Alexandria University
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Electrical and Electronics Engineering Department
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جامعة الإسكندرية
كلية الهندسة
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Lab1: Communication systems.

(Section-6)

Bluetooth module

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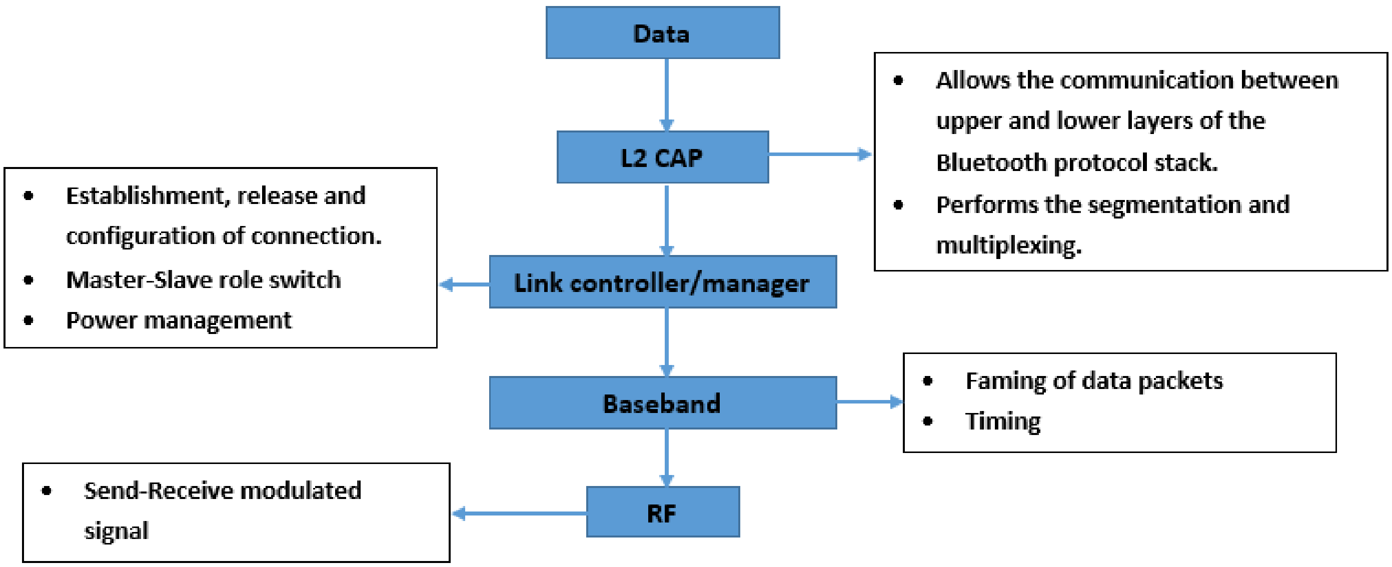
Problem 1: Bluetooth standards.

- **Bluetooth protocol stack.**



- **Bluetooth evolution.**

Bluetooth was invented back in 1994, but the first Bluetooth phone didn't hit shelves until 2001.

  - The Bluetooth 1.0 specification also officially launched 1999, leading to the release of the first Bluetooth-equipped chipsets, mice and wireless PC cards.
  - **The Bluetooth 1.0 specification offered peak data speeds of just 721 kbps and connections couldn't reach much farther than 10 meters.**
  - Fast forward a couple more years, and Bluetooth 1.2 was ready to shine in 2003. It was the first Bluetooth update that increased the data transfer speed, kicking things up to 1Mbs.
  - **The Bluetooth 1.2 Introduced something called "Adaptive Frequency Hopping" that made Bluetooth more resistant to interference from radio frequencies.**

Bluetooth version	Year	Specifications	Features
2.0	2004	• Allowed users to theoretically boost data transfer to a maximum of 3 megabits per second (Mbit/s). In reality, however, it could be boosted to 2.1 Mbit/s. • Power consumption was also cut in half	Enhanced data rate.
2.1	2007	---	Secure simple pairing.
3.0	2009	In theory, Bluetooth 3.0 could achieve data transfer speeds up to a whopping 24/Mbps. However, those speeds didn't happen solely over Bluetooth. Instead, Bluetooth 3.0 established a link connection to the 802.11 protocol (AKA, Wi-Fi).	High speed with 802.11 Wi-Fi radio.
4.0	2010	Bluetooth 4.0 retained the same 24/Mbps speed when used with non-BLE devices, along with adding 128-bit encryption for enhanced security.	Low-energy protocol. (BLE:Bluetooth low-energy)

4.1	**2013**	**---**	**Indirect IoT device connection.**
4.2	**2014**	**Bluetooth 4.2 devices couldn't be tracked unless a user specifically gave permission.**	**IPv6 protocol for direct internet connection.**

- **Topics related to Bluetooth standard.**

Bluetooth 5.0 was both a technical and branding update for the Bluetooth standard when it was officially rolled out in July 2016. On the technical side of things, we saw an increase in maximum range up to 243.84 meter, along with significantly faster max data transfer speeds up to 50/Mbps. Similarly, Bluetooth 5.0 added the ability to transmit audio between two devices at once — allowing for simultaneous audio playback on two headphones at once.

