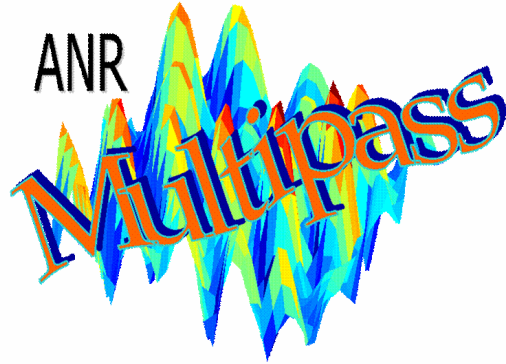


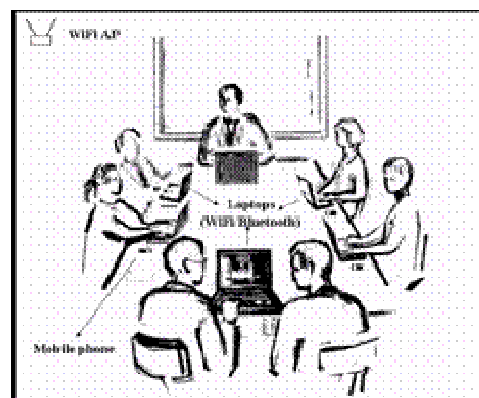
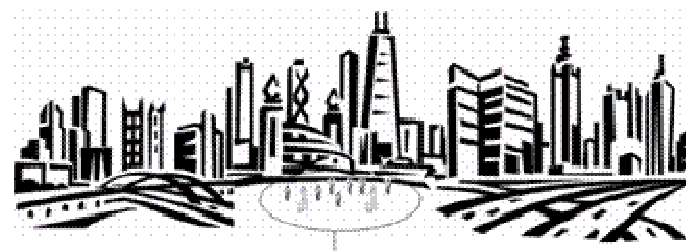
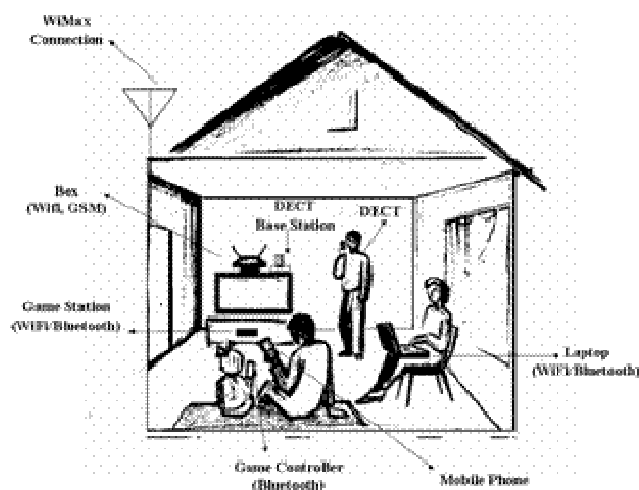


## Projet MULTIPASS

<http://multipass.elibel.tm.fr/>

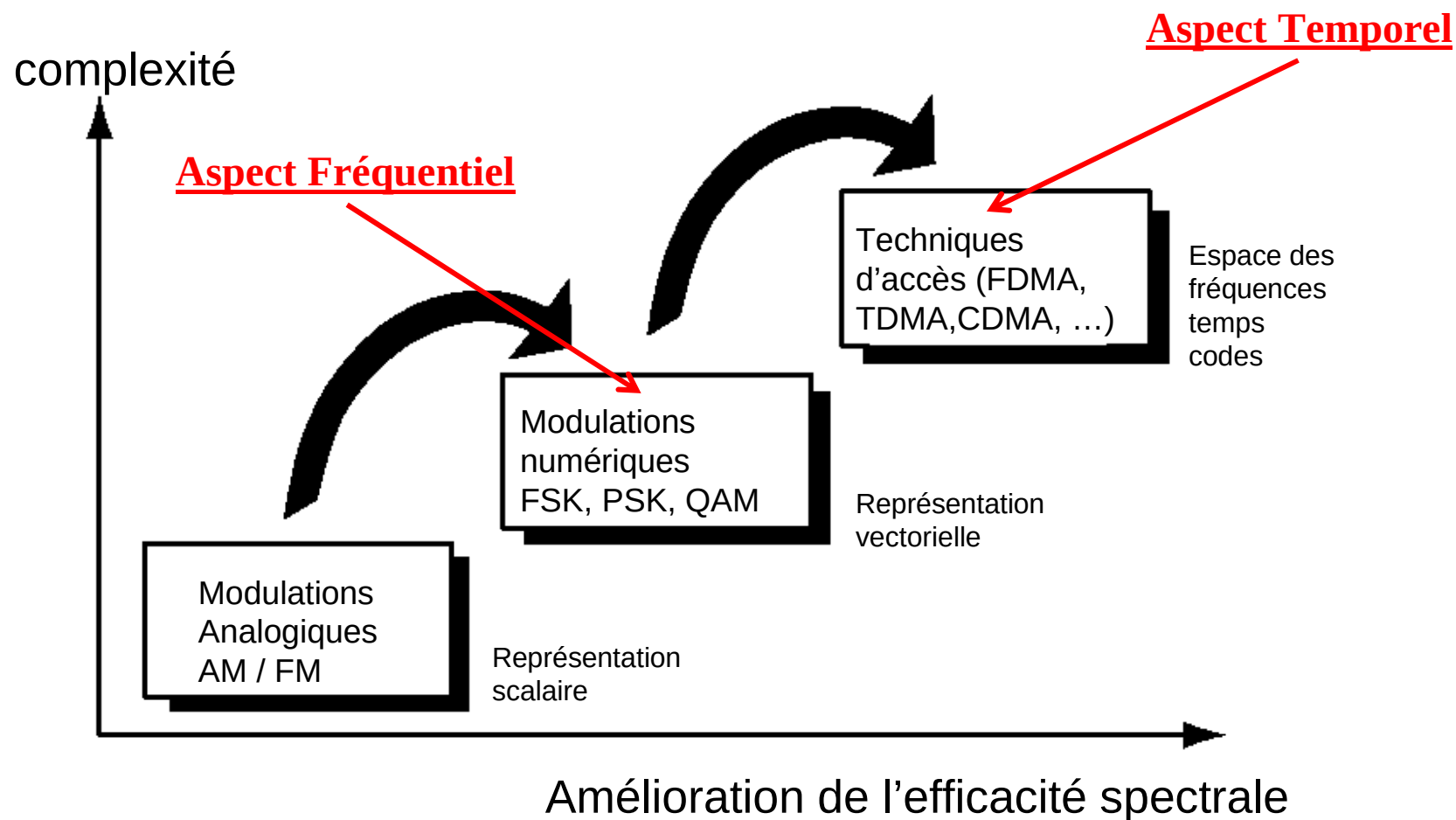


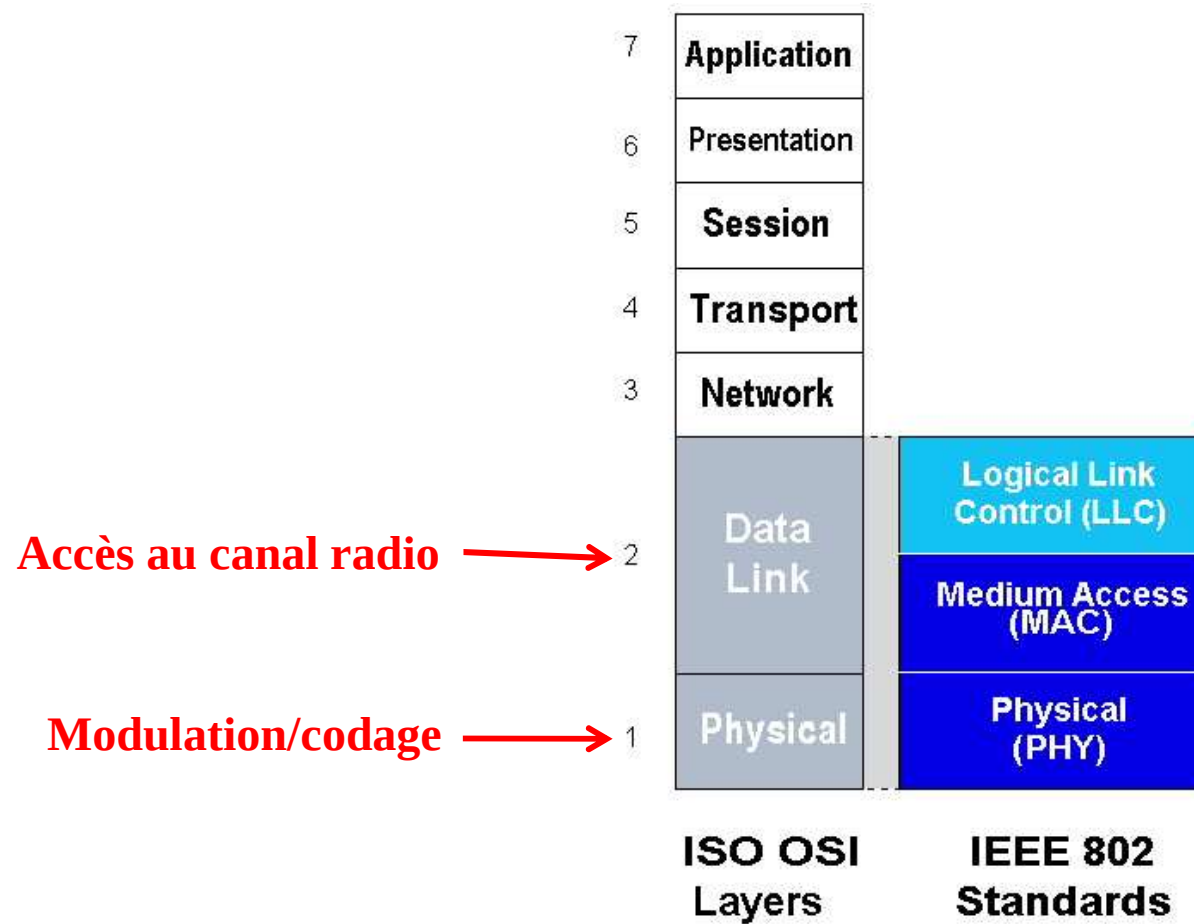
# Problématique de la mesure des signaux apériodiques



Analyse des  
systèmes existants

2G, 3G, 802.xx,  
BlueTooth, RFID,  
Wifi, DECT....



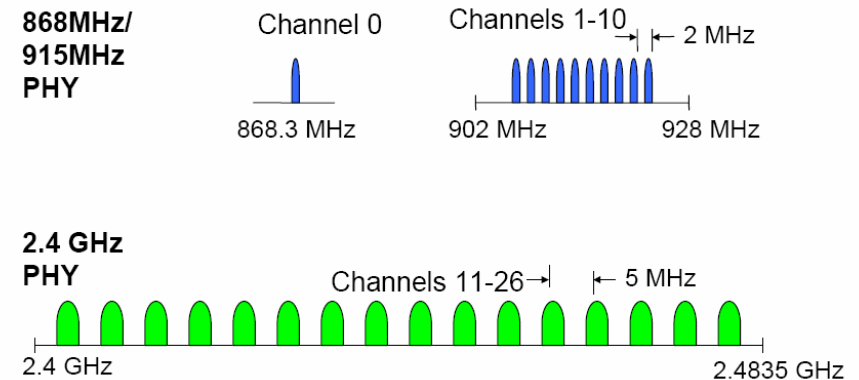


## Description du standard IEEE802.15.4

### 1) Les caractéristiques:

- Fréquence et canaux : 2,4 GHz/16; 915 MHz/10; 868 MHz/1
- Débits max radio: 20, 40 ou 250 Kbps (suivant la bande de fréquence utilisée)
- Faible temps d'accès au canal ~15 ms
- Fonctionnement en mode ad hoc ou contrôlé
- Réservation de ressource (times slots garantis: GTSS)
- Adresse des modules sur 16 ou 64 bits (+65000 par réseaux)
- Utilisation du protocole MAC CSMA/CA pour l'accès à la ressource radio
- Transfert de données avec Ack pour une meilleur fiabilité
- Faible consommation de puissance avec contrôle de niveau (RSSI)
- Mécanisme de détection d'énergie (ED)
- Indication de qualité de la liaison radio
- Deux types de devices: Full Fonction Device (FFD) et Reduced Fonction Device (RFD) plus le « coordinator node »

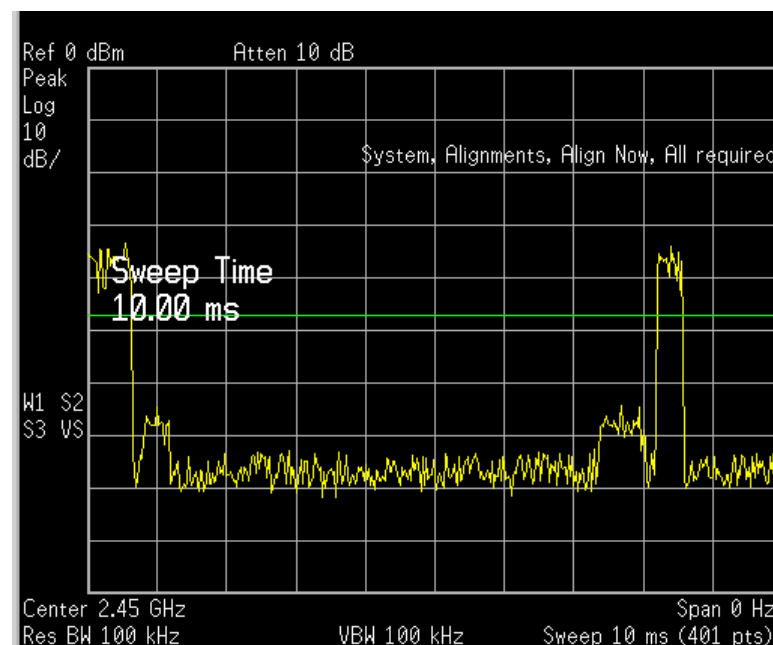
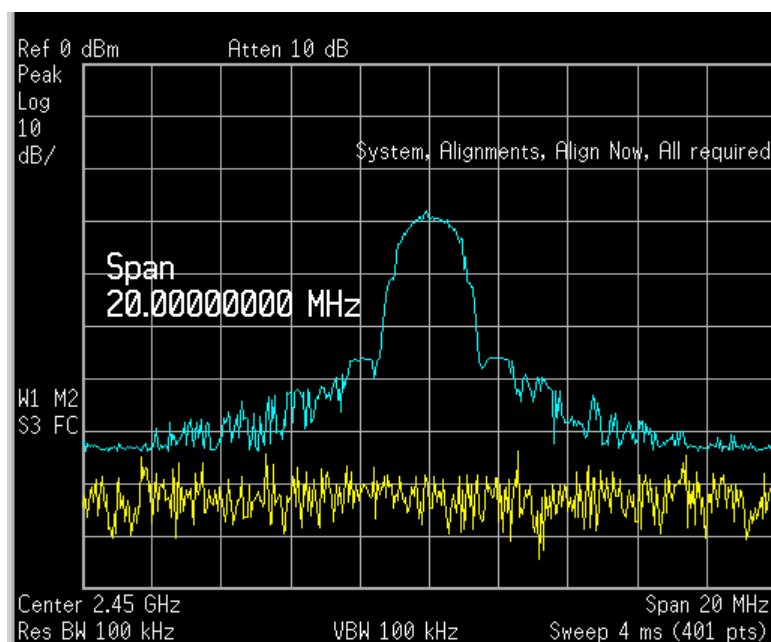
### Operating Frequency Bands



