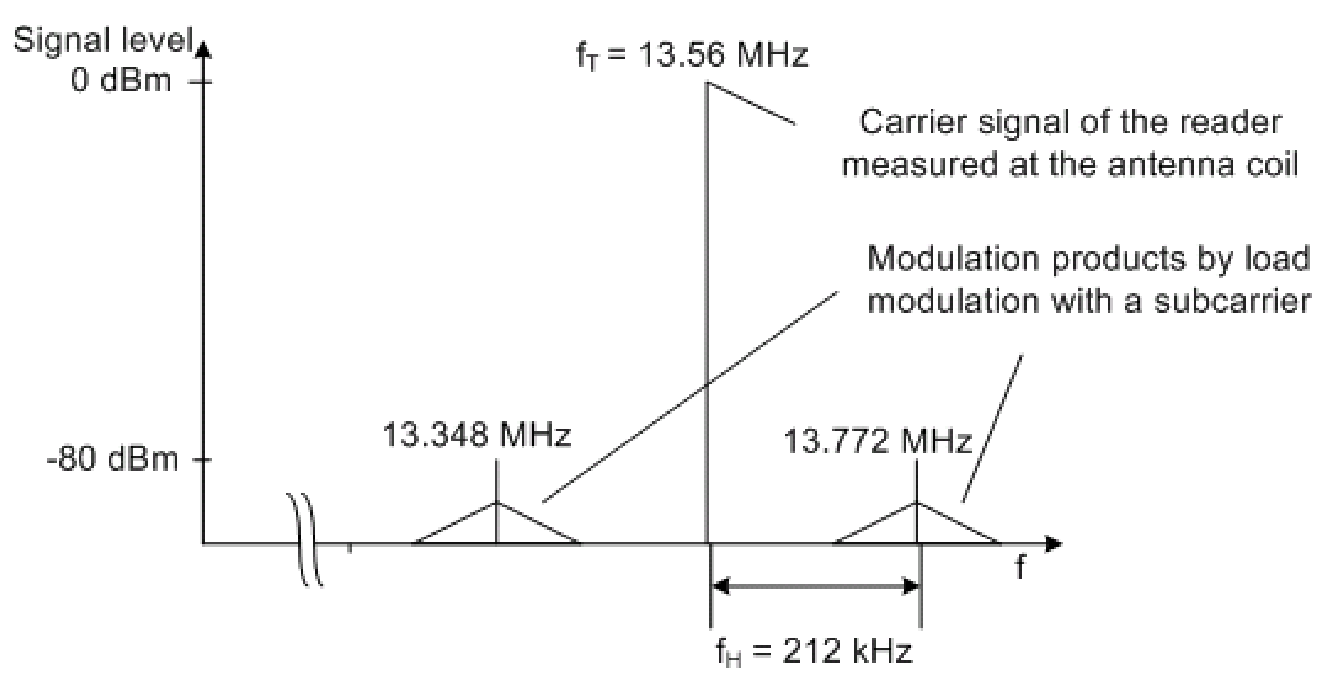


Why use subcarrier modulation?



