

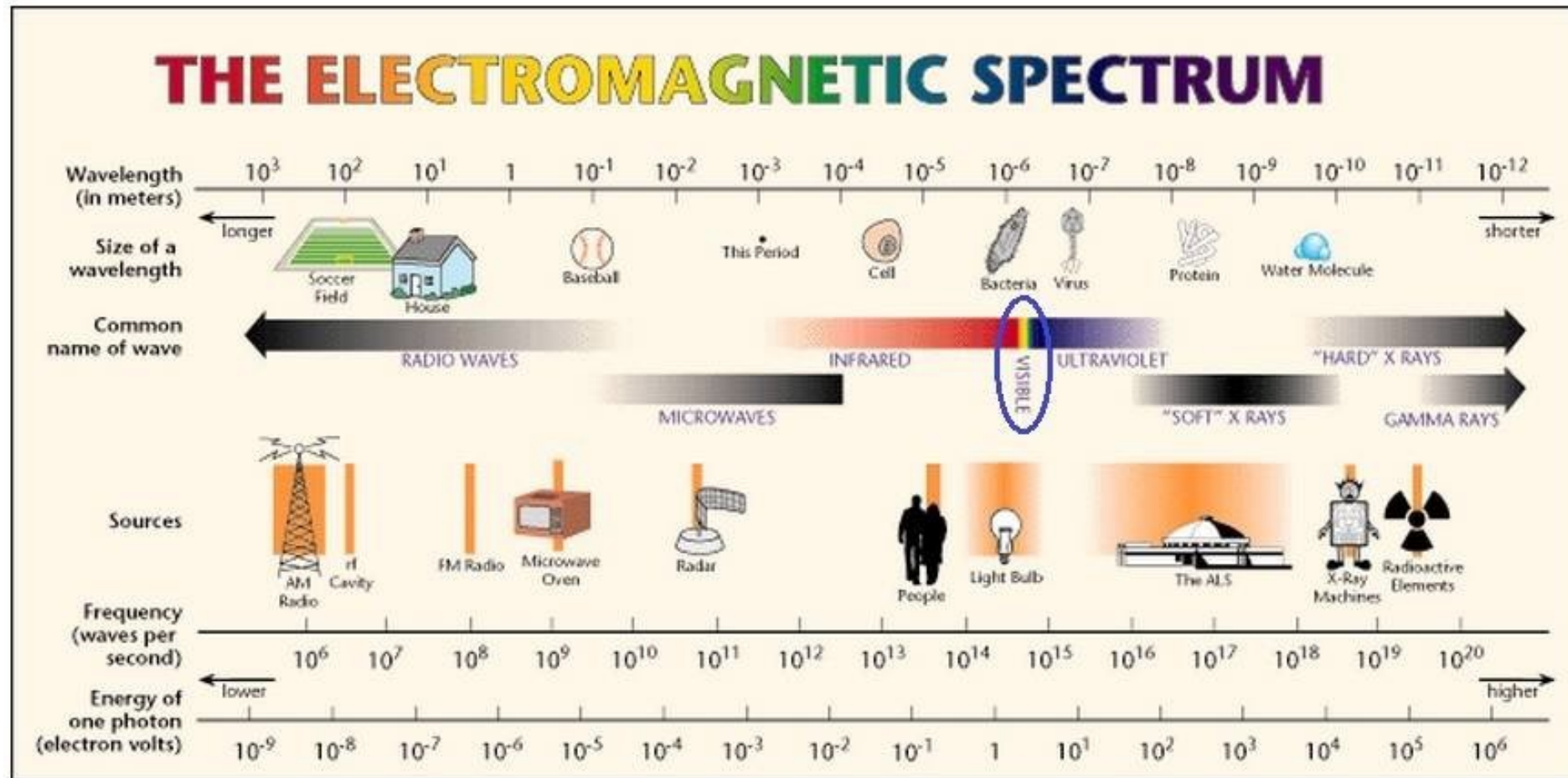
# Agenda

Chapter 1	Historique, Spectre, Règlementation
Chapter 2	Propriété ondes EM, Antennes, Diversity, Câblage
Chapter 3	Modulation. Numérique/Analogique
Chapter 4	Interférence, C/N
Chapter 5	Linéarité, Intermodulation
Chapter 6	Conclusion

# Historique



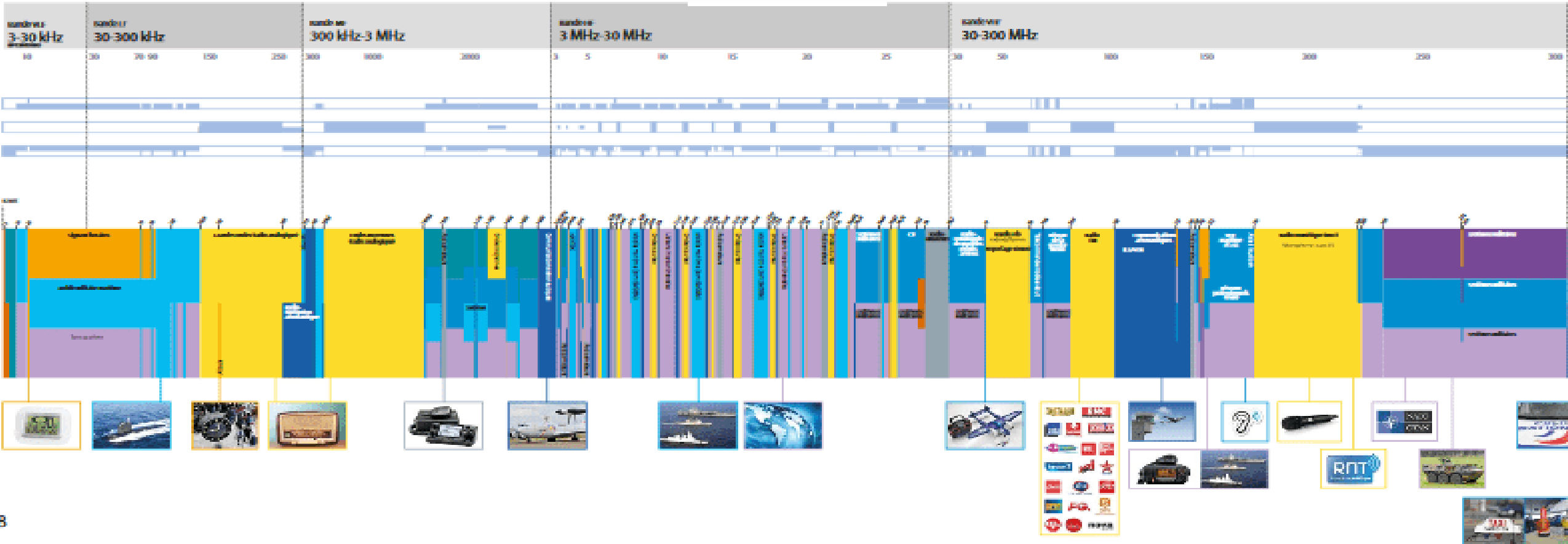
# Le Spectre Electromagnétique



# Reglementation



# Le Spectre Electromagnétique



# Règlementation - Outils

▶ ANFR

- <https://scanfrequencies.anfr.fr/>

▶ Tapage/DCA

- <http://www.scanzone.fr/>

Coordonnées GPS (degrés décimaux)\*

Latitude : 43.2545

Longitude : 5.3722

Afficher sur la carte

\* Système géodésique mondial WGS 84

Mémoriser le point de mesure

Afficher les points de mesure



dByV/m dBm

Télécharger au format CSV



Listes des émetteurs

Ville : LILLE CodePostal : 59800 Longitude : 3.066 Latitude : 50.633

594.500

Mes HF

Critique

Important

Moyen

Faible

Fréquences / Canaux  
590 Mhz - 598 Mhz

Détail émetteur  
Station : LILLE Canal : 36  
Chaîne : R Local Type : TNT  
Pays : France Puissance : 10 KW

# Règlementation



Headphones & Soundbars

Pro Audio

Office Headsets

Business

Support



## Sennheiser International Frequency Advisor (SIFA)

Your peace of mind is our goal.