### 3 bandes de fréquences:

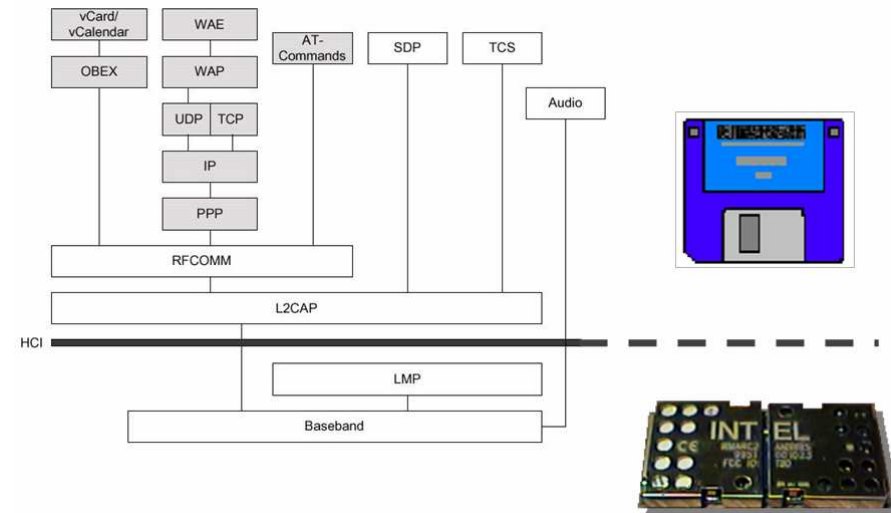
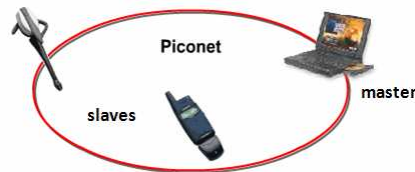
- 868 MHz (20Kbps) Europe
- 915 MHz (40 Kbps) USA
- 2,4 GHz (250 Kbps) ISM

## Spectre d'un signal ZigBee: Xbee-Pro



## Aspect temporel de ZigBee : Xbee-Pro

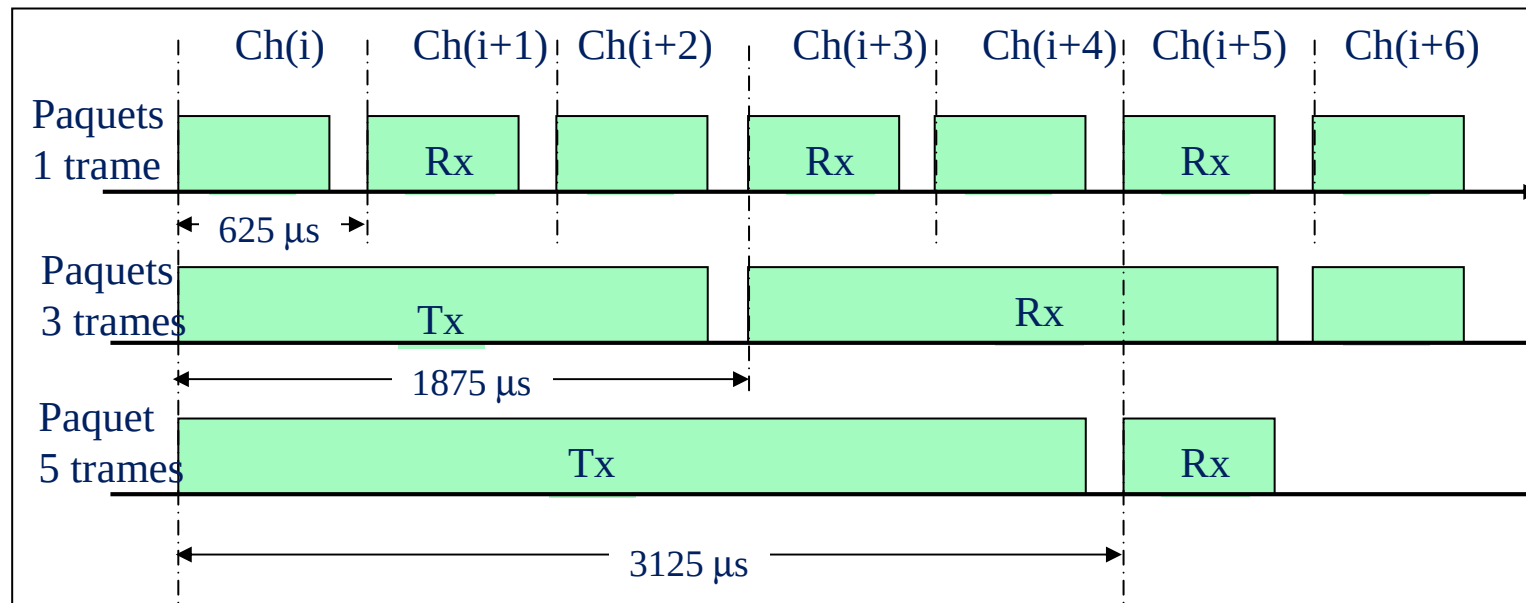
## Piconet et Scatternet: notion de maitre/esclave





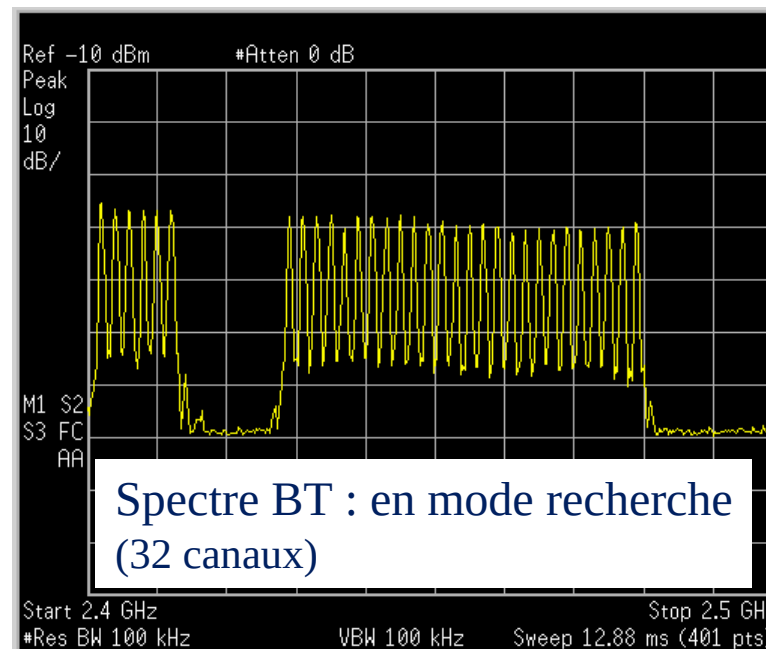
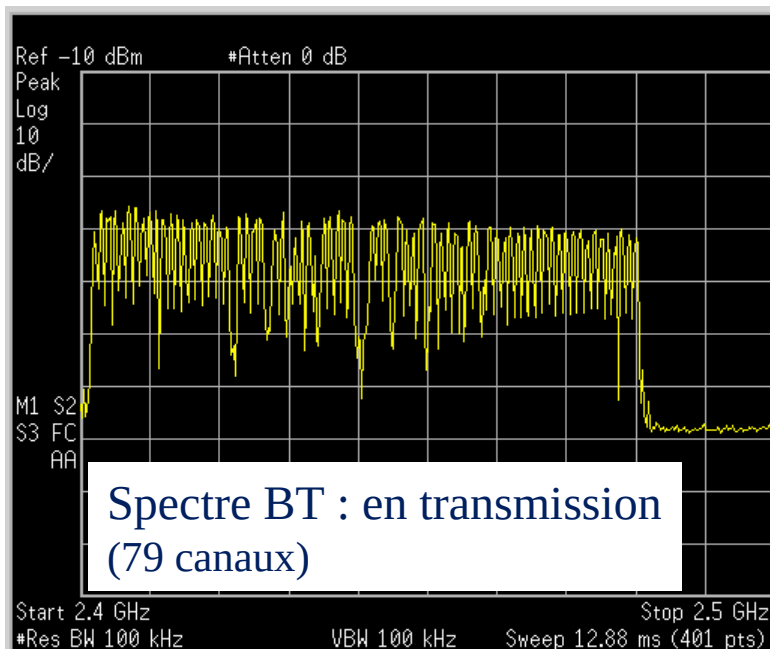
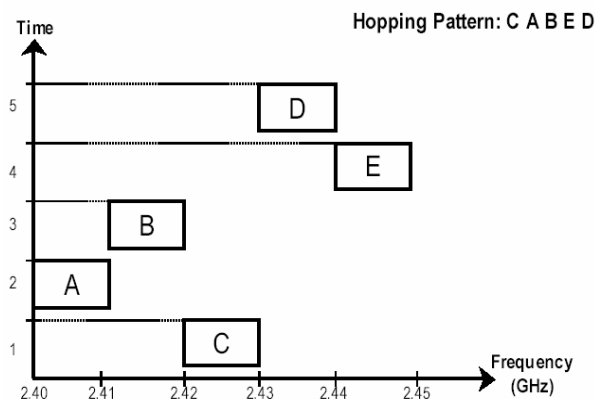
## Aspect temporel

Synchronisation des paquets en multi trames.



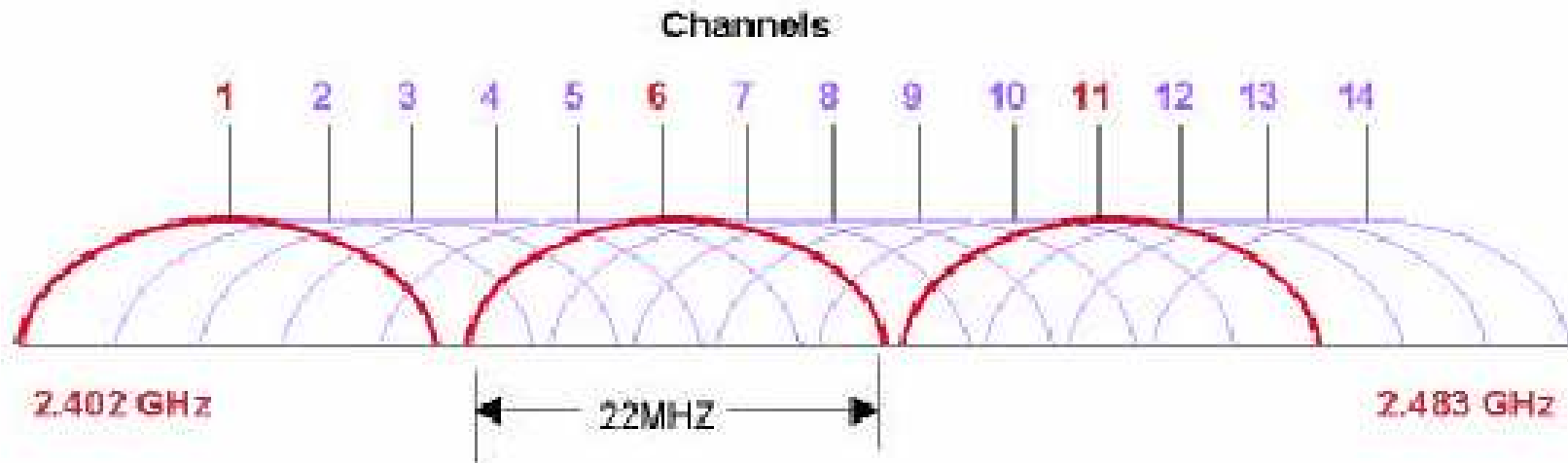
## Aspect Fréquentiel

Bande de fréquences utilisée :