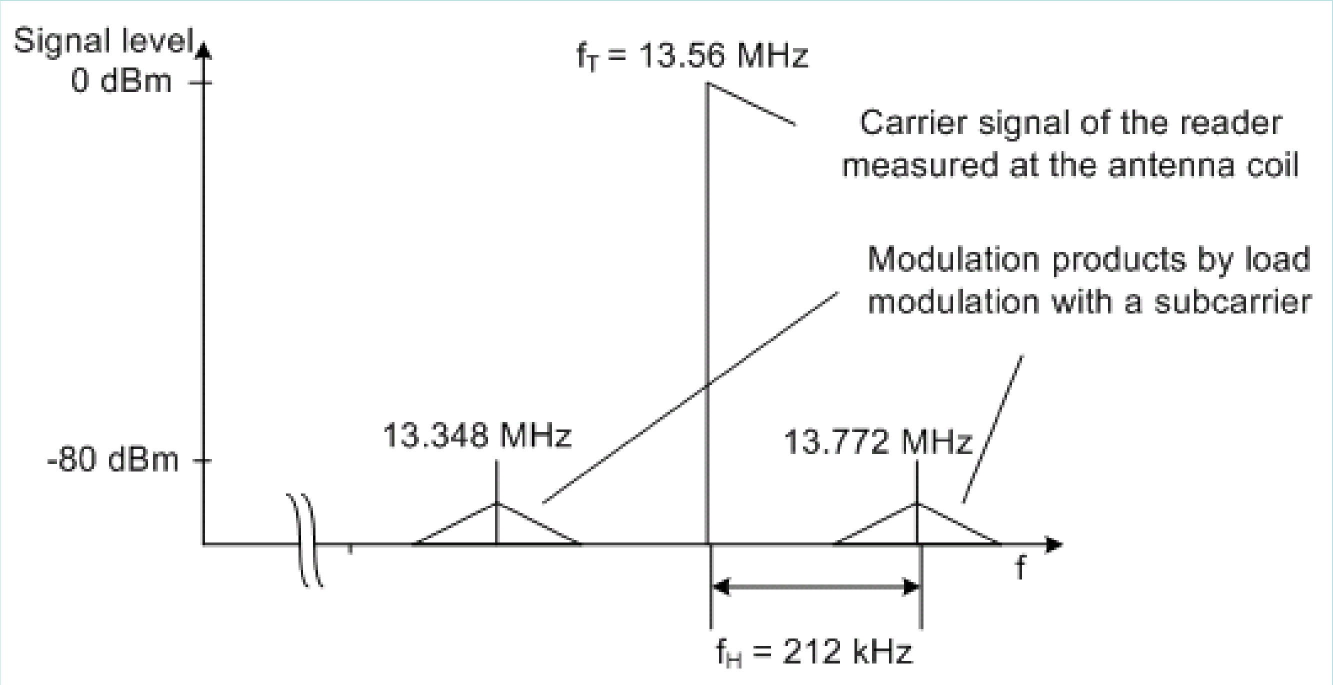
- Generates two spectral lines at a distance ± the subcarrier frequency f_H around the operating frequency.

Why use subcarrier modulation?



- If load modulation in the baseband were used, the sidebands of the data stream would lie directly next to the carrier signal at the operating frequency.

Why use subcarrier modulation?



- In very loosely coupled transponder systems, one of the two subcarrier modulation products can be filtered out and demodulated by shifting the frequency of the modulation sidebands of the data stream.