<https://fr-fr.sennheiser.com/sifa>

# Règlementation

MHz Range	TV CH	License Status	Max Transmission Power	Bandwidth	Notes	Source Reference
174.0000 - 223.0000	-	Licence Exempt	50mW ERP			<a href="#">View</a>
470.0000 - 694.0000	-	Licence Exempt	50mW ERP			<a href="#">View</a>
823.0000 - 826.0000	-	Licence Exempt	20mW EIRP		Up to 100mW permitted for body-worn equipment.	<a href="#">View</a>
826.0000 - 832.0000	-	Licence Exempt	100mW EIRP			<a href="#">View</a>
1785.0000 - 1800.0000	-	Licence Exempt	20mW EIRP			<a href="#">View</a>



# Règlementation - Largeur de bande

2

Draft ETSI EN 302 217-2 V3.0.8 (2016-06)

Reference  
REN/ATTM-0431

Keywords  
antenna, DFRS, digital, DRRS, FWA,  
point-to-point, radio, regulation, transmission

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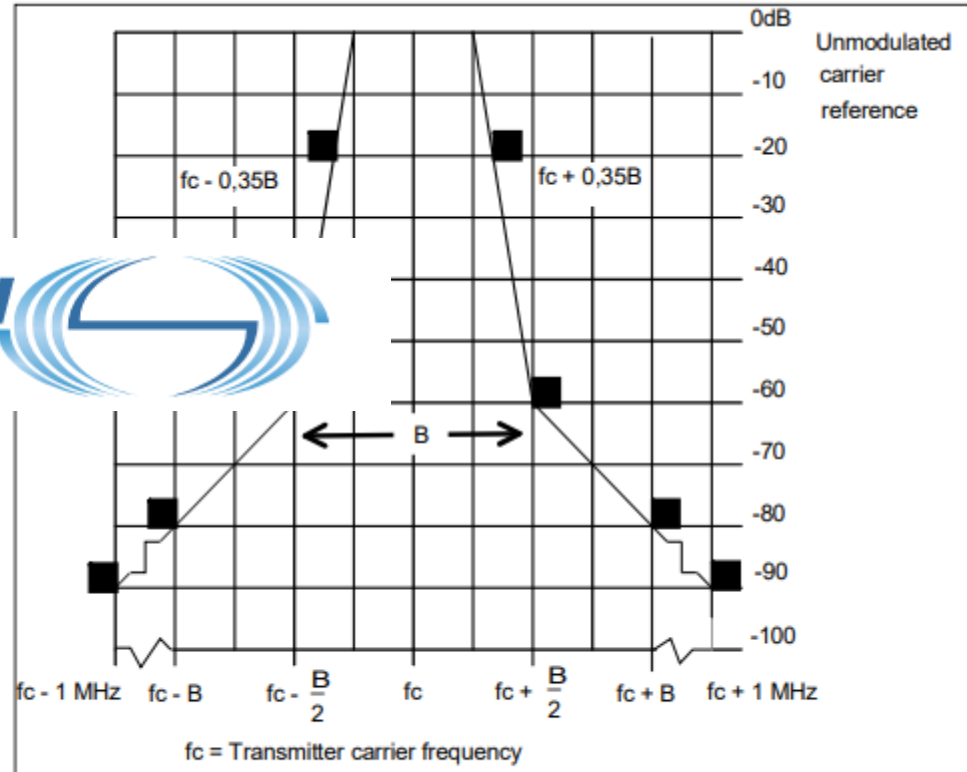


Figure 3: Spectrum mask for analogue systems

# Le Spectre Electromagnétique

- ▶ Longueur d'onde – Propriétés

**F**

**$\lambda$**

300MHz – 3GHz (UHF)

1m – 10cm

470 MHz – 694 MHz

autour de 50cm

1,9 GHz

environ 15cm

2,4 GHz

environ 12cm

- ▶ Phénomène ondulatoire / Réflexion, Diffraction
- ▶ Taille antenne, propagation, occupation.



# Spectre – réglementation – Onde EM

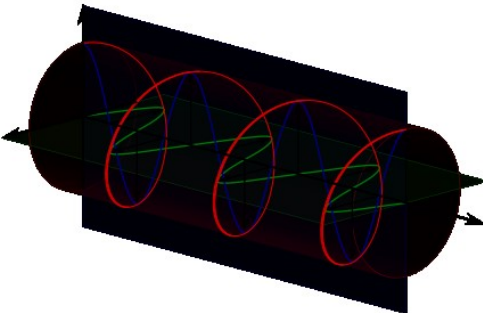
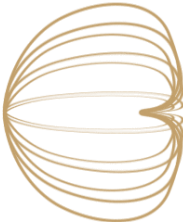
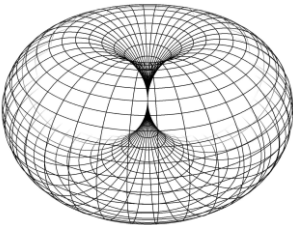
- ▶ Spectre UHF

470MHz – 694MHz

Duplex Gap LTE, DECT, Wi-Fi...

- ▶ Occupation spectrale – 200KHz
- ▶ **Propagation.** La pénétration décroît avec la fréquence
- ▶ **Reflexion.** Les hautes fréquences se réfléchissent plus que les basse fréquences (Dans nos environnements)
- ▶ **Portée.** Les hautes fréquences nécessitent plus de puissance pour couvrir la même distance.
- ▶ **Cable Loss.** La perte dans les câbles croît avec la fréquence.