## Wifi: une famille de protocoles a, b, g, n, ...

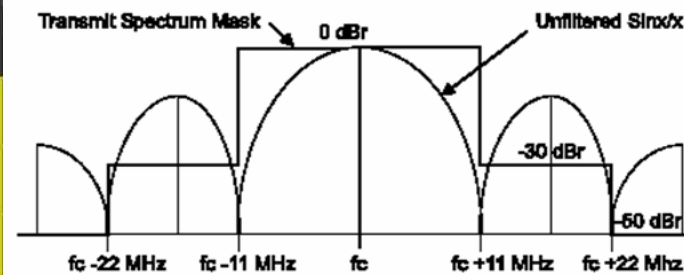
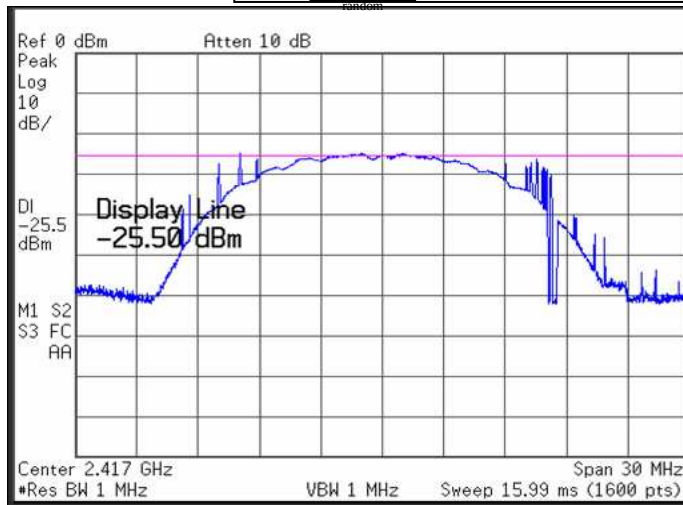
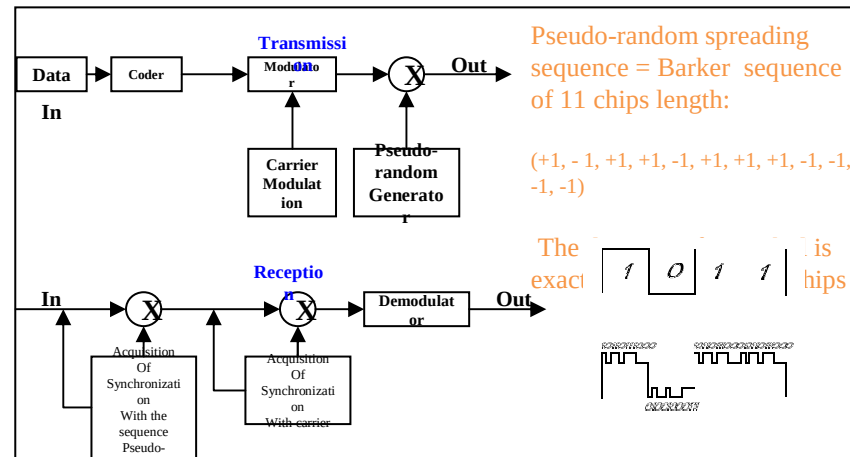
| Standards    | Frequency<br>(MHz) | Data<br>(Mbit/s) | Phy Layer Access Control                                                                            |
|--------------|--------------------|------------------|-----------------------------------------------------------------------------------------------------|
| IEEE 802.11b | 2400-2483,5        | 11               | DSSS (Direct Sequence Spread Spectrum), CSMA/CA (Carrier Sense Multiple Access Collision Avoidance) |
| IEEE 802.11a | 5150 – 5350        | 54               | OFDM (Orthogonal Frequency Division Multiplexing), CSMA/CA                                          |
| IEEE 802.11g | 2400-2483,5        | 54               | OFDM, CSMA/CA                                                                                       |
| IEEE 802.11n | 2400-2483,5        | 108 ?            | OFDM, MIMO                                                                                          |



La bande de fréquence occupée par un équipement WiFi ne dépend pas du taux de transfert (1, 2, 5.5 , 11 Mbps) et est égale à 20/22 MHz,

=> règles dans le choix d'attribution des canaux (typiquement en France : 1, 6, 11 ou 1, 7, 13)

=> On ne peut utiliser simultanément que trois canaux différents si l'on ne pas d'interférence ("overlapping") => débit maximal = 33Mbps



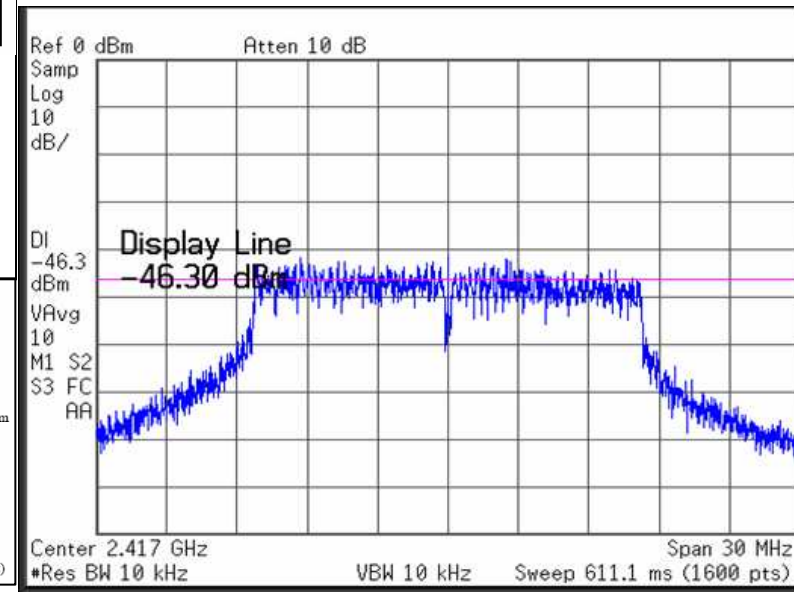
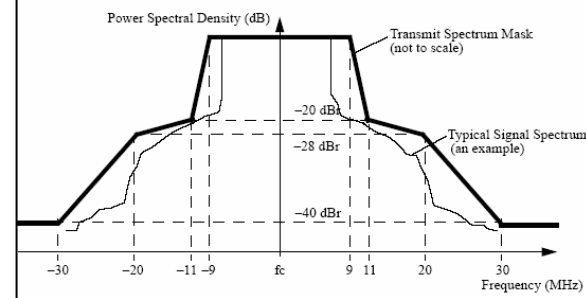
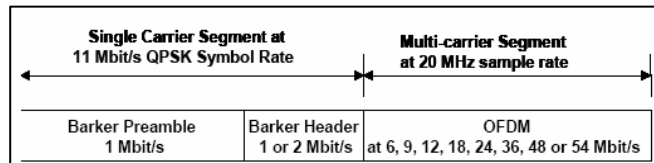
Another improvement standards  
**802.11a/g**

Modification of the physical layer  
802.11

Improved data rate: 6, 9, 12, 18, 22, 24, 33, 36, 48 et 54 Mbps (>108 Mbps)

Use of a new modulation of type  
OFDM (Orthogonal Frequency  
Division Multiplexing)

| Data rate (Mbits/s) | Modulation | Coding rate (R) | Coded bits per subcarrier (N <sub>CBPS</sub> ) | Coded bits per OFDM symbol (N <sub>CBPS</sub> ) | Data bits per OFDM symbol (N <sub>DBPS</sub> ) |
|---------------------|------------|-----------------|------------------------------------------------|-------------------------------------------------|------------------------------------------------|
| 6                   | BPSK       | 1/2             | 1                                              | 48                                              | 24                                             |
| 9                   | BPSK       | 3/4             | 1                                              | 48                                              | 36                                             |
| 12                  | QPSK       | 1/2             | 2                                              | 96                                              | 48                                             |
| 18                  | QPSK       | 3/4             | 2                                              | 96                                              | 72                                             |
| 24                  | 16-QAM     | 1/2             | 4                                              | 192                                             | 96                                             |
| 36                  | 16-QAM     | 3/4             | 4                                              | 192                                             | 144                                            |
| 48                  | 64-QAM     | 2/3             | 6                                              | 288                                             | 192                                            |
| 54                  | 64-QAM     | 3/4             | 6                                              | 288                                             | 216                                            |

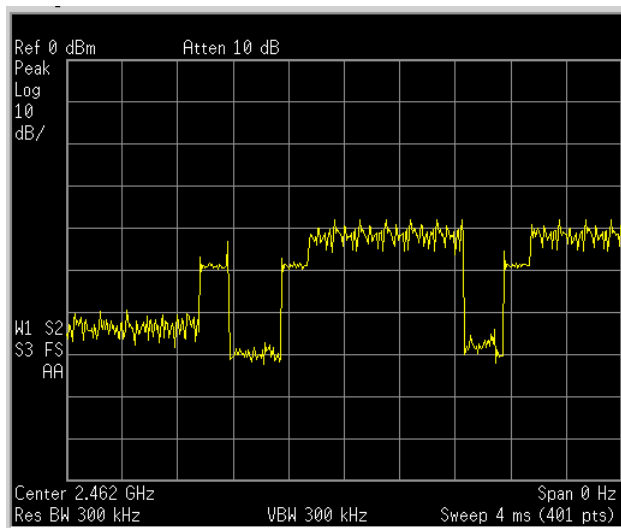
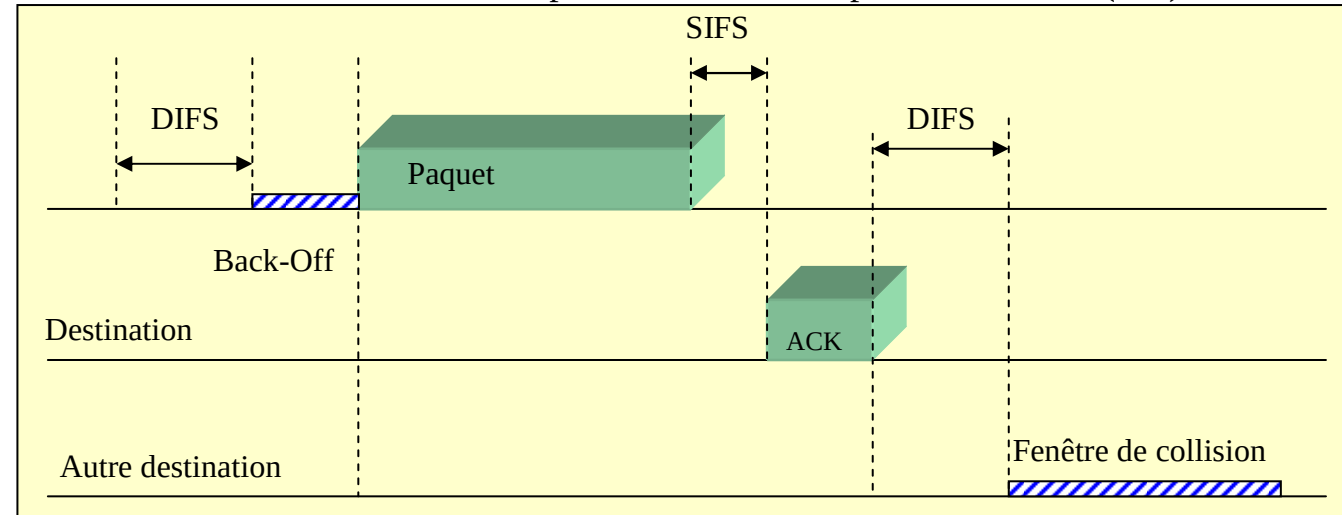


## CSMA/CA et Contrôle d'accès au canal par l'utilisation d'espace inter-trame (IFS)

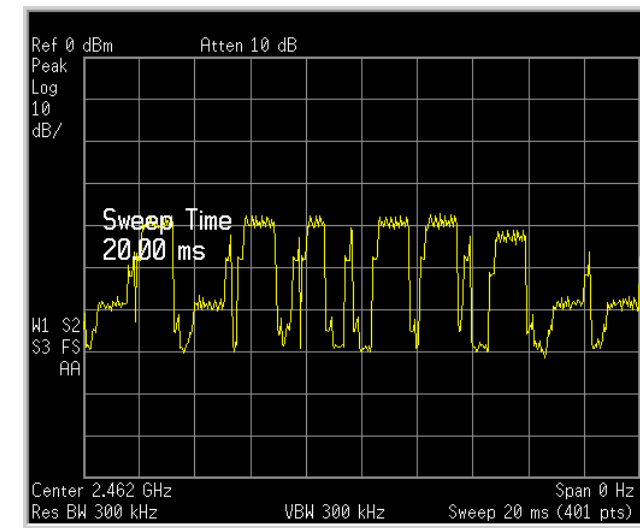
SIFS (Short IFS) : séparation entre les données et un ACK ; 10µs,

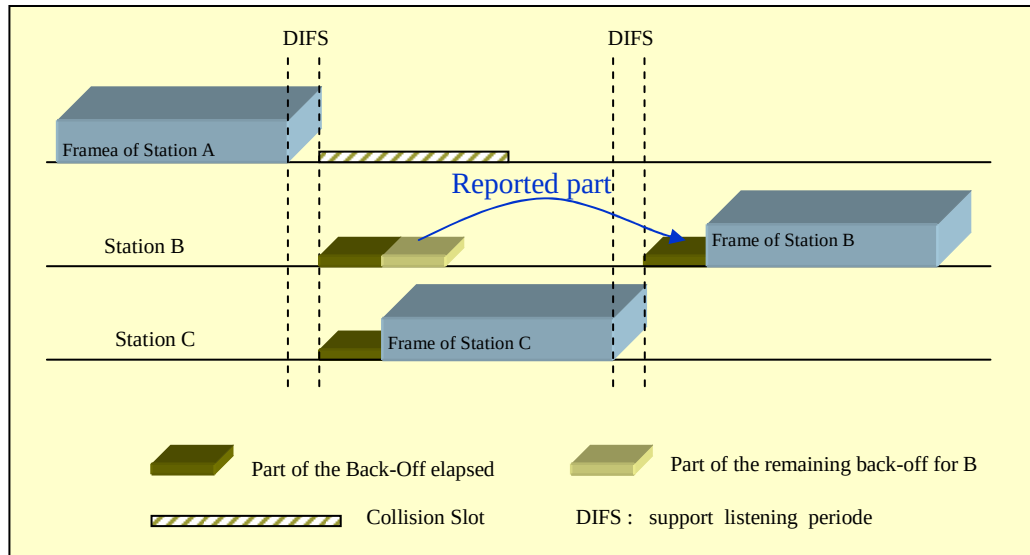
PIFS (PCF IFS) : utilisé par un point d'accès pour accéder avec priorité au média ; 30µs (SIFS + 1 timeslot de 20µs),

DIFS (DCF IFS) : utilisé par une station lorsqu'elle veut accéder au média ; 50µs.