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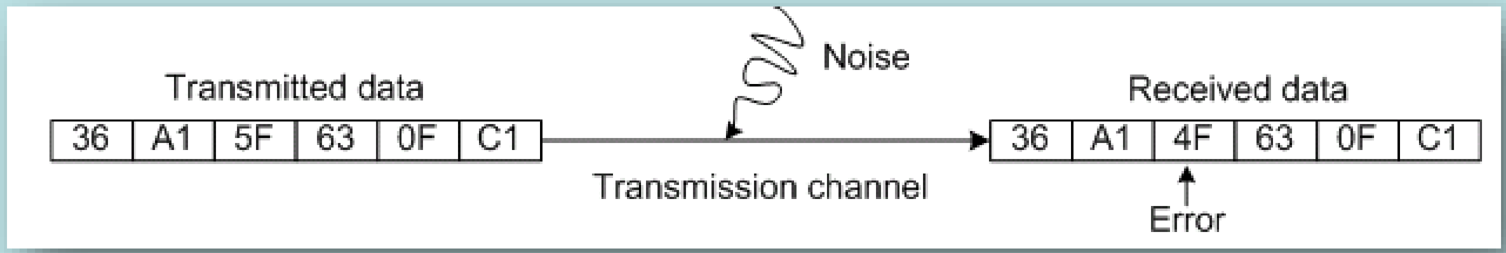
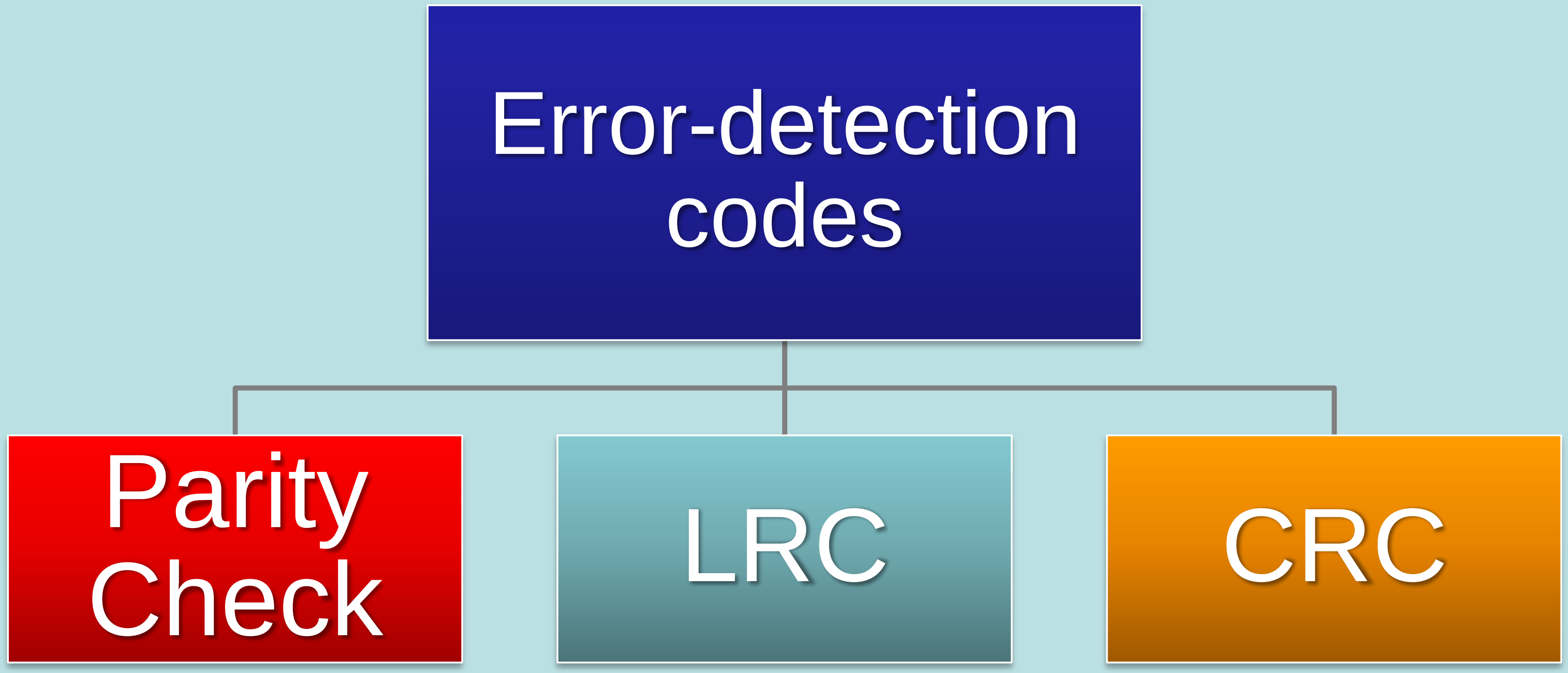
Data Integrity



- Error-detection codes
  - – Detect presence of erroneous data
- Error-correction codes
  - – Detect and correct

Data Integrity



Parity Check

- Additional one bit added to end of every byte (8 bits)
- XOR Operation
- In reality, even simpler
  - E.g.
    E5h = 1 1 1 0 0 1 0 1
- This is even parity. For odd parity, just invert the output bit