# Antennes



+4dBi



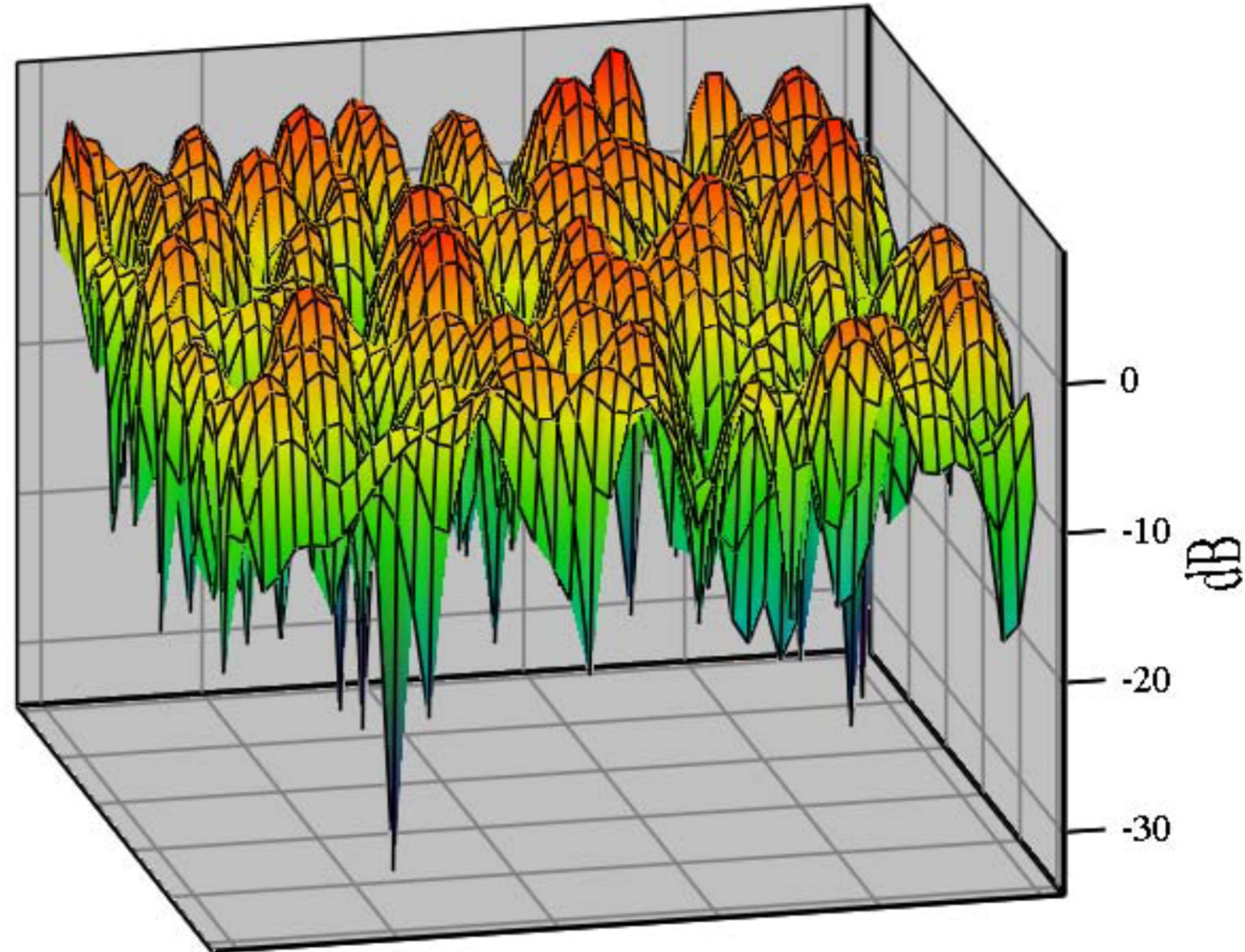
+8dBi



Antenna Polarization

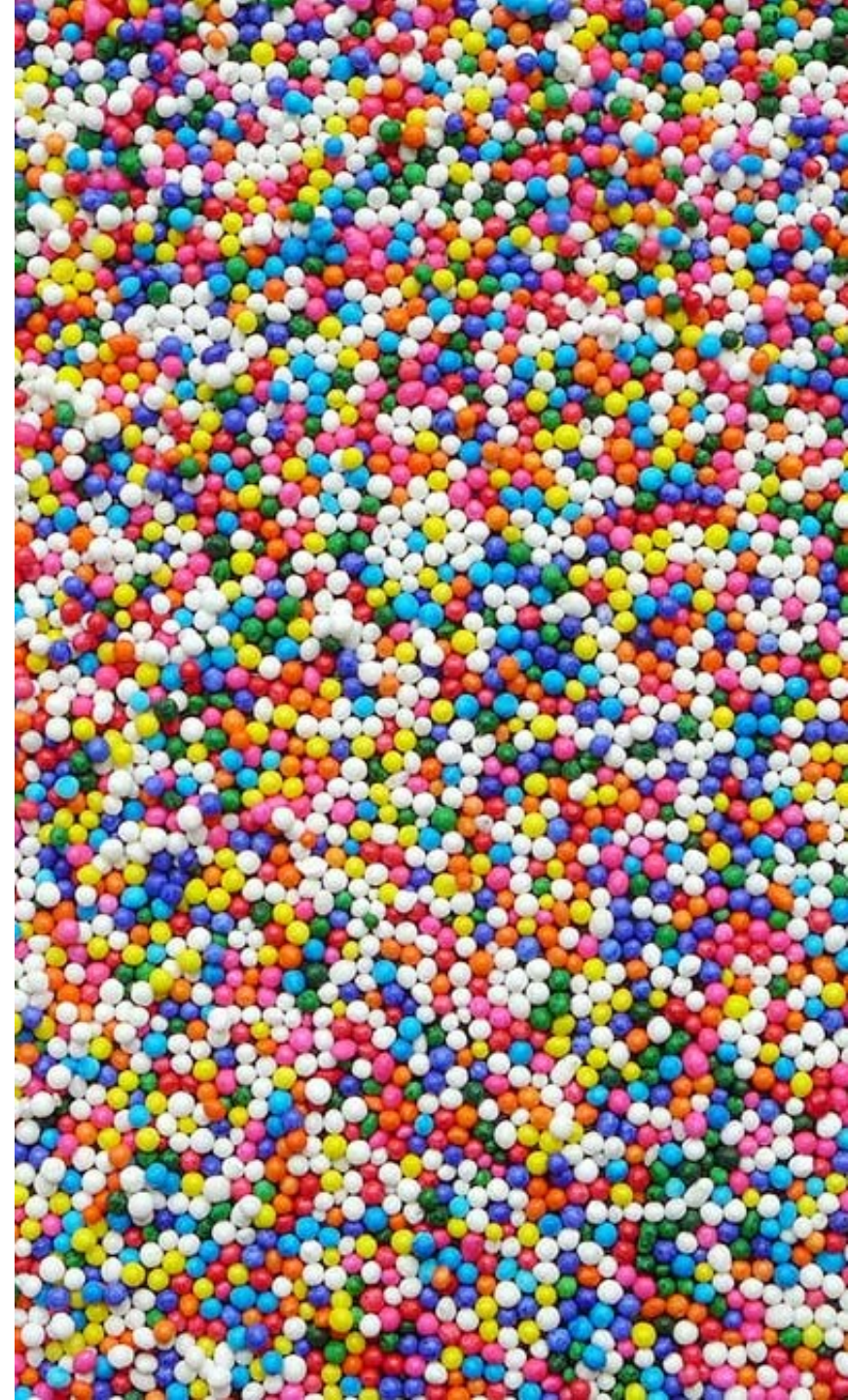
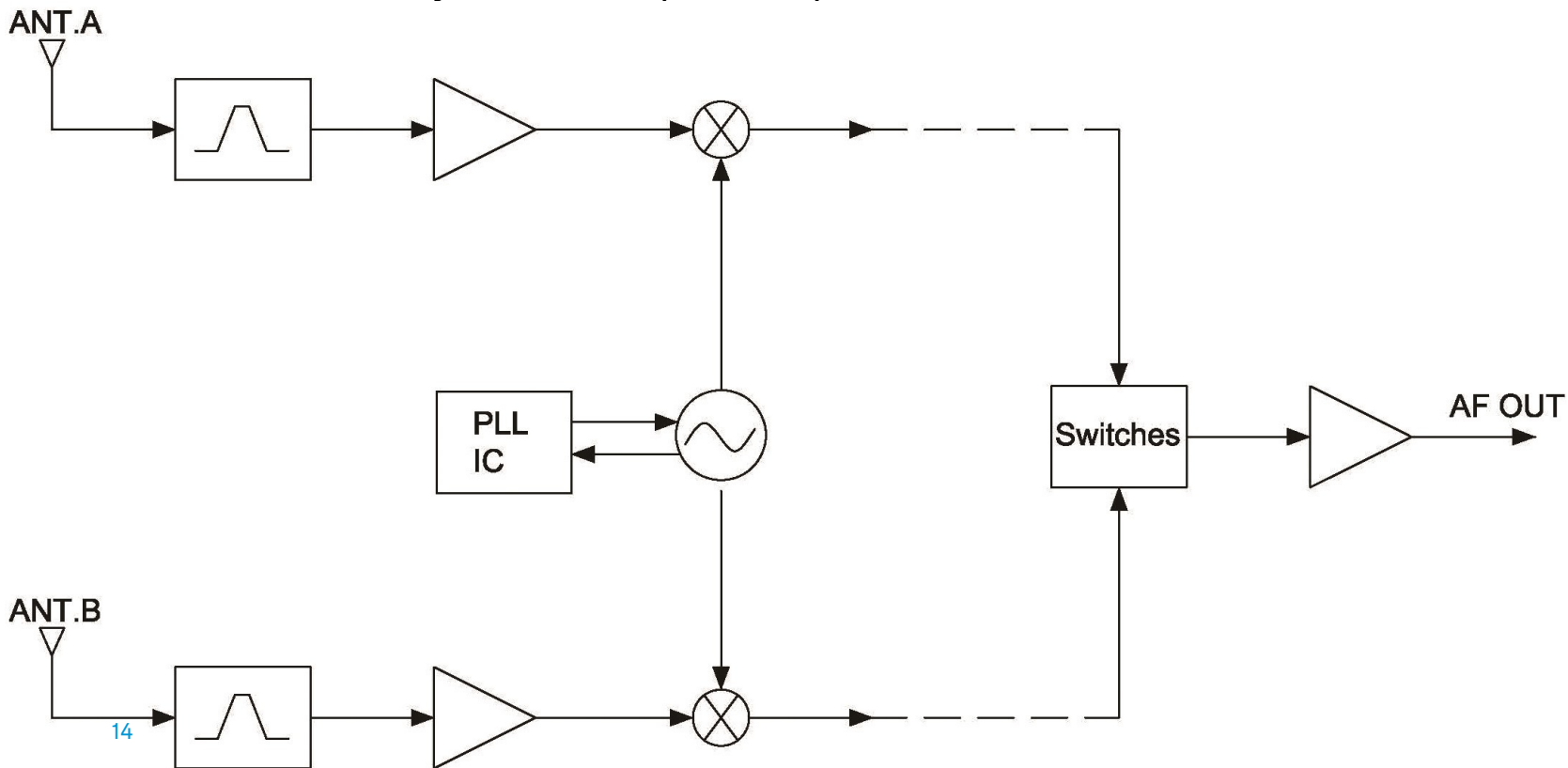
## Propagation - Réflexion