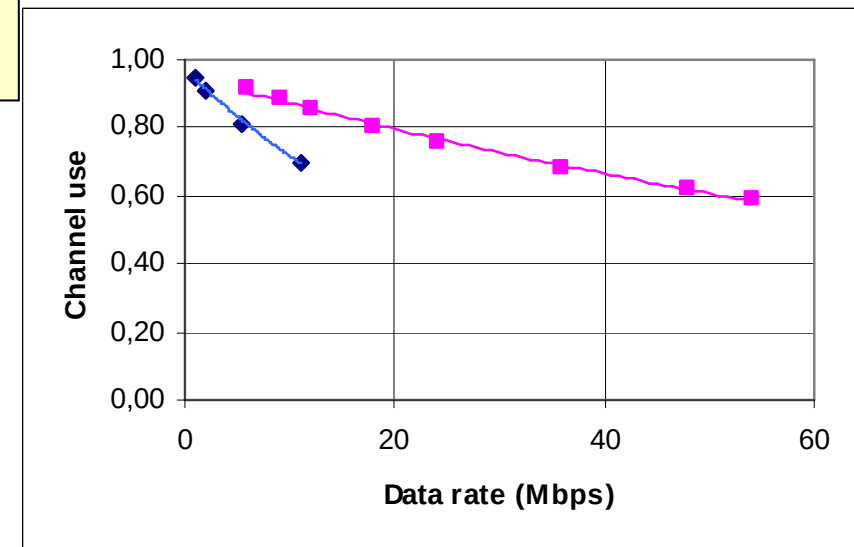


Aspect temporel des échanges de données en mode récepteur accordé "Span zéro"

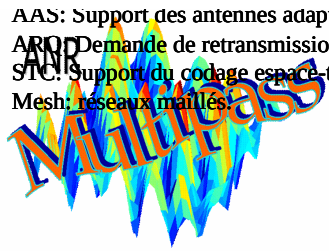




Aspect temporel: le protocole CSMA/CA





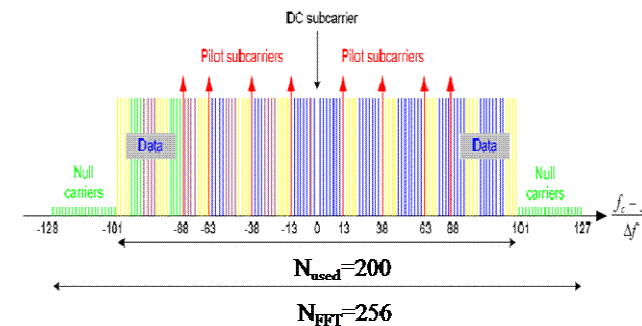


# Wimax / IEEE802.16

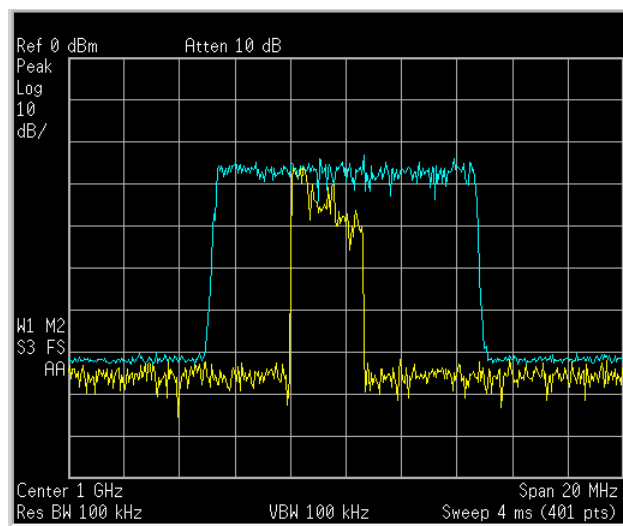


| Désignation       | Fréquences | LoS/NLoS | Options             | Duplexage |
|-------------------|------------|----------|---------------------|-----------|
| WirelessMAN-SC    | 10-66Ghz   | LoS      |                     | TDD,FDD   |
| WirelessMAN-SCa   | 2,5-11Ghz  | NLoS     | AAS, ARQ, STC       | TDD,FDD   |
| WirelessMAN-OFDM  | 2,5-11Ghz  | NLoS     | AAS, ARQ, STC, Mesh | TDD,FDD   |
| WirelessMAN-OFDMA | 2,5-11Ghz  | NLoS     | AAS, ARQ, STC       | TDD,FDD   |
| Wireless-HUMAN*   | 2,5-11Ghz  | NLoS     | ARQ, STC, Mesh      | TDD       |

AAS: Support des antennes adaptatives,  
 ARQ: Demande de retransmission automatique,  
 STC: Support du codage espace-temps,  
 Mesh: réseaux maillés.

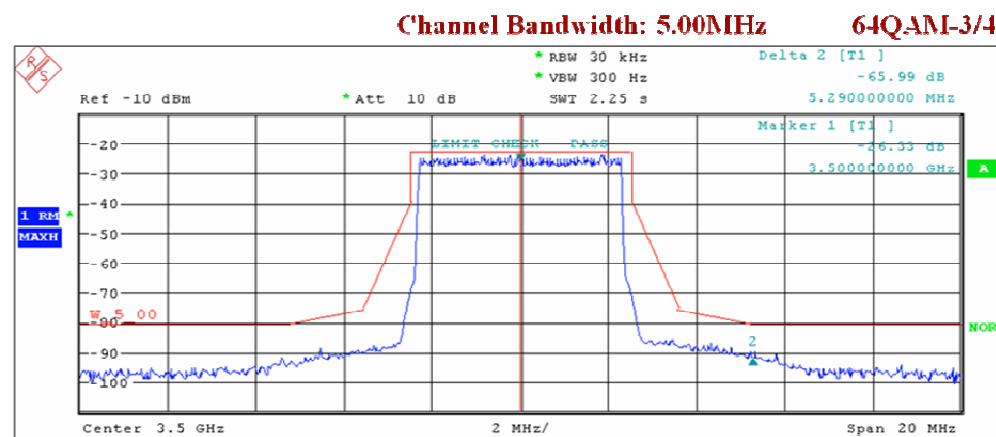


## Aspect fréquentiel de wimax



Spectre d'un signal Wimax de 10MHz de bande

| Parameter         | OFDM-2004                                   | OFDMA-2004                       | SOFDMA-16e                       | WIBRO        |
|-------------------|---------------------------------------------|----------------------------------|----------------------------------|--------------|
| FFT size          | 256                                         | 2048                             | 128,512,1024                     | 1024         |
| System bandwidth  | 1.25 – 28 MHz                               | 1.25 – 28 MHz                    | 1.25 – 20 MHz                    | 8.75 MHz     |
| Pilots            | Fixed (8)                                   | Fixed & Variable                 | Fixed & Variable                 | Fixed        |
| Preamble          | Long Preamble on DL<br>Short Preamble on UL | DL preamble only                 | DL preamble only                 | DL only      |
| Subchannelisation | UL only                                     | FUSC & PUSC                      | FUSC & PUSC                      | OFUSC & PUSC |
| CP ratio          | 1/4, 1/8, 1/16, 1/32                        | 1/4, 1/8, 1/16, 1/32             | 1/4, 1/8, 1/16, 1/32             | 1/8          |
| Frame length      | 2.5, 4, 5, 8, 10, 12.5, 20 ms               | 2, 2.5, 4, 5, 8, 10, 12.5, 20 ms | 2, 2.5, 4, 5, 8, 10, 12.5, 20 ms | 5 ms         |



## Aspect temporel: Exemple de structure de trame OFDMA en mode TDD

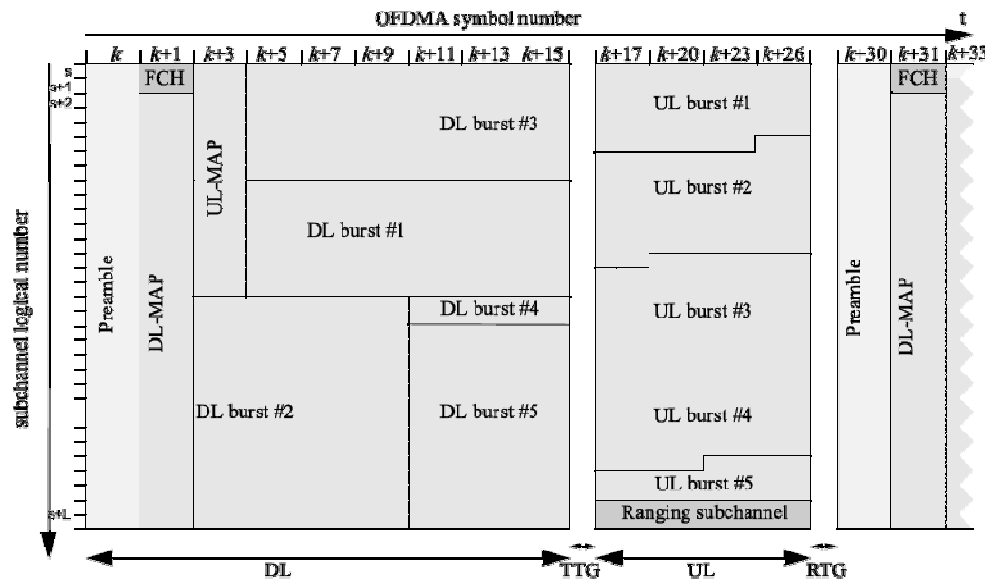
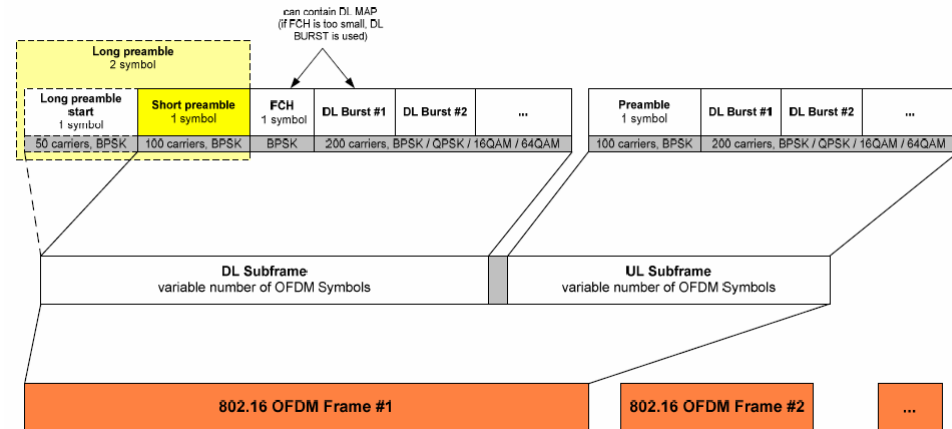
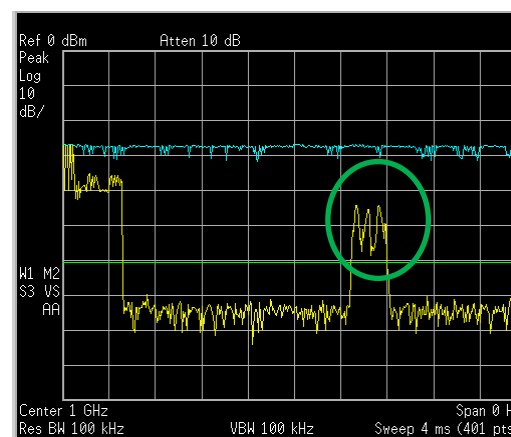
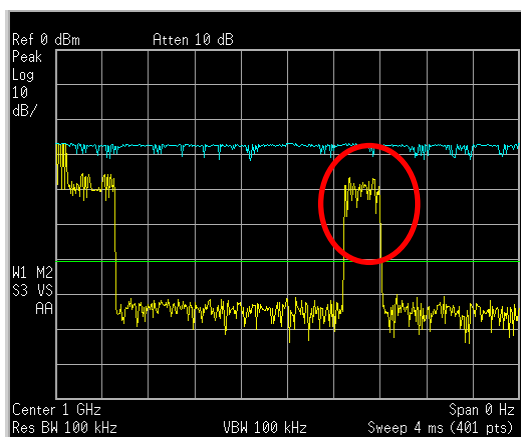


Table 274—OFDMA frame duration ( $T_F$  ms) codes

| Code (N) | Frame duration (ms) | Frames per second                                 |
|----------|---------------------|---------------------------------------------------|
| 0        | N/A                 | AAS-only gap up to 200 ms following (see 8.4.6.3) |
| 1        | 2                   | 500                                               |
| 2        | 2.5                 | 400                                               |
| 3        | 4                   | 250                                               |
| 4        | 5                   | 200                                               |
| 5        | 8                   | 125                                               |
| 6        | 10                  | 100                                               |
| 7        | 12.5                | 80                                                |
| 8        | 20 ms               | 50                                                |
| 9–255    | reserved            |                                                   |

## Problématique de la variation de puissance: PAPR en OFDM



Trames Wimax (DL+UL) 5ms

La zone UL est présentée avec deux modulations  
différentes

QAM64

et

QPSK

### Some DECT properties:

- Audio codec: G.726
- Net bit rate: 32 kbit/s
- Frequency: 1880 MHz–1900 MHz in Europe, 1900 MHz-1920 MHz in China, 1910 MHz-1930 MHz in Latin America and 1920 MHz–1930 MHz in the US
- Carriers: 10 (1,728 kHz spacing) in Europe, 5 (1,728 kHz spacing) in the US
- Time slots: 2 x 12 (up and down stream)
- Channel allocation: dynamic
- Average transmission power: 10 mW (250 mW peak) in Europe, 4 mW (100 mW peak) in the US
- The DECT physical layer uses:
  - Frequency division multiple access (FDMA),
  - Time division multiple access (TDMA) and
  - Time division duplex (TDD)

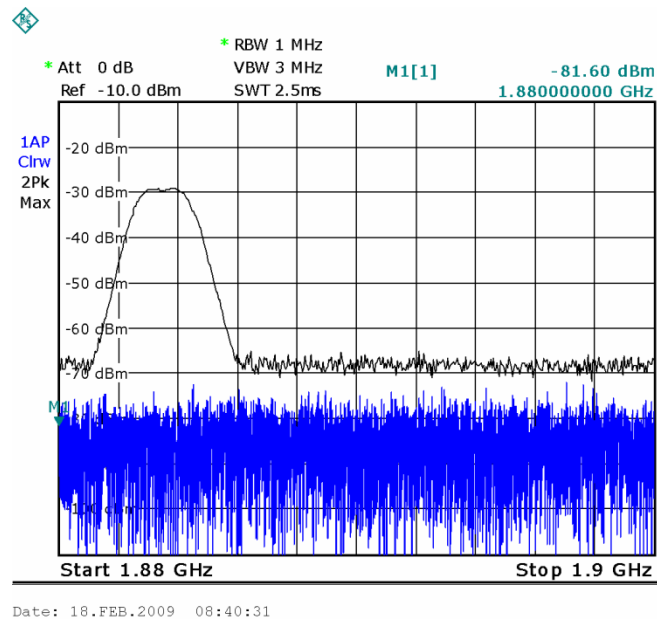
This means that the radio spectrum is divided into physical channels in two dimensions: frequency and time.

- The maximum allowed power for portable equipment as well as base stations is 250 mW. A portable device radiates an average of about 10 mW during a call as it is only using one of 24 time slots to transmit.