Problem 2: Specifications

1) frequency range of the Bluetooth : 2.4 GHz

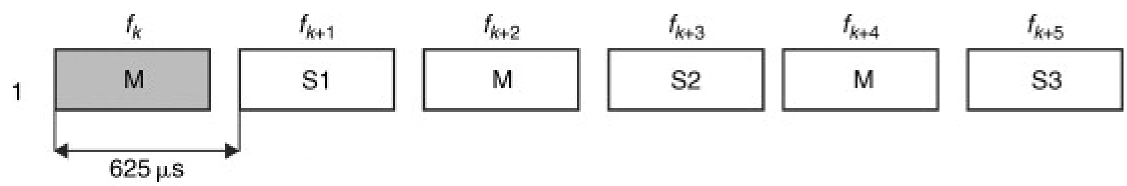
Applications: smart phones, computers, head sets and radio devices.

2) The type of modulation does the basic rate of Bluetooth use is **GFSK.**

3) **An eight-level modulation allows 3 bits to be simultaneously transmitted.** Since **the symbol rate in EDR remain the same** as the basic rate, up to three times more data can be transferred at the same time and bandwidth.

4) Bluetooth have **79 channels** and each channel has a bandwidth of **1 MHz.**

5)



- **Scatter-nets (many Piconets overlapping).**
- **Each Piconet has single master.**
- **Piconet is divided into time slots, each one of them is 625 µs in length.**

6) **Bluetooth power classes**

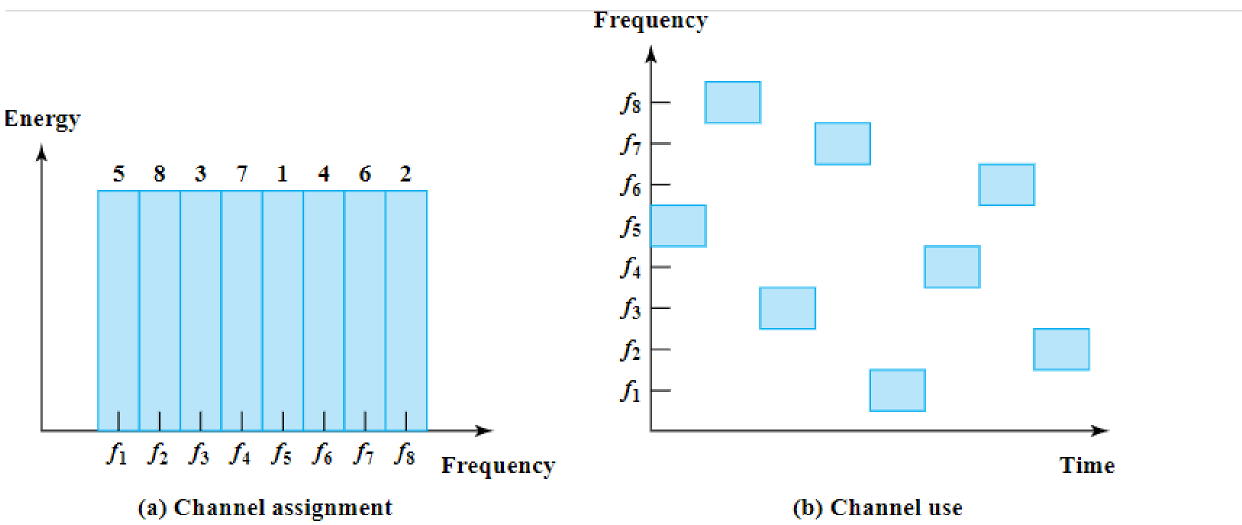
BT Class	>Maximum Power	Operating Range
Class 1	100 mW (20 dBm)	100 meters
Class 2	2.5 mW (4 dBm)	10 meters
Class 3	1 mW (0 dBm)	1 meter

7) **Master device is the device that initiate the connection and each Piconet has one master device and up to 7 slave devices.**