- ▶ La somme des réflexions donne lieu ponctuellement à des annulations de phase.
- ▶ Les émetteurs en mouvement font évoluer ces zones en fonction des déplacements.



# TRUE DIVERSITY

- 2 antennes:
- Sur les deux une fonctionne mieux
- True diversity = 2 tuners par récepteur



## Câblage – Distribution d’antenne

- ▶ Puissance / Tension - Ordre de Grandeur
- ▶ Perte dans les câbles coaxiaux
- ▶ Distribution de signaux / distribution d’antenne



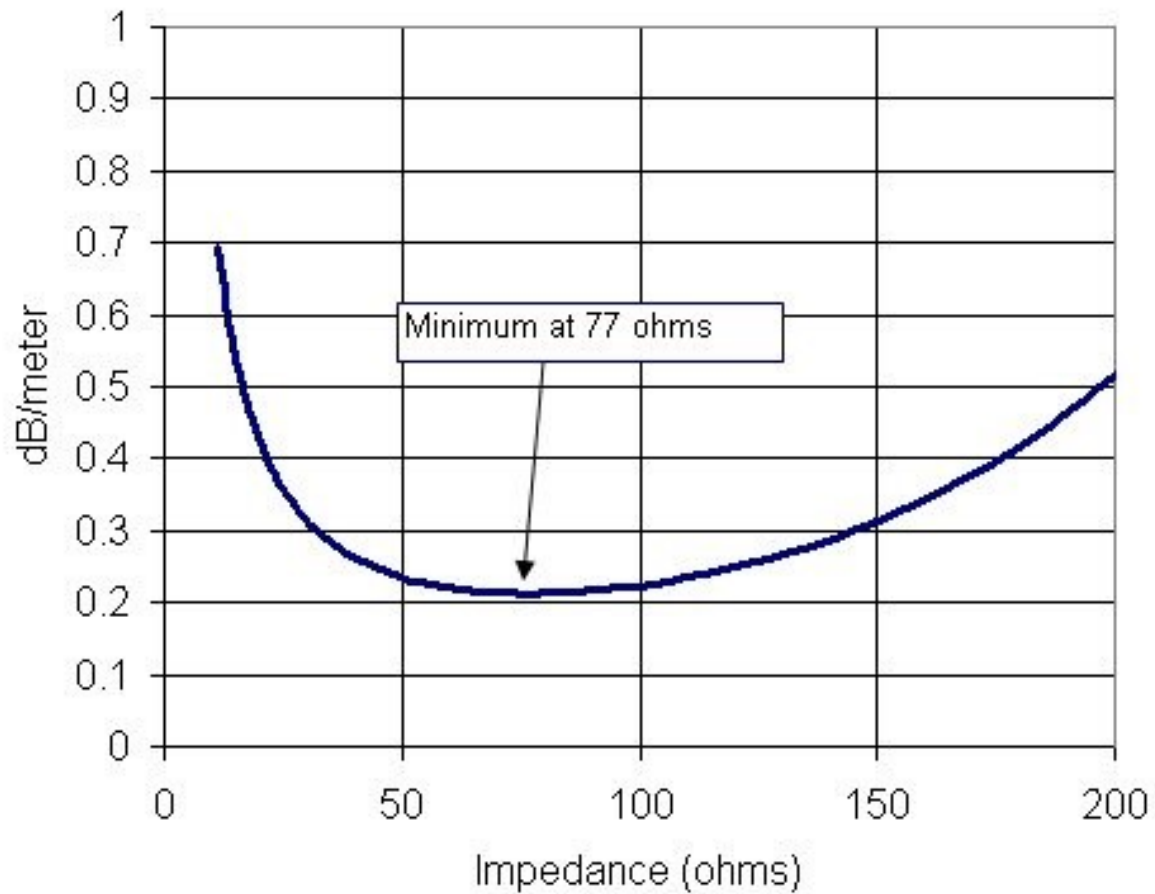
# Cablage – Distribution d'antenne

- ▶ Puissance / Tension - Ordre de Grandeur
- ▶ Perte dans les cables coaxiaux
- ▶ Distribution de signaux / distribution d'antenne