	0	1
1		
0		

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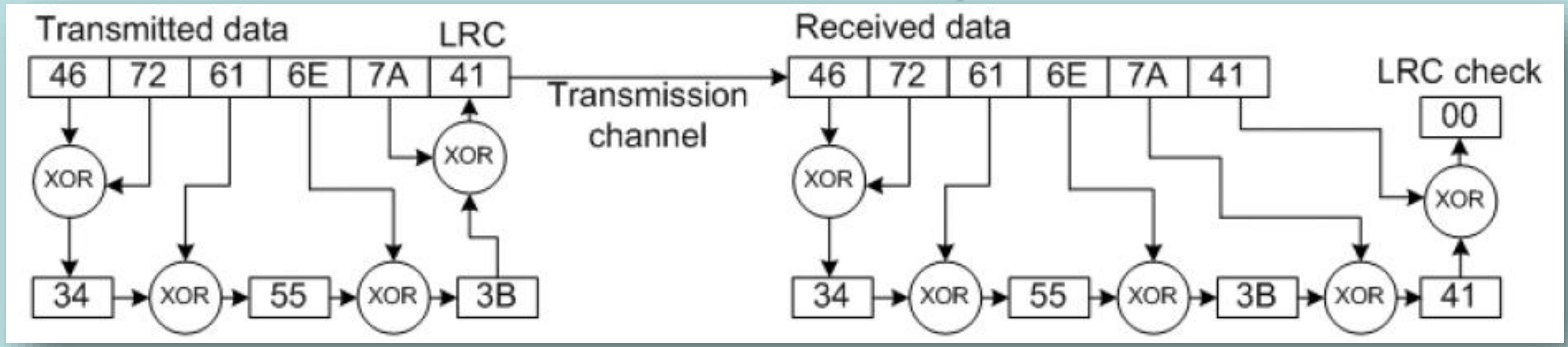
LRC (Longitudinal Redundancy Check)



- Final output, the LRC value, is appended to the data block and transmitted
- Disadvantage – unreliable
- Used for rapid checking of small data blocks (e.g. 32 byte)

CRC (Cyclic Redundancy Check)

- CRC checksum is calculated with a generator polynomial
- CRC value of a byte is “fed” to next byte for next operation
- Reliable even for large data quantities

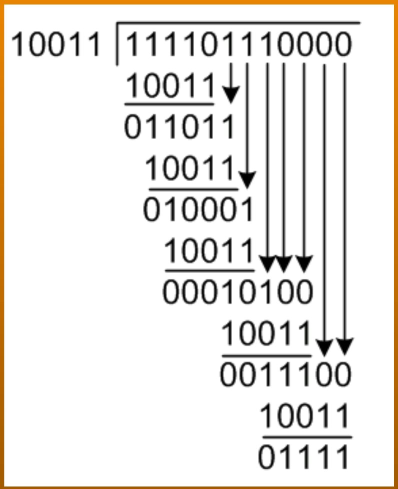
Example:

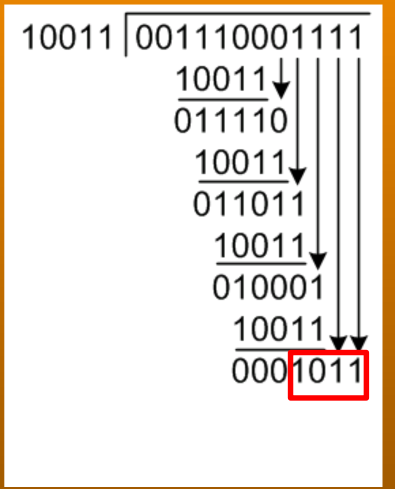
We want to compute a 4-bit CRC checksum for a data block of F7h and 38h