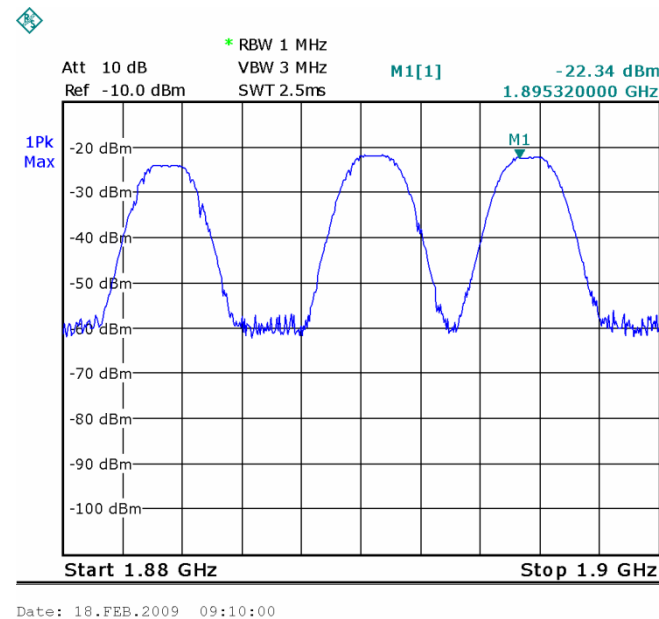
## Aspect fréquentiel:

- le téléphone et la base n'utilise qu'un canal parmi 10 pour les canaux commun et user, changement de fréquence si besoin.

### Un canal



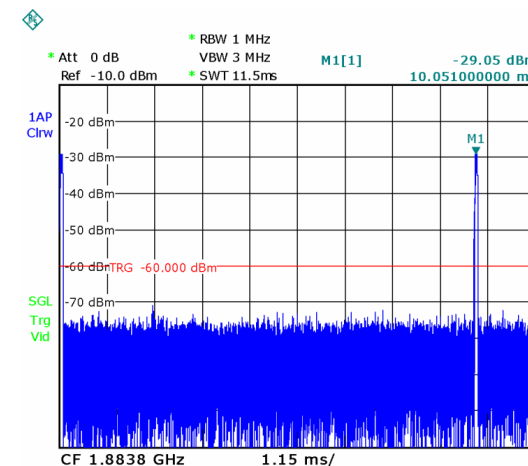
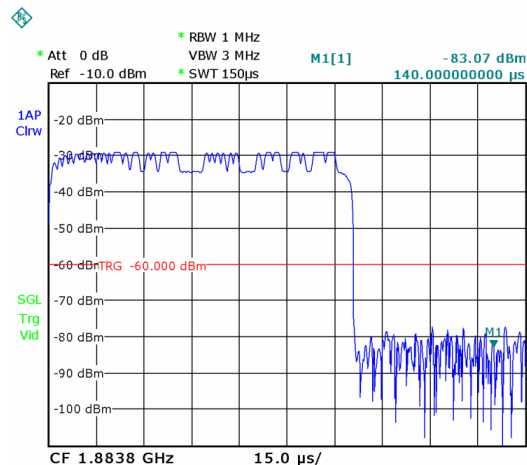
### Plusieurs canaux dans la bande 1880-1900MHz



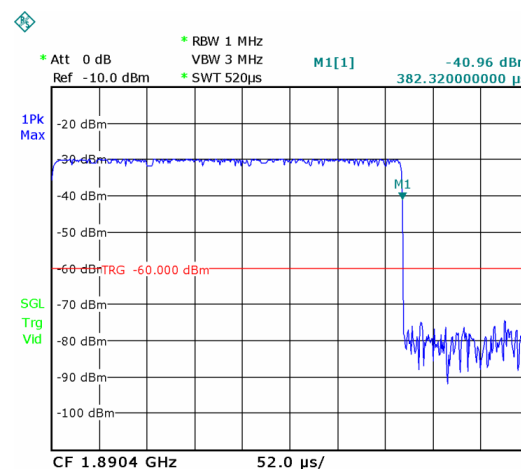
## Aspects temporel:

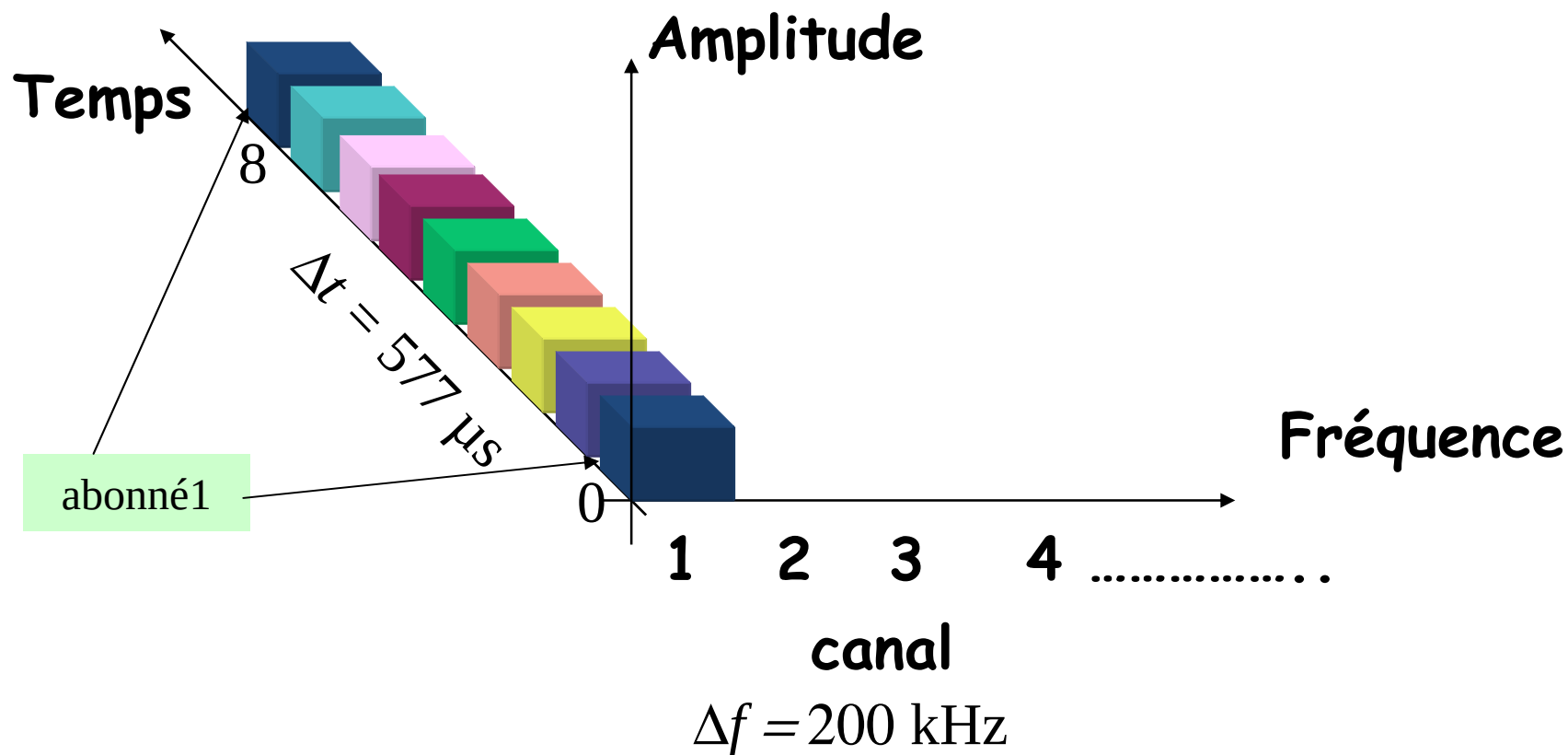
Remarque importante: La base émet continuellement (10ms de période), le combiné n'émet que s'il est en communication.

Burst de signalisation: 0.105 /10ms

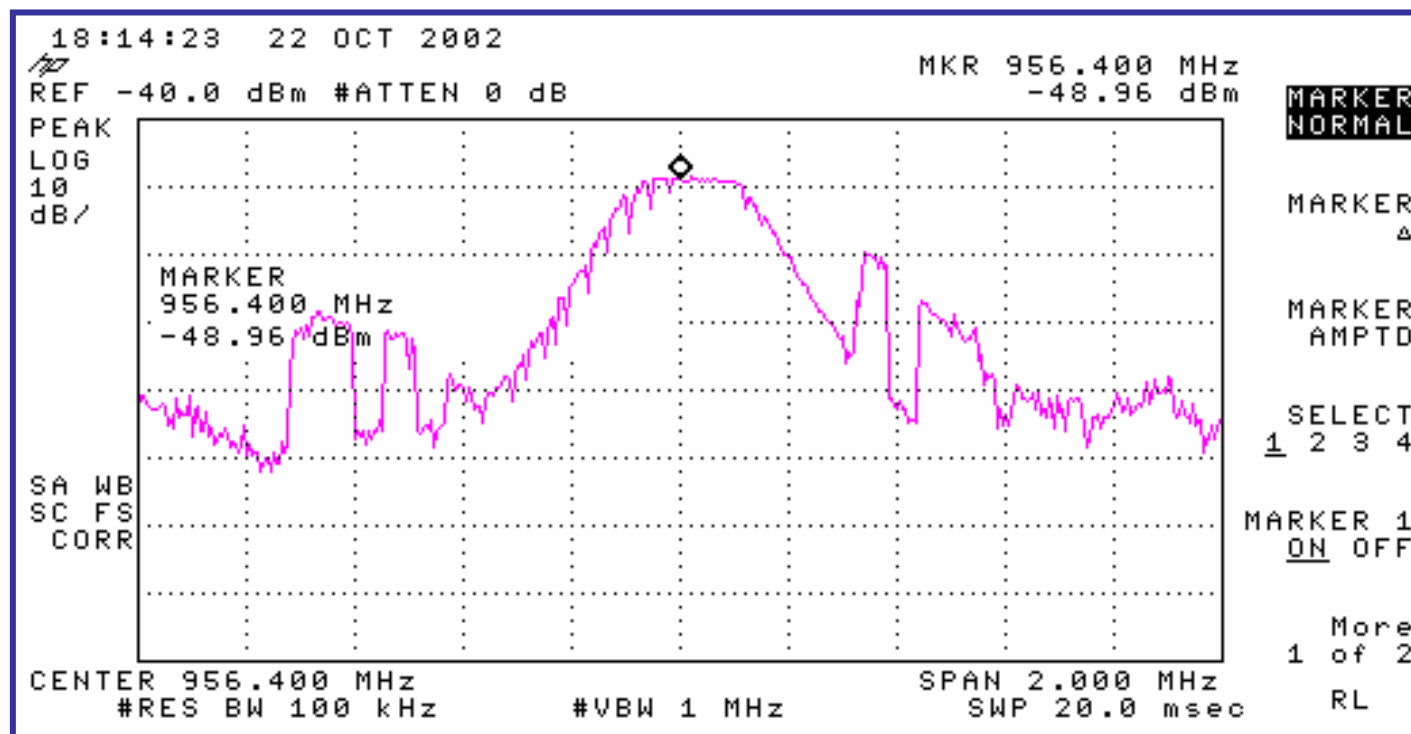


Burst en mode communication: 0.385/10ms









- fonctionnement avec des bandes 5 MHz de spectre
  - 12 bandes pour le mode FDD-WCDMA préférentiellement
  - 12 bandes pour le mode TD-CDMA uniquement (7 en Europe)