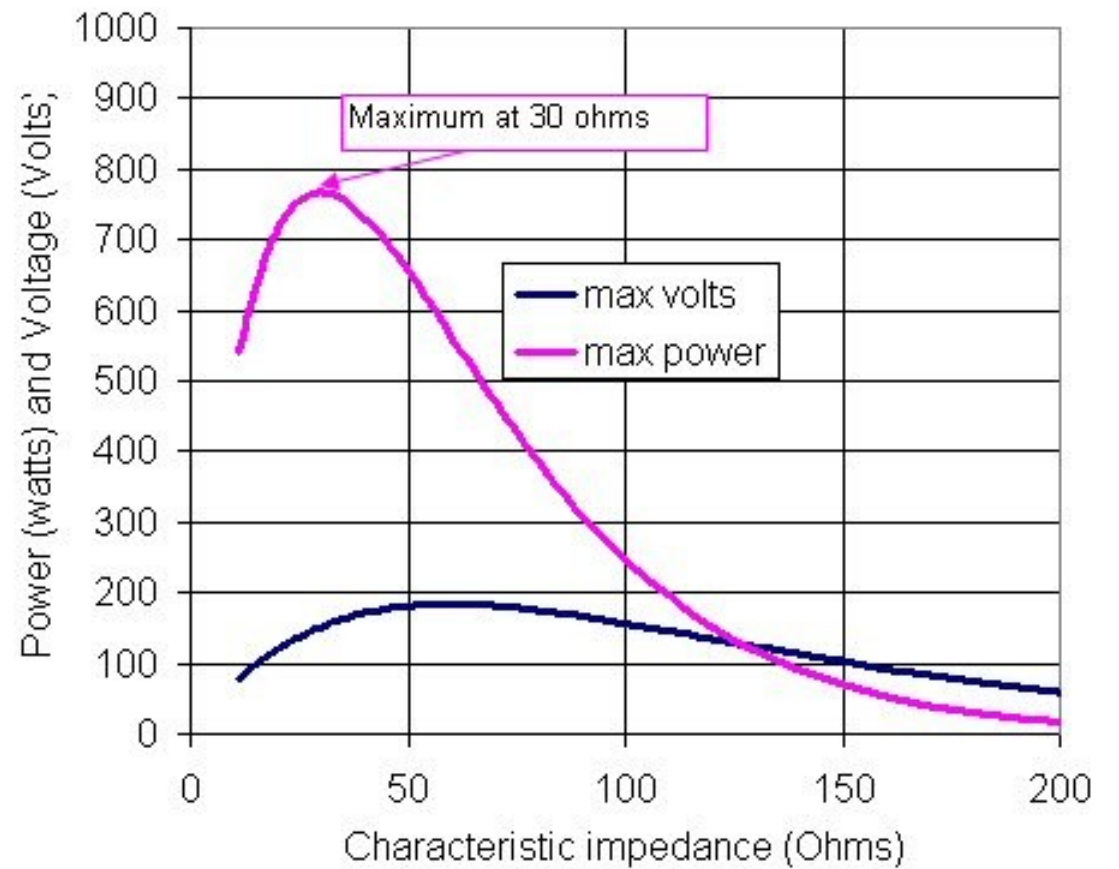


# POURQUOI 50 OHMS

Loss versus impedance  
10 mm diameter copper coax



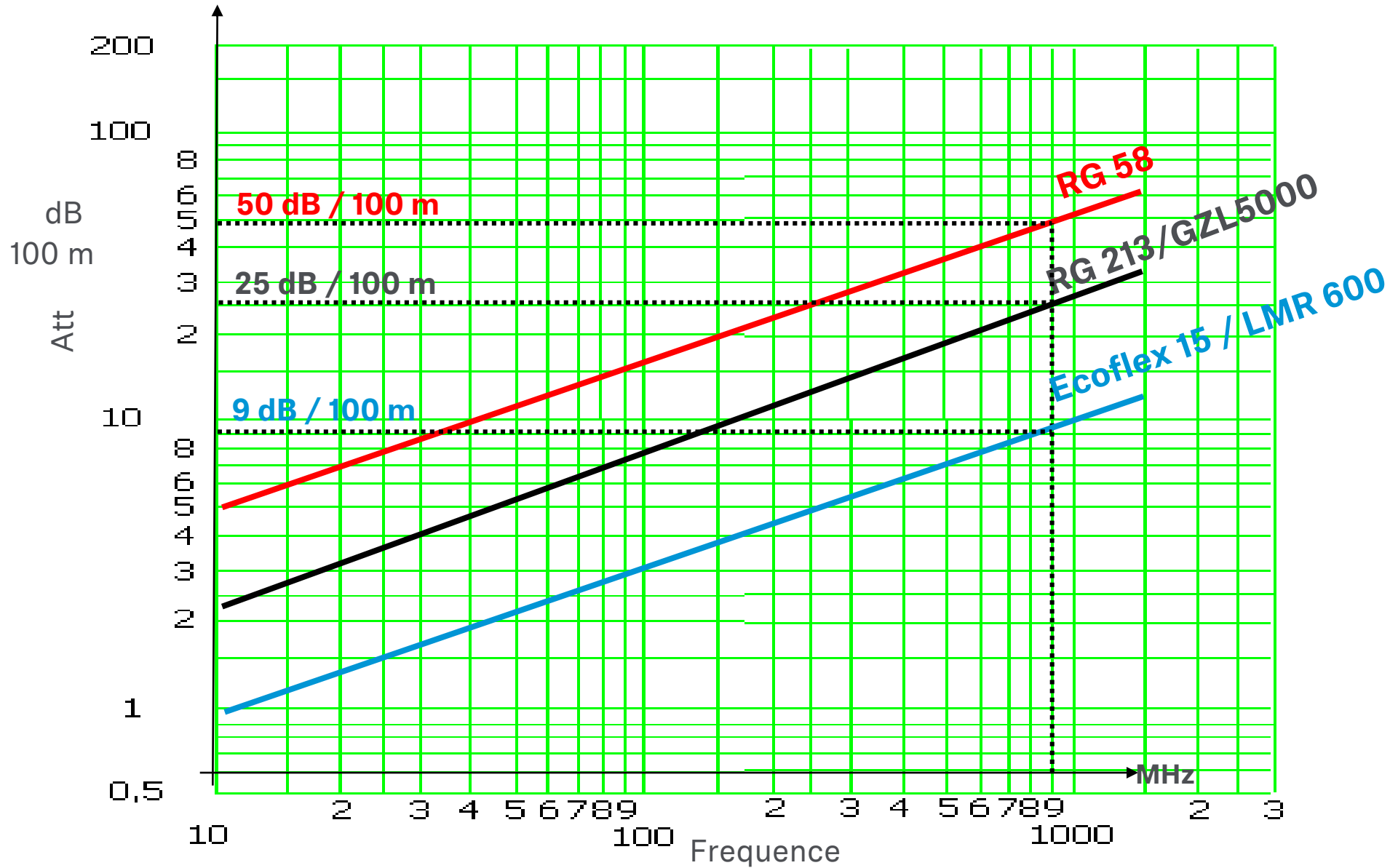
Maximum power handling of 10 mm coax  
Voltage breakdown at 100,000 volts/meter