F7h = 11110111b

38h = 00111000b

We use a generator polynomial of 10011b





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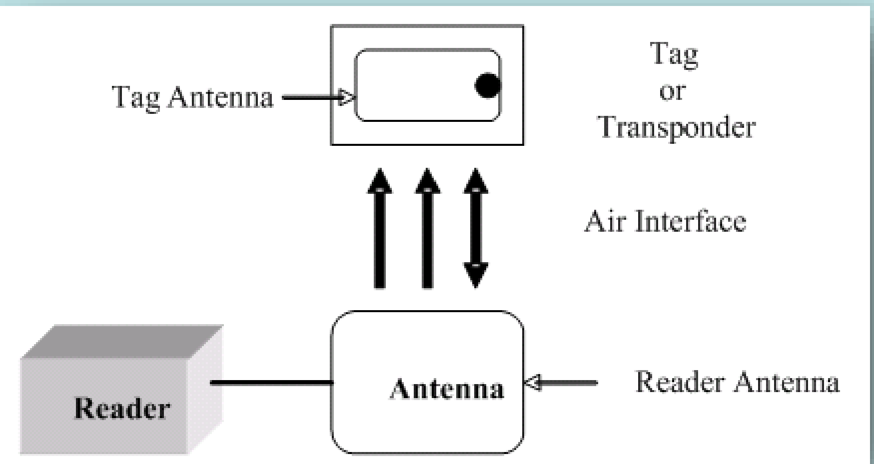
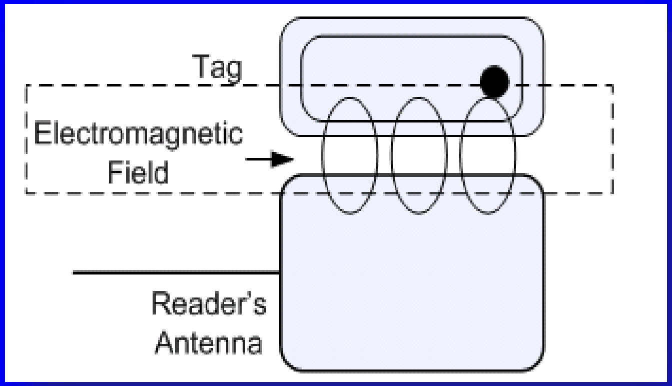
Read/Write Mechanism

1. An RFID tag passing through the electromagnetic/ interrogation zone detects the reader's activation signal
2. Tag gets activated
3. Activated tag sends information to the reader
4. The reader decodes the data encoded in the tag's integrated circuit.



Read/Write Mechanism

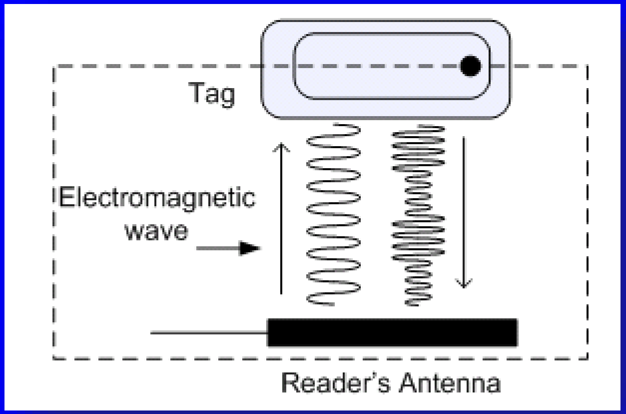
Near-field systems



- Inductive coupling of tag using reactive energy circulating around the reader antenna
- Applied to RFID systems operating in LF and HF bands
- Shorter read range

$$\frac{\lambda}{2\pi}$$

Far-field systems



Radiative coupling of tag to the real energy contained in the propagating electromagnetic plane waves

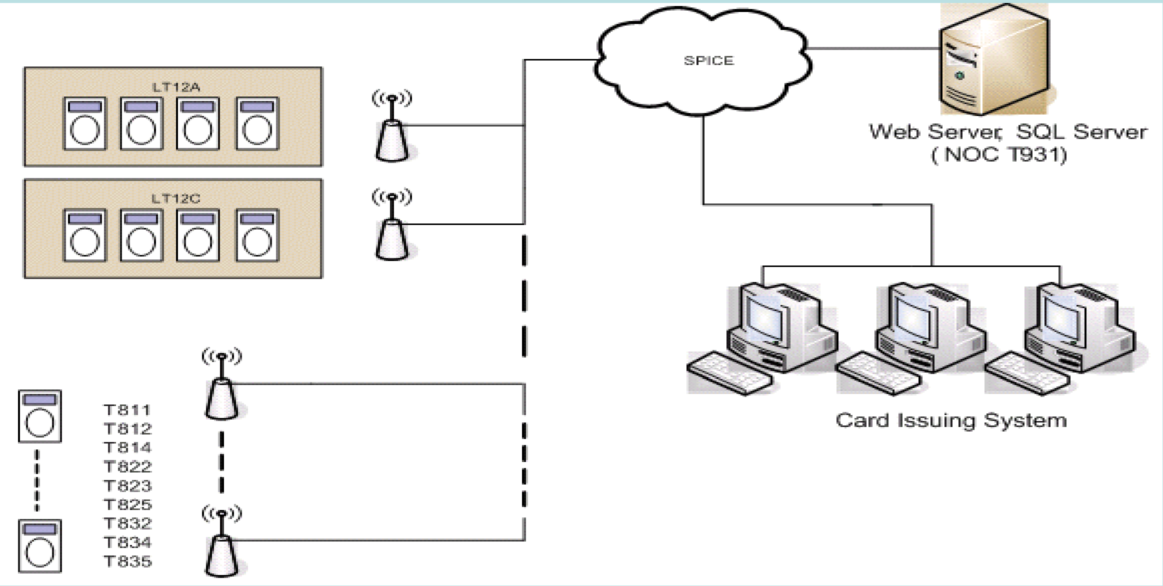
Applied to RFID systems operating in UHF and microwave