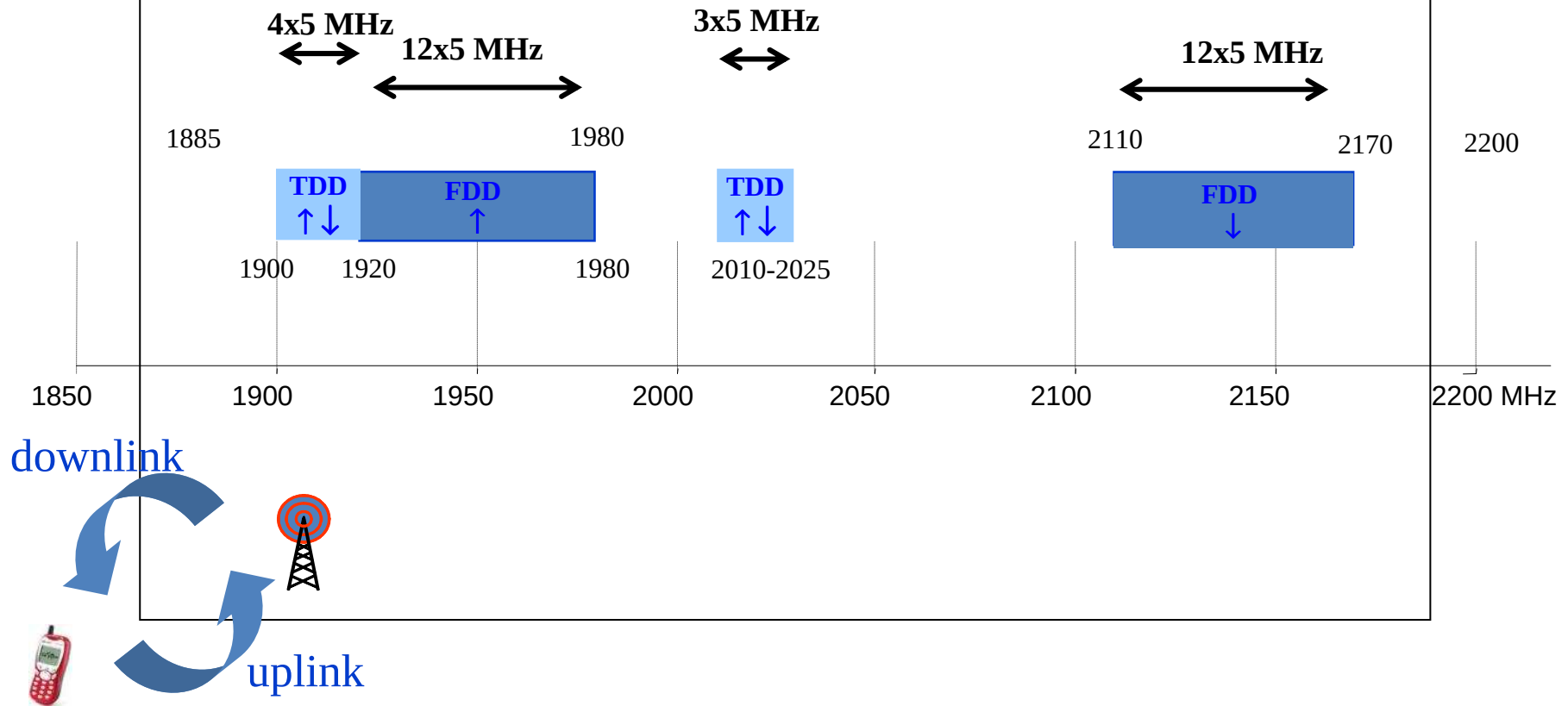
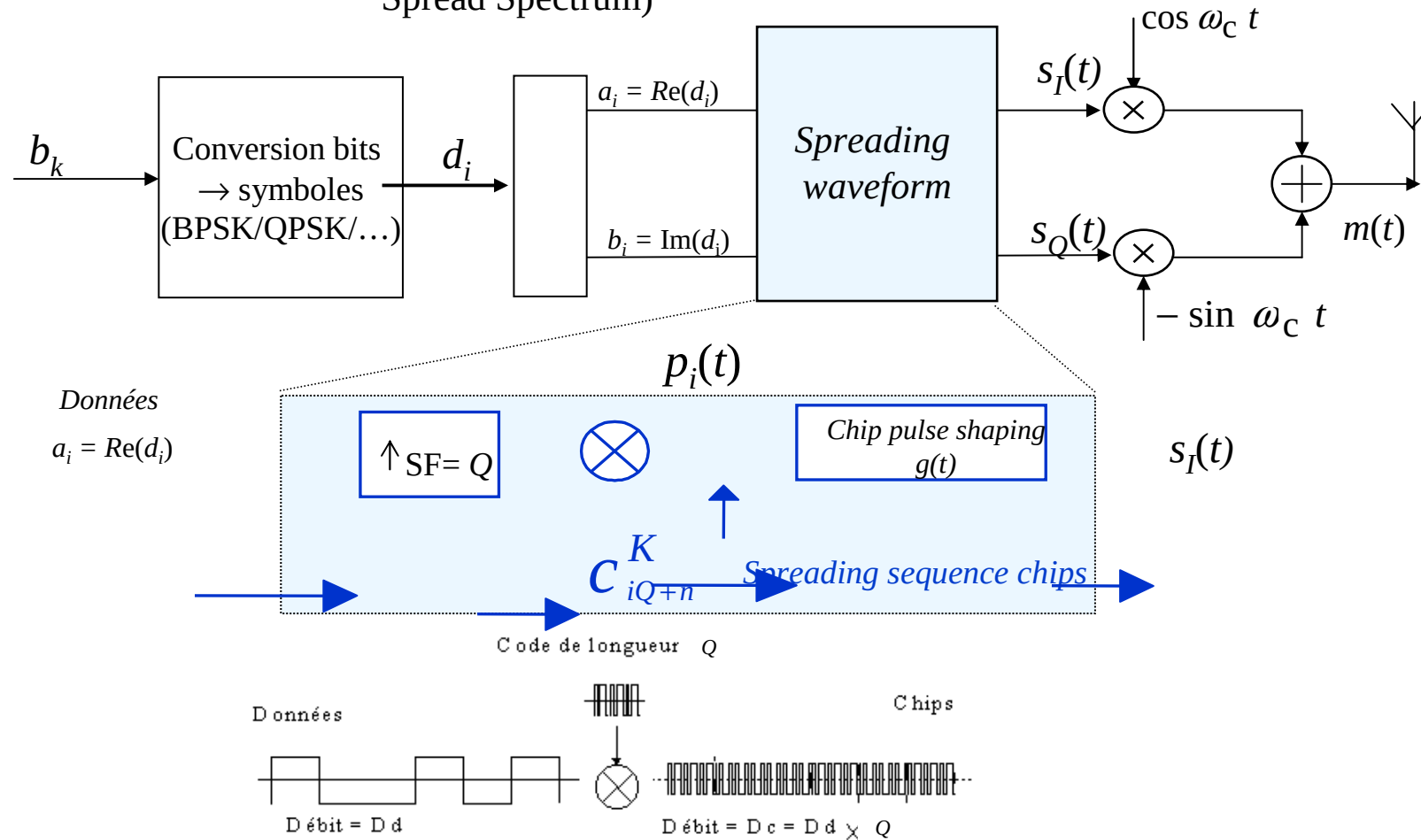
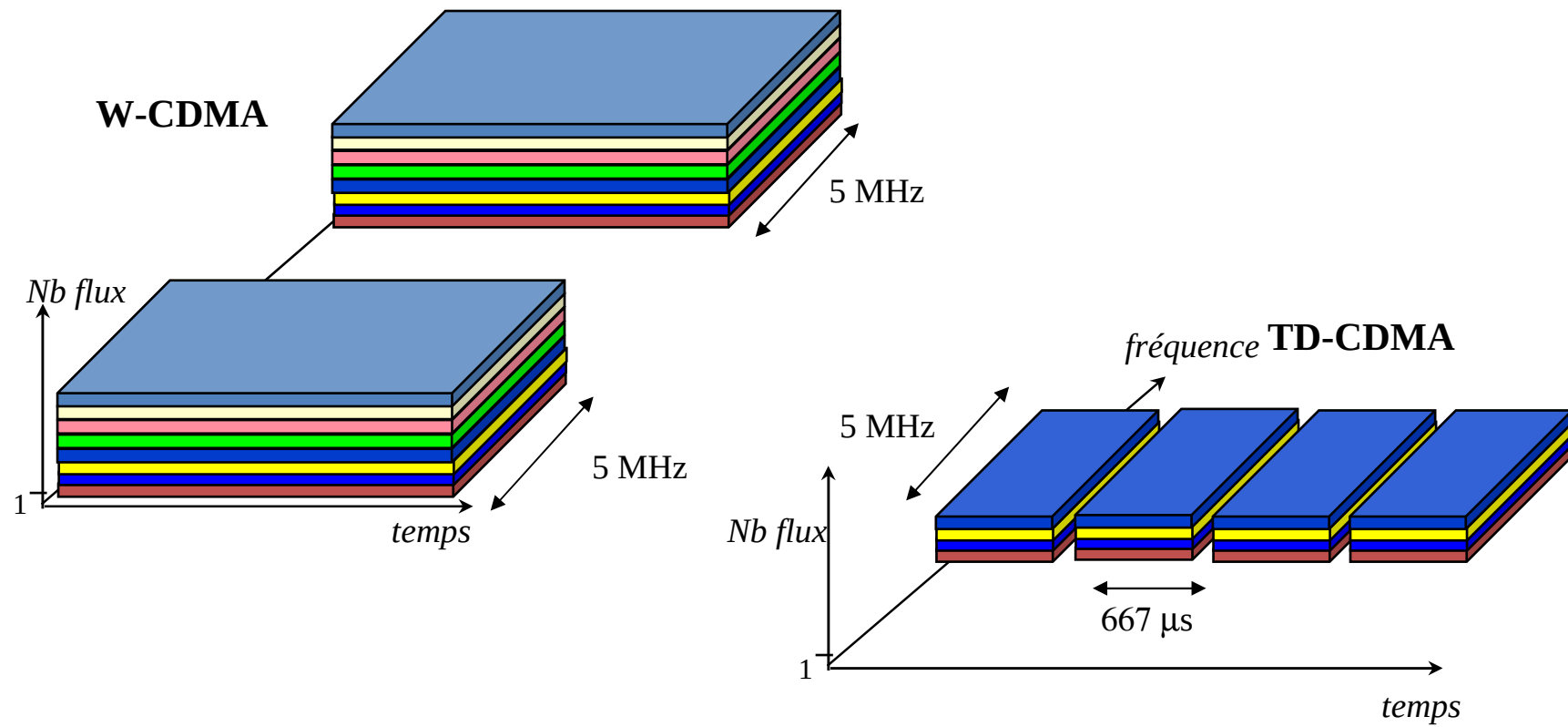
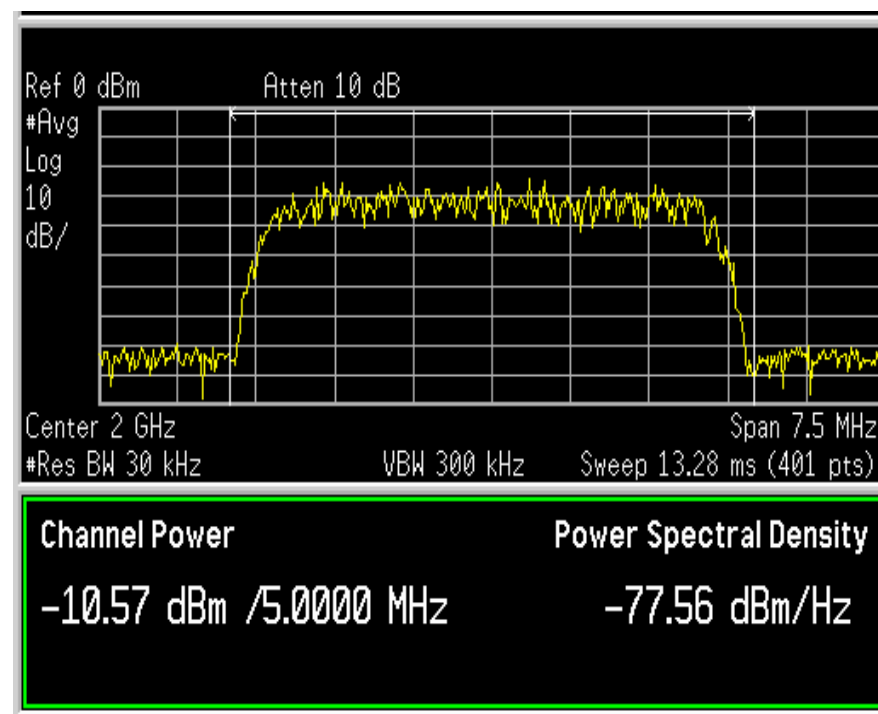
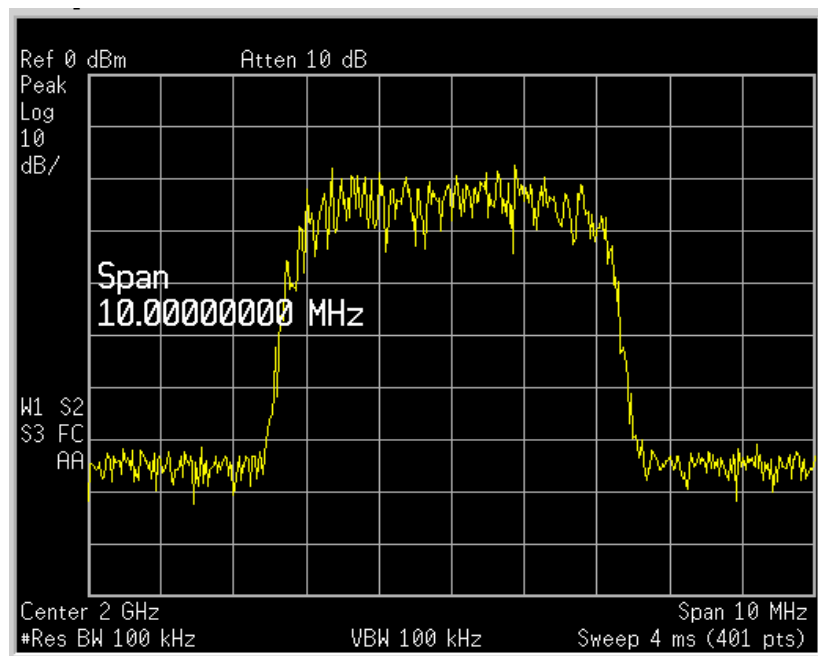


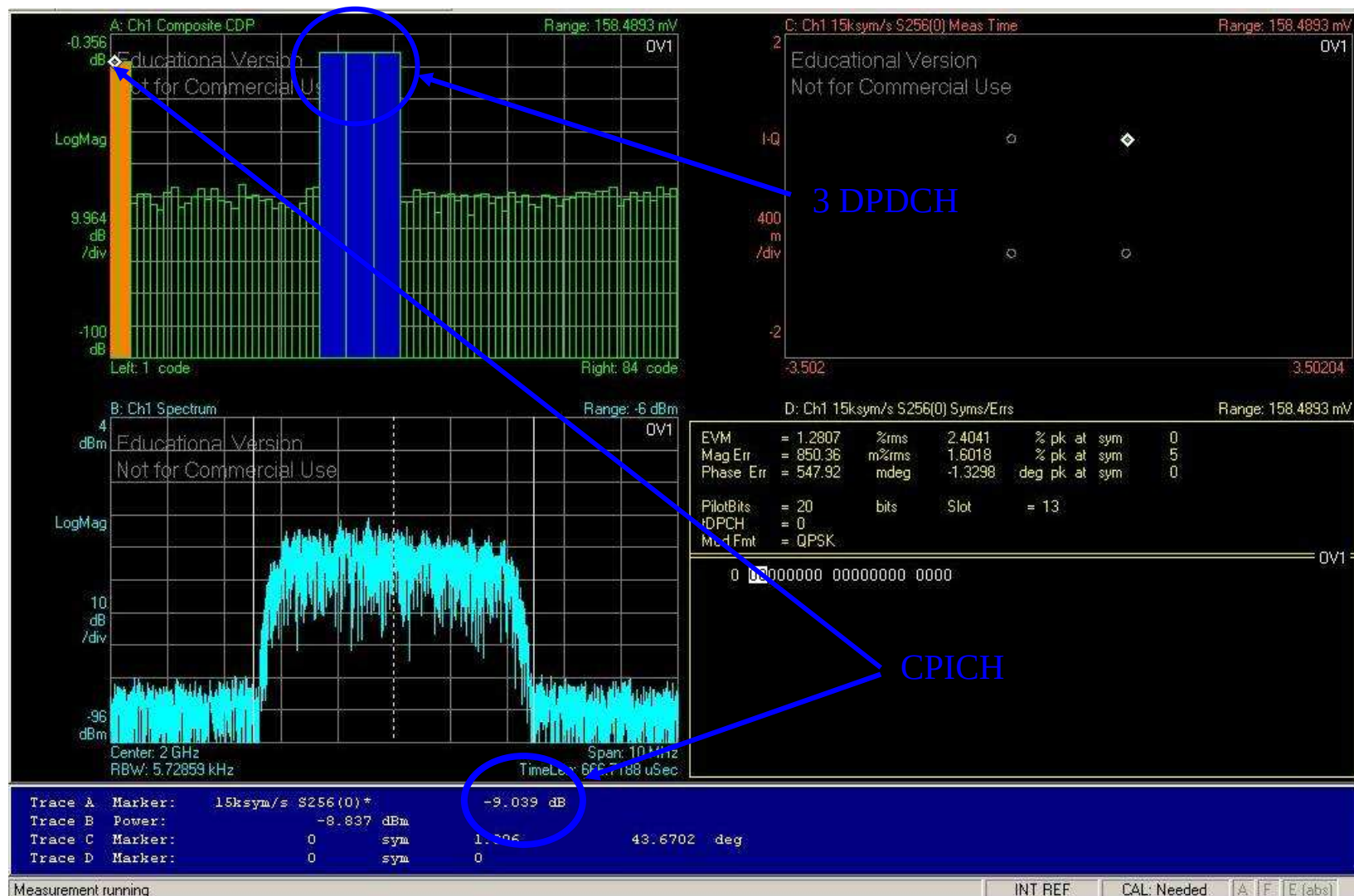
Schéma du modulateur à étalement de spectre (DSSS Direct Sequence Spread Spectrum)