CABLES VIDEO  
CABLES WORD CLOCK



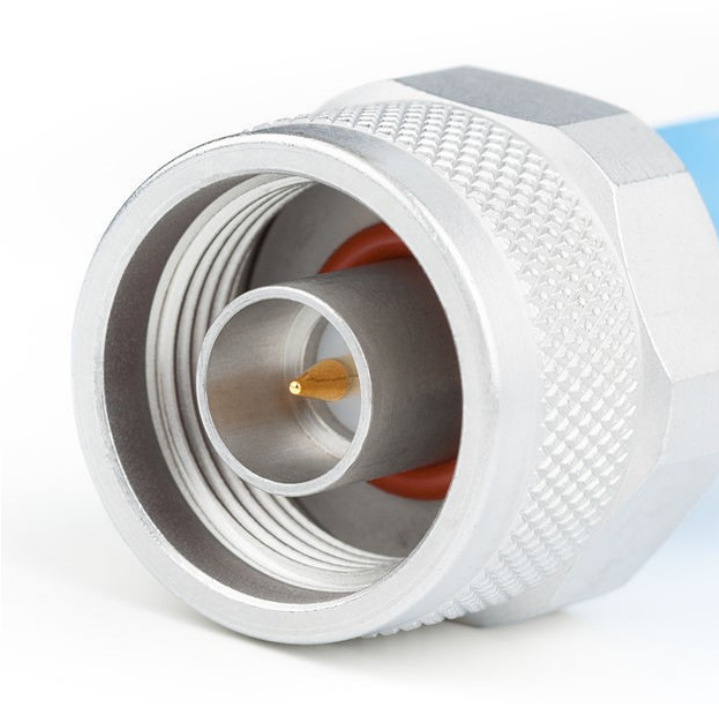
# Perte dans le cable



CONNECTEURS



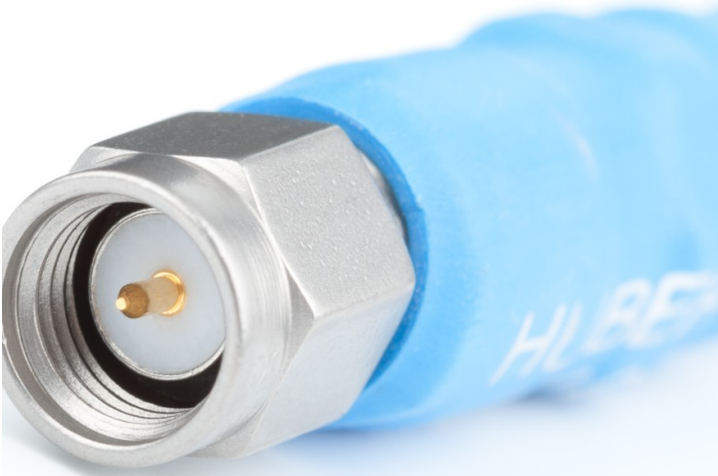
CONNECTEURS



N

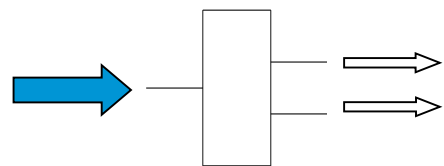


BNC

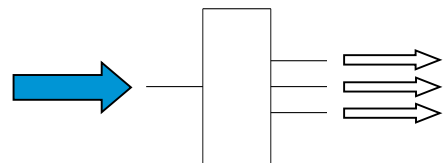


SMA

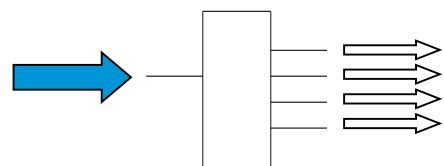
# SPLITTERS ET BOOSTERS



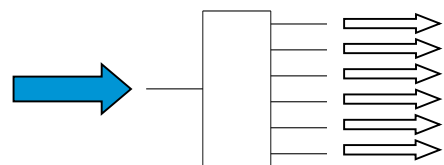
1 : 2      -4 dB



1 : 3      -7 dB



1 : 4      -8 dB



1 : 6      -11 dB

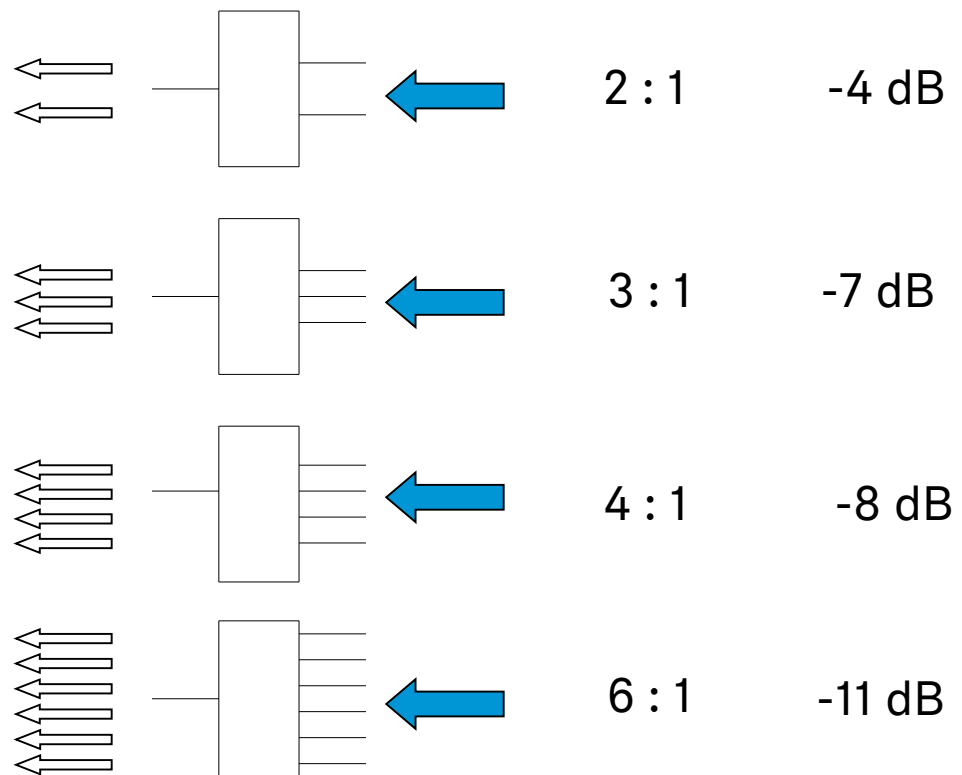


Splitter passif



Un T Vidéo n'est pas un splitter

# SPLITTERS ET BOOSTERS



Splitter passif

# COMPENSER LES PERTES

## Booster - ampli

### GAIN AJUSTABLE



AB 3700

Large bande



AB 1036 TV



AB 9000

Filtrage Réglable

### GAIN FIXE



AB 4

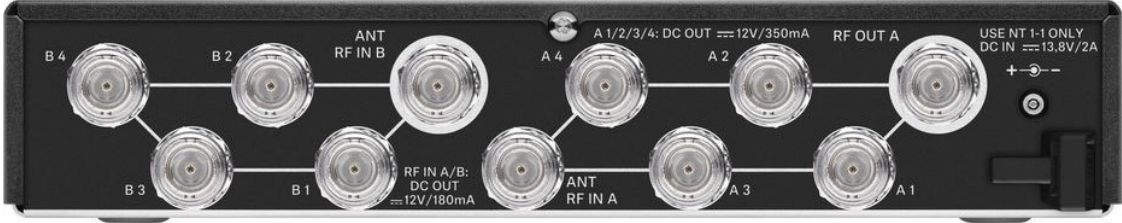


AB 2, AB3

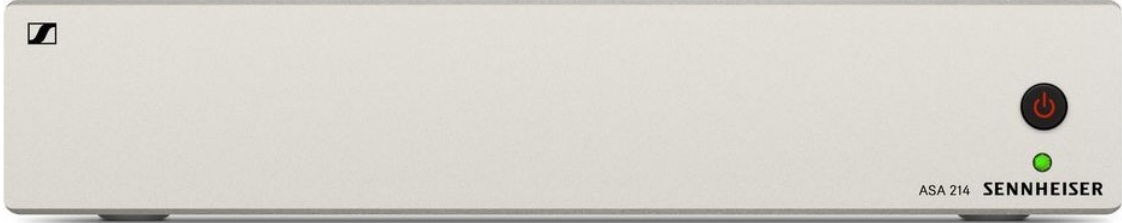
Filtrage Fixe



SPLITTER ACTIFS  
BOOSTER + ASP (courant faible)