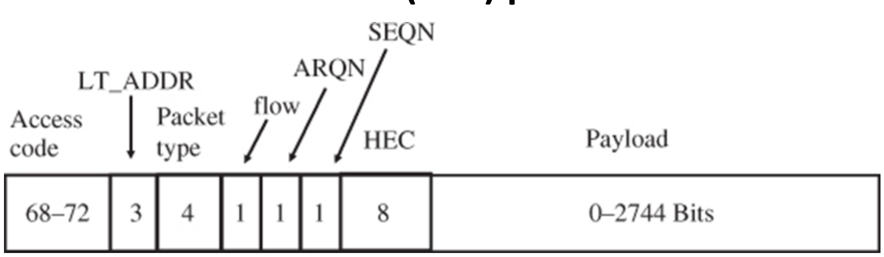
8) **Frequency hopping spread spectrum**

A method of transmitting radio signals by rapidly changing the carrier frequency among many distinct frequencies occupying a large spectral band.

- **FHSS is used to decrease interference**



9) **Asynchronous Connectionless (ACL) packets.**



An ACL packet consists of a 68- to 72-bit access code, an 18-bit header and a payload (user data) field of variable size between 0 and 2744 bits.

- **Access Code**: Access code are used for timing synchronization.
- **Header**: The header contains information for packet acknowledgement, packet numbering for out-of-order packet reordering, flow control, slave address and error check for header.
- **Payload**: The packet payload can contain either voice field, data field or both.

<u>Error transmission and correction:</u>

There are 3 error-correction schemes defined for Bluetooth baseband controllers:

- 1/3 rate forward error correction code (FEC).
  Every bit is repeated three times for redundancy.
- 2/3 rate forward error correction code (FEC).
  A generator polynomial is used to encode 10-bit code to a 15-bit code.
- Automatic repeat request (ARQ) scheme for data.

10) What is Bluetooth low energy (BLE)? Describe the main features of it.

- Bluetooth Low Energy technology — also referred to as **BLE**
- **BLE was designed to offer more efficient connections to smaller wireless devices —** often seen in fitness trackers that don't require a lot of power.

Problem 3: Questions Related to the Experiment

1) Bluetooth module RN41/RN41N specifications

Data rate	3-Mbps
Coverage distance	Up to 100 meters
Power class	1
Bluetooth version	2.1
Backwards-compatible with Bluetooth version	2.0, 1.2 and 1.1.

2)

- **To change the Bluetooth module name in the given code.**

```
do {
  UART3_Write_Text("SN,BlueTooth-1111");   // Name of device
  UART3_Write(13);                          // CR
  Delay_ms(500);
} while (BT_Get_Response() != BT_AOK);
```

After the change

```
do {
  UART3_Write_Text("SN,LAB1");   // Name of device
  UART3_Write(13);                          // CR
  Delay_ms(500);
} while (BT_Get_Response() != BT_AOK);
```

- **to change the Bluetooth module from Slave to Master**

```
do {
  UART3_Write_Text("SM,0");                 // Set mode (0 = slave, 1 = master, 2 = trigger, 3 = auto, 4 = DTR, 5 = ANY)
  UART3_Write(13);                          // CR
  Delay_ms(500);
} while (BT_Get_Response() != BT_AOK);
```

0 for slave and 1 for master.

Problem 4: Mini-Simulation

```
clc;
clear all;
%%

% System parameters
M      = 8;                    % Number of Symbols
k      = log2(M);              % Number of bits per Symbol
N_bits = 1000000;              % total number of bits
SNR = 0;
%%

Xn= randi([0 1],1,N_bits);     %Generate a sequence of bits equal to the
total number of bits
Zn = dpskmod(Xn,M);                  % Generate a Modulated sequence
rn = Zn + (1/(2*sqrt(SNR)))*(randn + j*randn);    % Generate a recieved seq.
Dn = dpskdemod(rn,M);                % Generate a DeModulated sequence
[N_error_bits,BER] = biterr(Xn,Dn);        %Calculate the bit error rate BER
%%
SNR = 0:0.5:15;
BER_vec = zeros(1,15);   % Use this vector to store the resultant BER

for i = 1:length(SNR)
rn = Zn + (1/(2*sqrt(SNR(i))))*(randn(1,N_bits) + j*randn(1,N_bits));
% Generate a recieved seq.
Dn = dpskdemod(rn,M);           % Generate a DeModulated sequence
[N_error_bits,BER_vec(i)] = biterr(Xn,Dn);   %Calculate the bit error rate
end
```

% Plotting results

```
plot(SNR,BER_vec,'d-b','linewidth',2); hold on;
xlabel('SNR(dB)','fontsize',10)
ylabel('BER','fontsize',10)
title('Relation between BER & SNR')
```