Longer read range

Anticollision

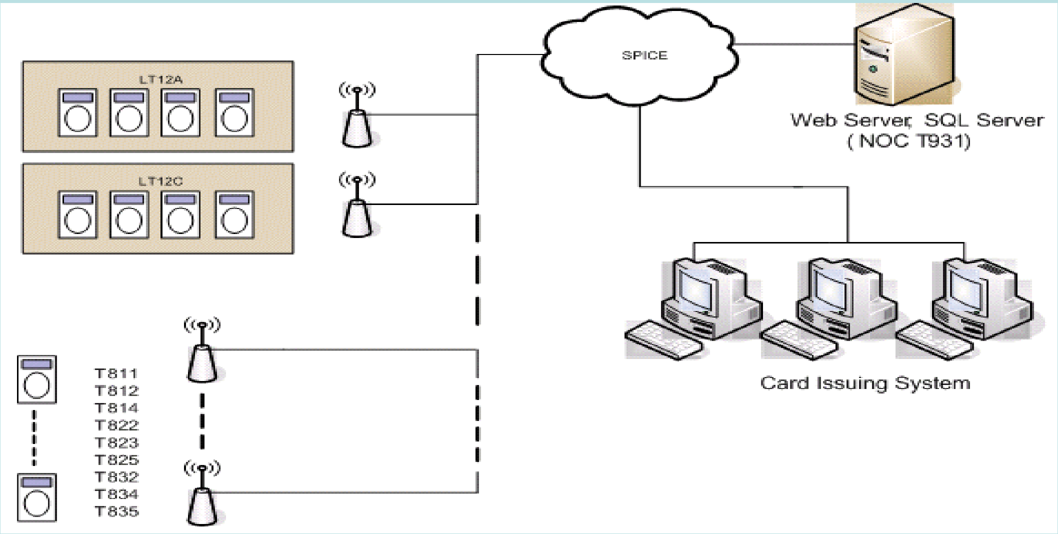
- An anticollision algorithm allows multiple tags to be read/written simultaneously
- Making sure that only 1 tag talks at any given time

Practical RFID System



- tags,
- tag readers,
- edge servers,
- middleware,
- and application software.

Practical RFID System



- Middleware helps to connect RFID equipment to applications.
- The architecture includes the controller/server, databases, tags, tag readers and reader antenna.
- The controller/server is to manage all communications between the reader/interrogator and the database.
- The database is to provide an organized repository or collection of data.

Practical RFID System

- Information flows as follow:
- The reader is activated using the staff RFID tag to start the attendance recording mode
- Students tap their student tags at the reader
- Attendance records with time stamps are temporarily stored at the reader
- Scheduler program at the server sends command to all the readers requesting to retrieve the attendance records at regular interval which is set by the system administrator.
- Reader sends host an acknowledgement of the request
- Server retrieves the attendance records by using ftp commands through wireless LAN.

Summary

1. What is RFID?
2. What are the fundamentals of an RFID system?
   - Readers and Tags
   - Coding and Modulation
   - Data Integrity (Error checking…)
   - Read/Write Mechanism (near field, far field)
   - Anticollision
   - Practical RFID System