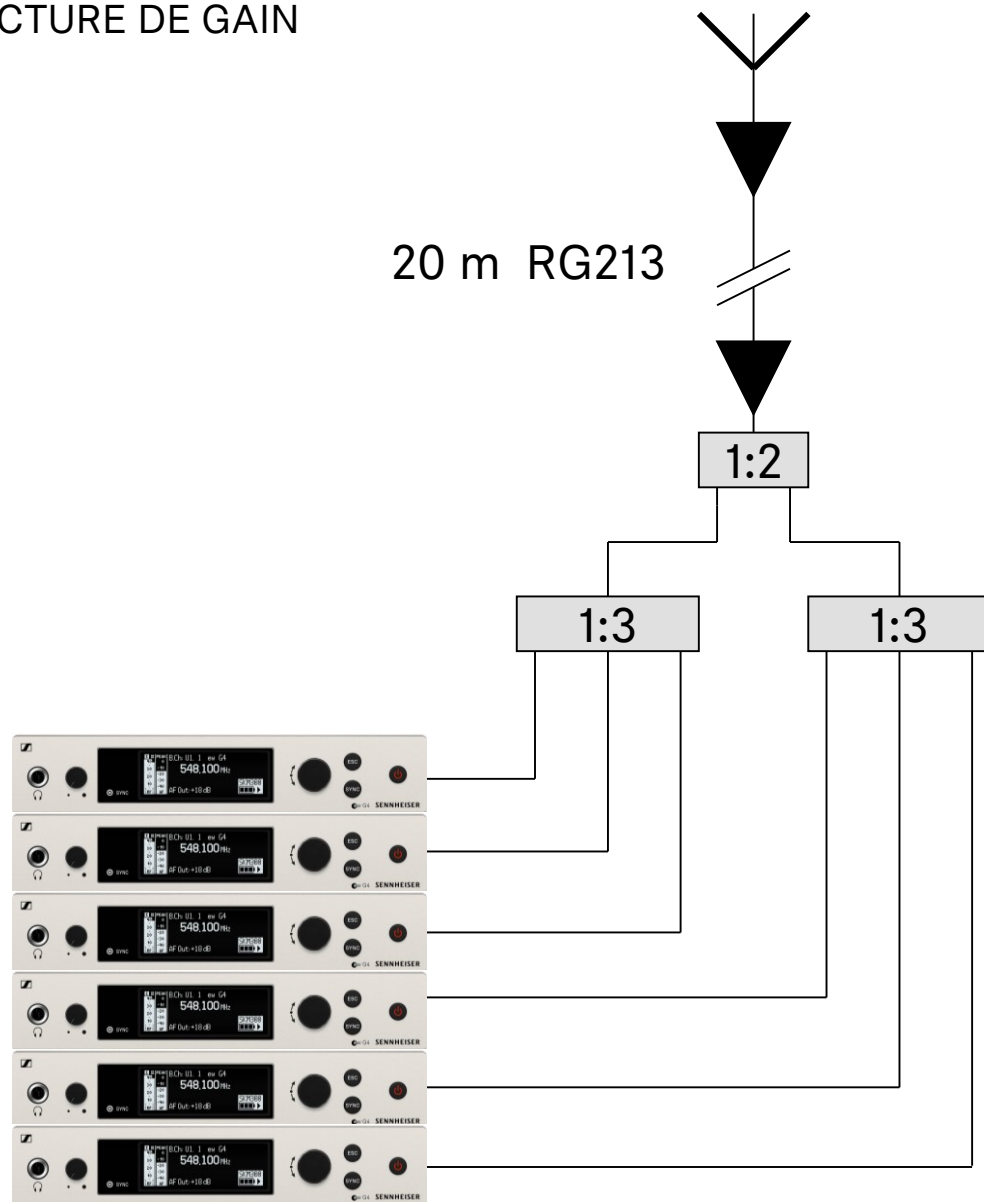


ASA 214



ASA 3000

# STRUCTURE DE GAIN



AMP  
+10 dB

PERTES

-6 dB

+10 dB

- 4 dB

- 7 dB

- 17 dB

+20 dB

Total +3 dB

# Cas des splitters intégrés



128 Channels



COMBINERS  
SPLITTER + BOOSTER (puissance!)