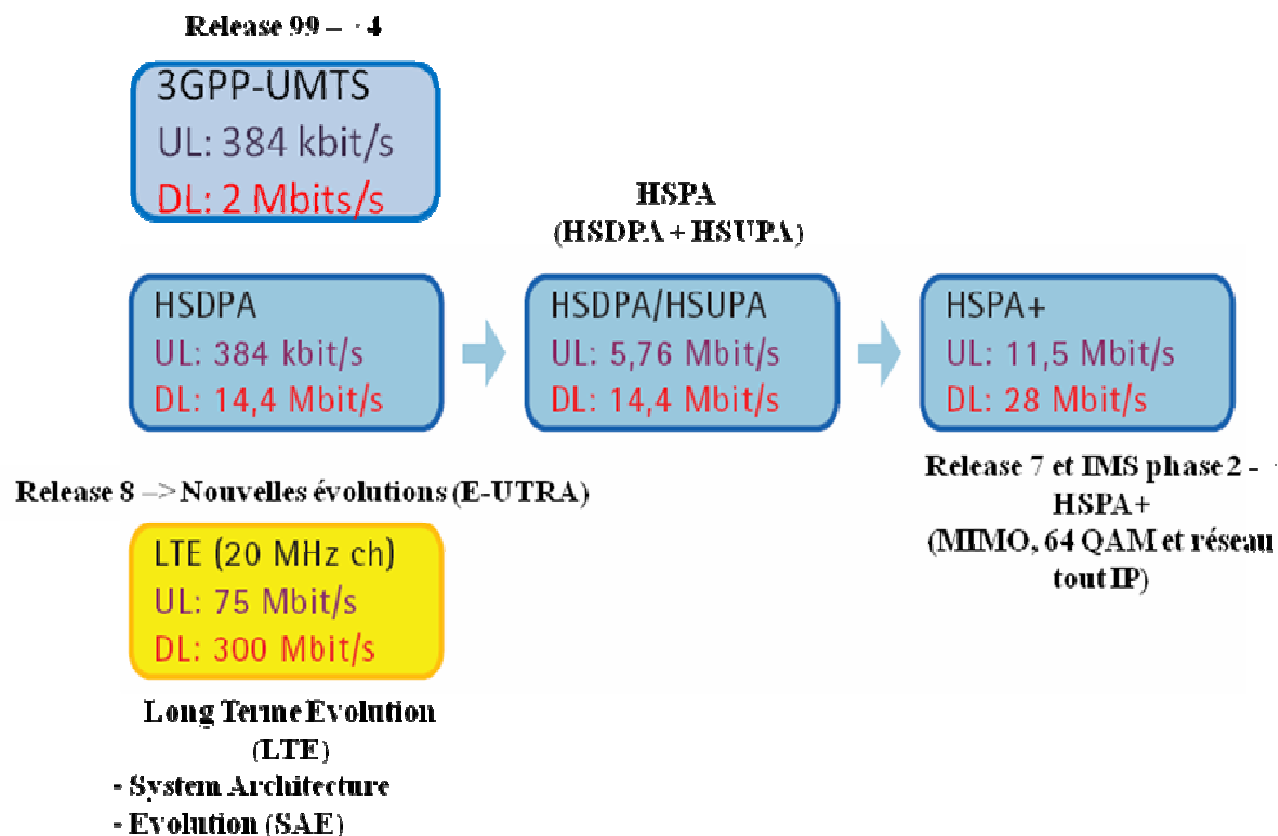




## Spectre UMTS

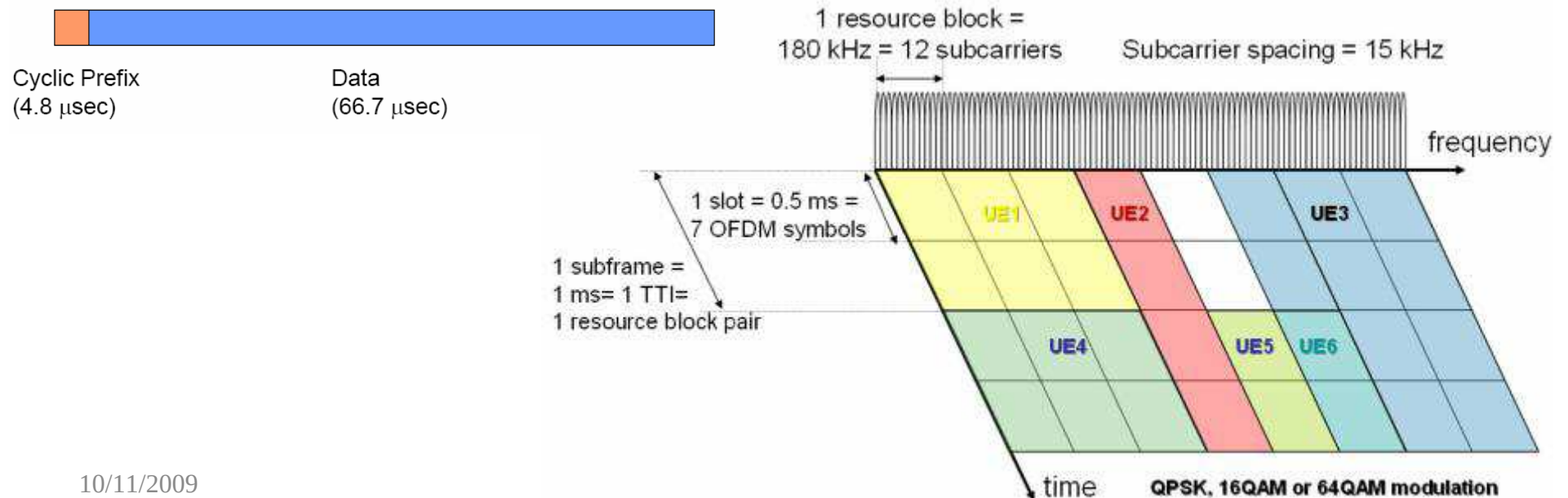




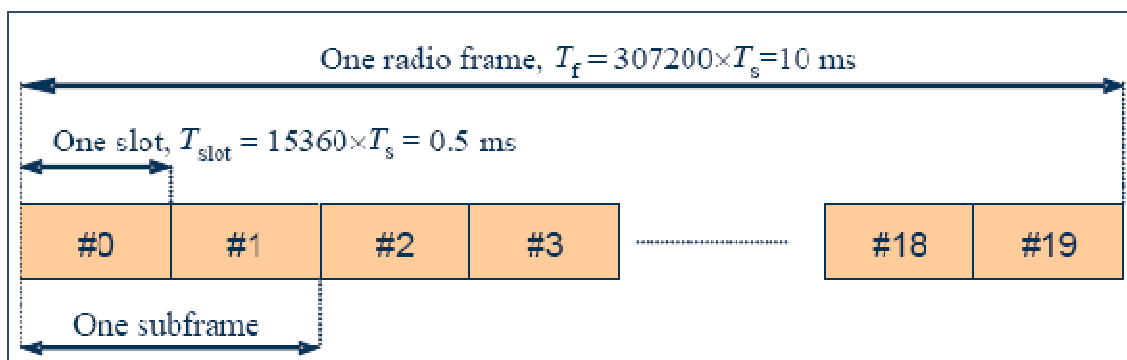


## Caractéristiques principales de LTE:

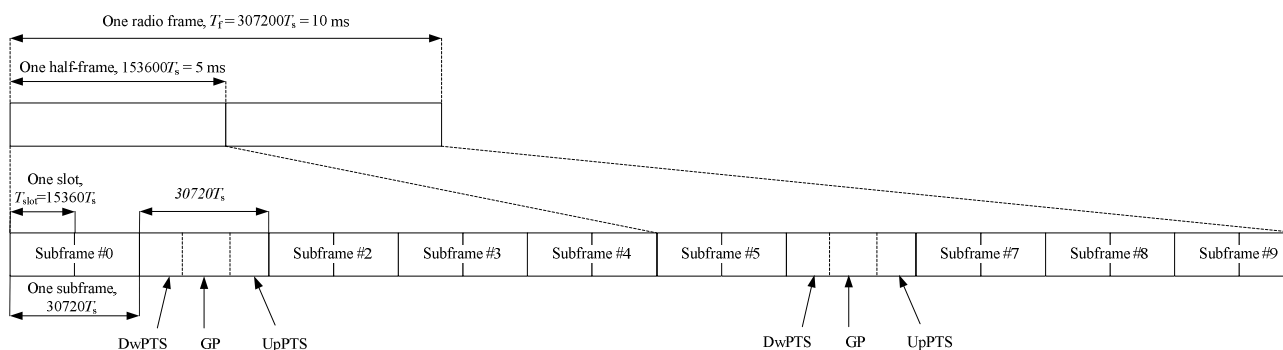
- nombre de sous-porteuses variable suivant la bande de fréquence (1,25 1,6 2,5 5 10 15 et 20 MHz),
- espacement entre sous-porteuses  $Df = 15$  kHz,
- Temps symbole  $T_s = 1/Df + \text{durée du préfixe cyclique}$ ,
- préfixe cyclique (CP) maintient l'orthogonalité entre les sous-porteuses malgré les multi-trajets = temps de garde, il élimine l'interférence entre symboles (ISI)
- modulation utilisées : QPSK, 16QAM et 64QAM,
- Symboles OFDM groupés en block de  $12 \times 15$  kHz = 180 kHz (domaine des fréquences) et de 0,5 ms (domaine des temps),
- Transmission Time Interval (TTI) = 1 ms ( $2 T_s$ )







Structure d'une trame LTE en mode FDD (type 1)



Structure d'une trame LTE en mode TDD (type 2)

|                                  | Band<br>number | Uplink |        | Downlink |        | UP/DL<br>spacing | Duplex<br>mode |
|----------------------------------|----------------|--------|--------|----------|--------|------------------|----------------|
|                                  |                | Low    | High   | Low      | High   |                  |                |
| Reg. 1<br>Only<br>Reg. 1<br>Only | 1              | 1920   | 1980   | 2110     | 2170   | 130              | FDD            |
|                                  | 2              | 1850   | 1910   | 1930     | 1990   | 20               | FDD            |
|                                  | 3              | 1710   | 1785   | 1805     | 1880   | 20               | FDD            |
|                                  | 4              | 1710   | 1755   | 2110     | 2155   | 355              | FDD            |
|                                  | 5              | 824    | 849    | 869      | 894    | 20               | FDD            |
|                                  | 6              | 830    | 840    | 875      | 885    | 35               | FDD            |
|                                  | 7              | 2500   | 2570   | 2620     | 2690   | 50               | FDD            |
|                                  | 8              | 880    | 915    | 925      | 960    | 10               | FDD            |
|                                  | 9              | 1749,9 | 1784,9 | 1879,9   | 1879,9 | 95               | FDD            |
|                                  | 10             | 1710   | 1770   | 2110     | 2170   | 340              | FDD            |
|                                  | 11             | 1427,9 | 1452,9 | 1475,9   | 1500,9 | 23               | FDD            |
|                                  | 12             | 698    | 716    | 728      | 746    | 12               | FDD            |
|                                  | 13             | 777    | 787    | 746      | 756    | -41              | FDD            |
|                                  | 14             | 788    | 798    | 758      | 768    | -40              | FDD            |
|                                  | 15             | 1900   | 1920   | 2600     | 2620   | 680              | FDD            |
|                                  | 16             | 2010   | 2025   | 2585     | 2600   | 560              | FDD            |
|                                  | 17             | 704    | 716    | 734      | 746    | 18               | FDD            |
|                                  | ...            | ...    | ...    | ...      | ...    | ...              | ...            |
|                                  | 33             | 1900   | 1920   | 1900     | 1920   | 0                | TDD            |
|                                  | 34             | 2010   | 2025   | 2010     | 2025   | 0                | TDD            |
| 35                               | 1850           | 1910   | 1850   | 1910     | 0      | TDD              |                |
| 36                               | 1930           | 1990   | 1930   | 1990     | 0      | TDD              |                |
| 37                               | 1910           | 1930   | 1910   | 1930     | 0      | TDD              |                |
| 38                               | 2570           | 2620   | 2570   | 2620     | 0      | TDD              |                |
| 39                               | 1880           | 1920   | 1880   | 1920     | 0      | TDD              |                |
| 40                               | 2300           | 2400   | 2300   | 2400     | 0      | TDD              |                |

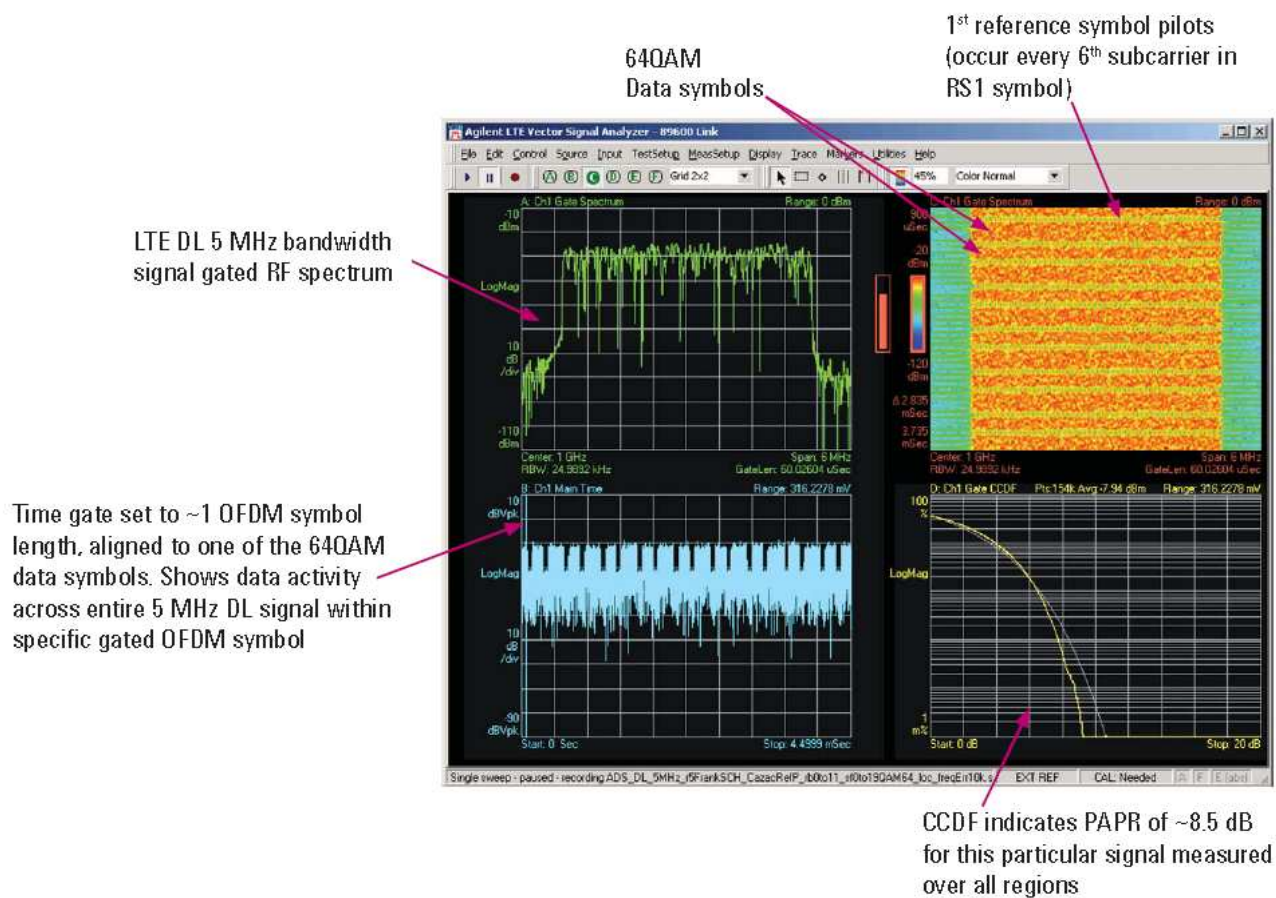


# 3GPP LTE/SAE



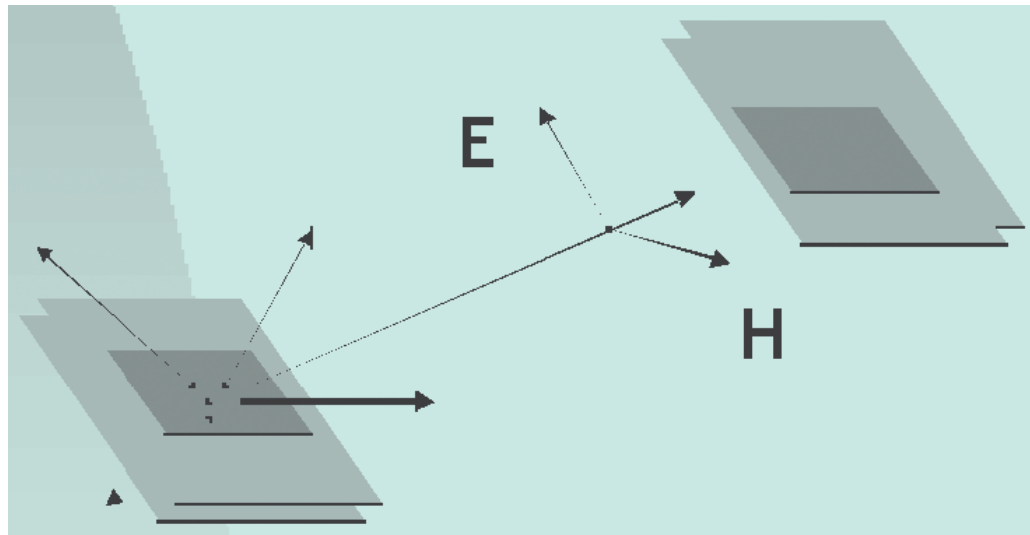
| Channel Bandwidth (MHz)                    |     |     |    |      |     |
|--------------------------------------------|-----|-----|----|------|-----|
| 1,4                                        | 3   | 5   | 10 | 15   | 20  |
| Transmission Bandwidth configuration (MHz) |     |     |    |      |     |
| 1,08                                       | 2,7 | 4,5 | 9  | 13,5 | 18  |
| Transmission Bandwidth configuration (RB)  |     |     |    |      |     |
| 6                                          | 15  | 25  | 50 | 75   | 100 |

| Transmission BW (MHz)           |          | 1.4                | 3    | 5    | 10    | 15    | 20    |
|---------------------------------|----------|--------------------|------|------|-------|-------|-------|
| Sub-frame duration              |          | 1.0 ms             |      |      |       |       |       |
| Sub-carrier spacing             |          | 15 kHz             |      |      |       |       |       |
| Sampling frequency (MHz)        |          | 1.92               | 3.84 | 7.68 | 15.36 | 23.04 | 30.72 |
| FFT size                        |          | 128                | 256  | 512  | 1024  | 1536  | 2048  |
| Number of occupied sub-carriers |          | 72                 | 180  | 300  | 600   | 900   | 1200  |
| CP length (μs)                  | Normal   | 4.69 × 6, 5.21 × 1 |      |      |       |       |       |
|                                 | Extended | 16.6               |      |      |       |       |       |

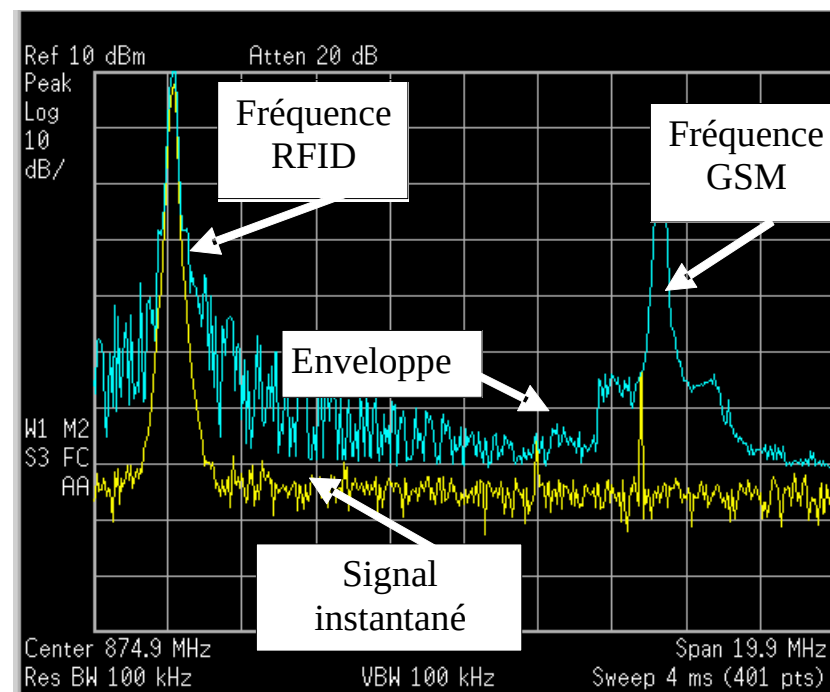
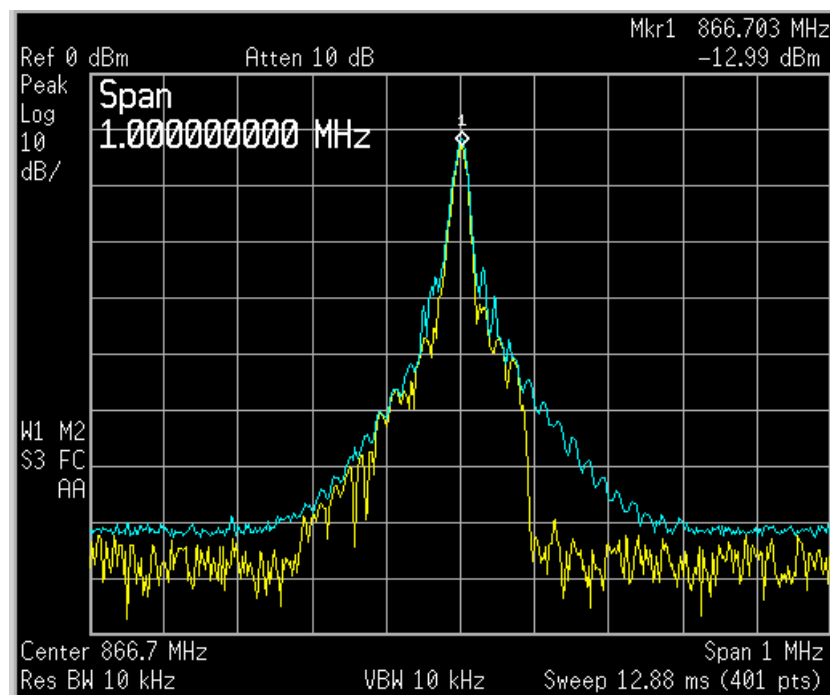


## ➤ Couplage lecteur/TAG

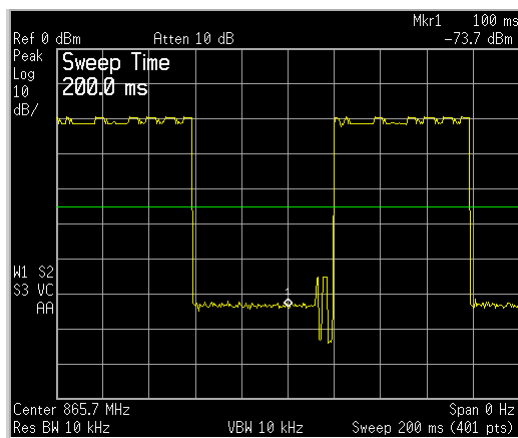
- Couplage en « hautes fréquences » : **868 MHz, 2.45 GHz**
  - Distances > longueur d'onde (dizaine de cm)
  - Antennes imprimées
  - Couplage radiatif champ proche/lointain
  - Décroissance du champ en  $1/r$



## Aspect Fréquentiel

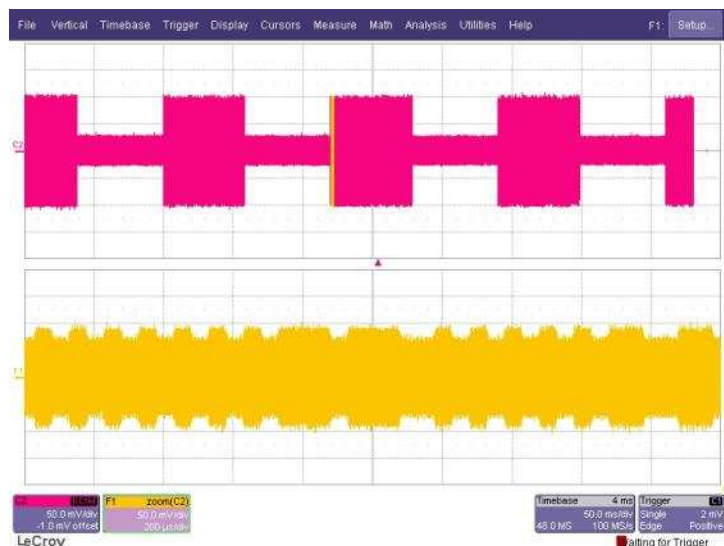
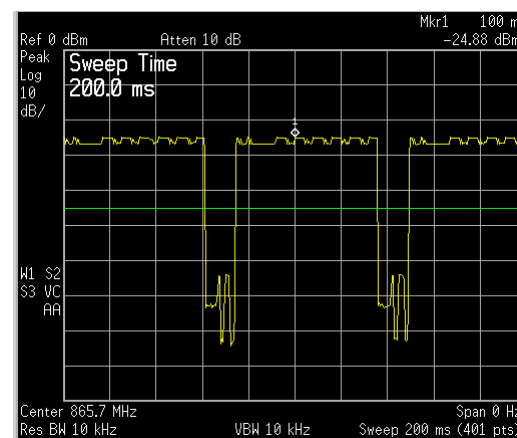


« à vide »

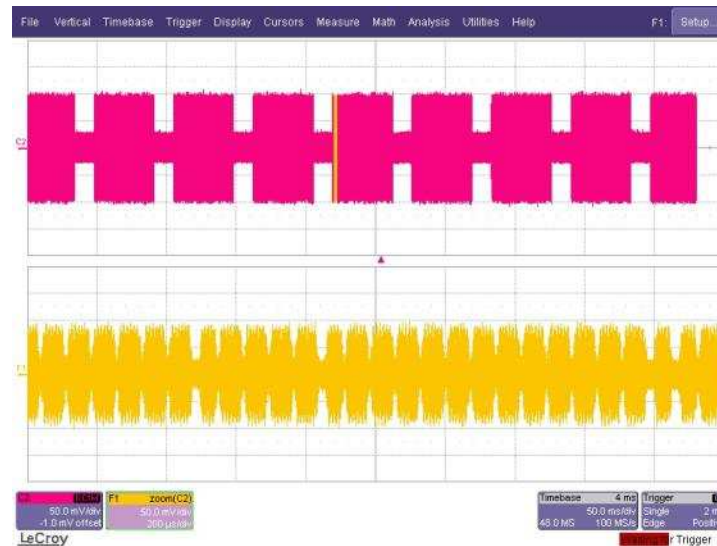


Aspect Temporel

« en charge »



10/11/2009



T. LETERTRE

39