AC 41



AC 3000, AC 3200, AC 3200 +

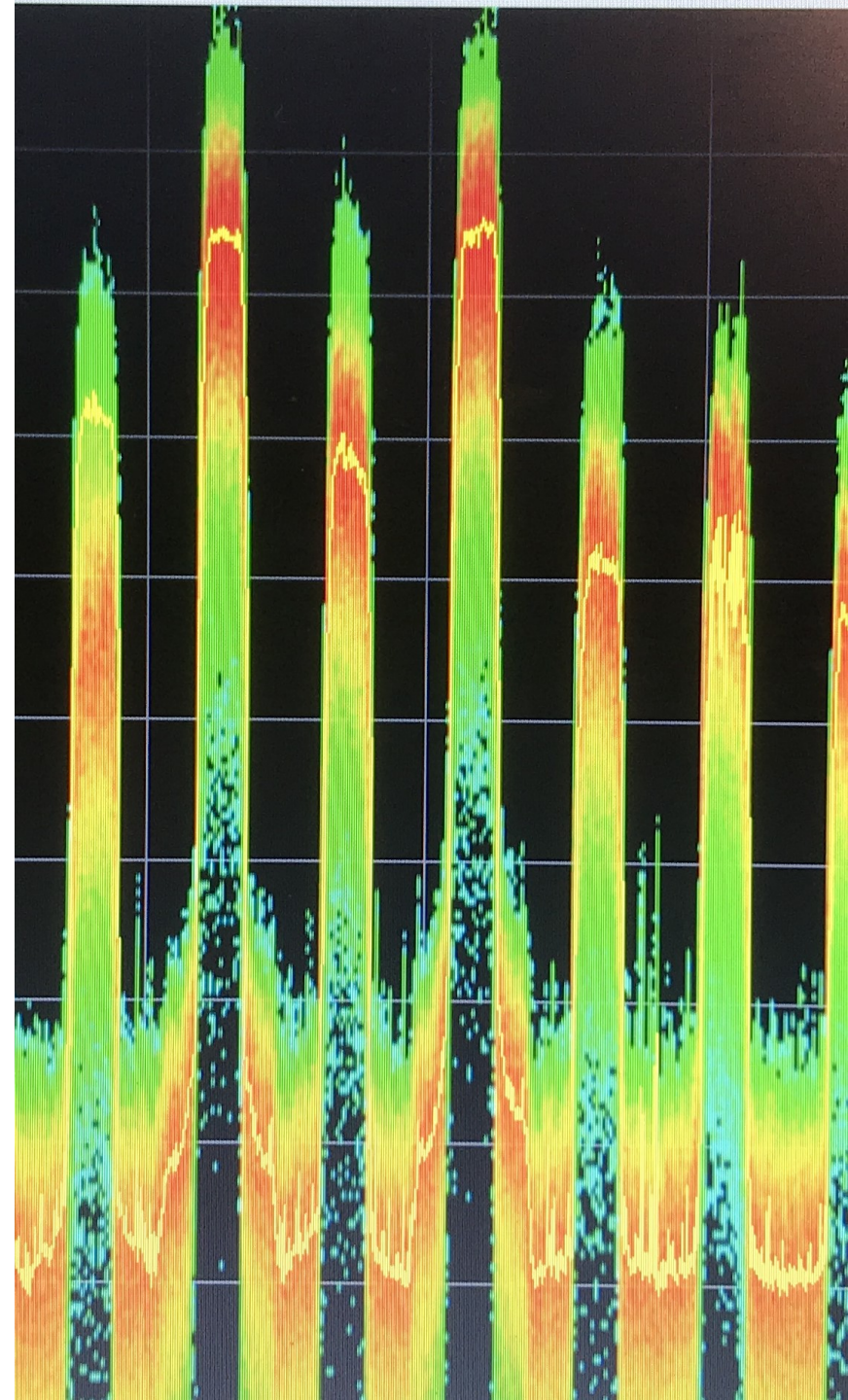


# Antennes – Diversity – Cablage - Distribution

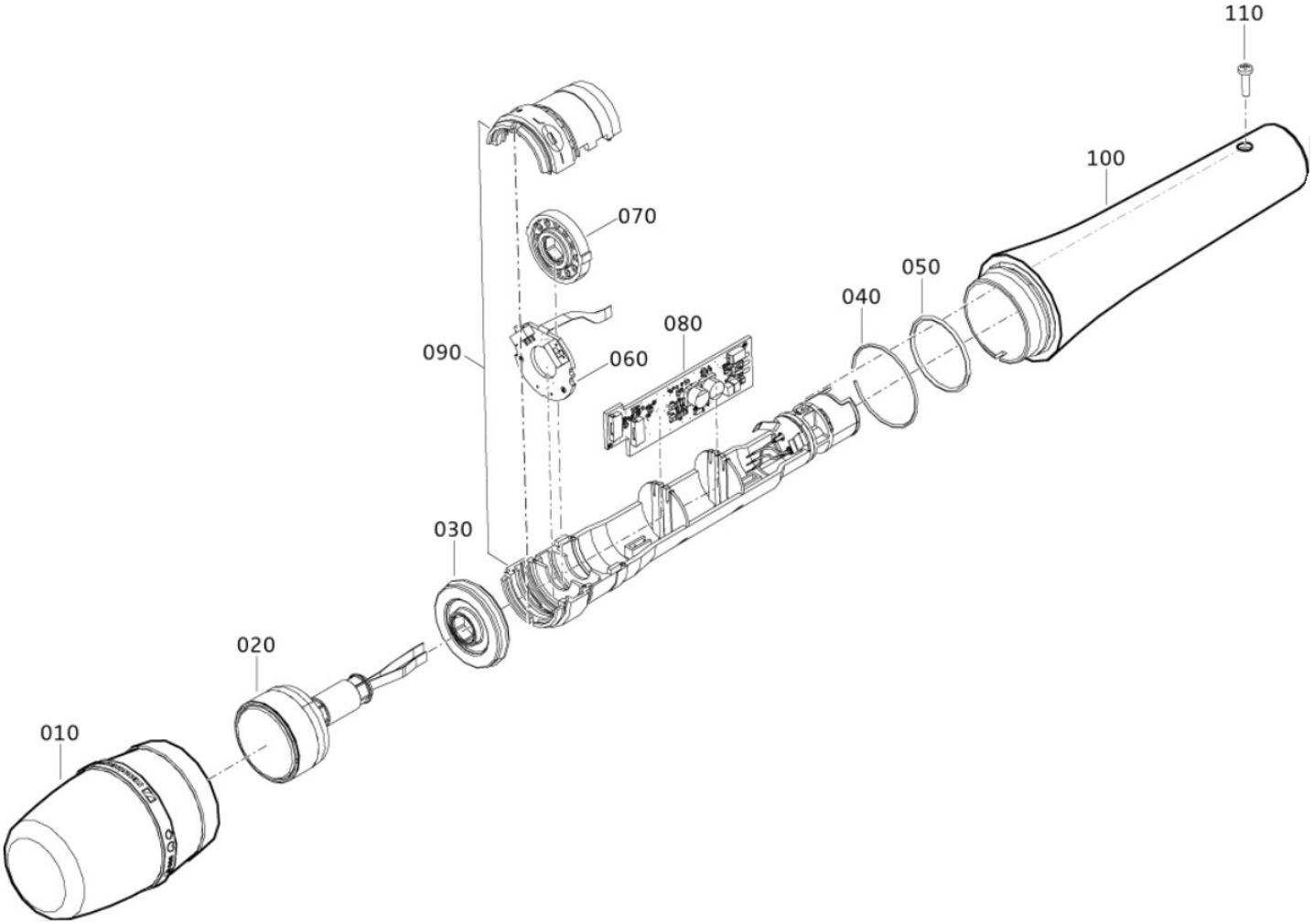
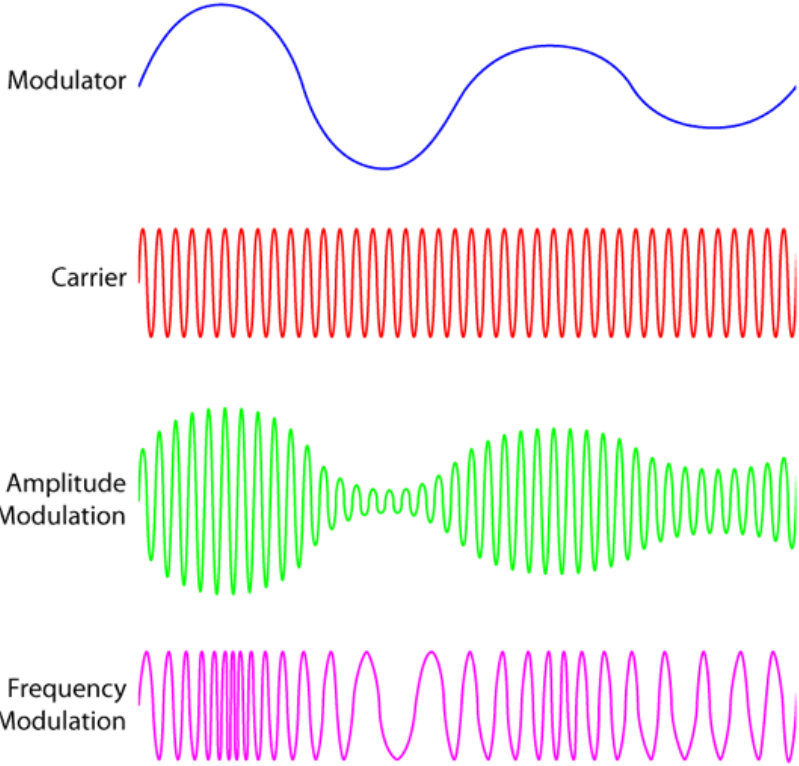
- ▶ Les boosters / antennes “actives” ne doivent être envisagés uniquement pour compenser des futures pertes existantes (atténuation dans le câble ou splitter passif).
- ▶ Se servir des propriétés directionnelles des antennes. Omni en intérieur, directionnelle pour atténuer une source de pollution HF.
- ▶ Câblage, allez au plus court ! Déport de l’audio plutôt que des antennes.
- ▶ Espacer suffisamment les antennes de Rx ( $>\lambda/4$ )
- ▶ Ne pas émettre trop proche des antennes Rx. (émetteur main ou antennes ears)
- ▶ Eloigner les antennes Rx de structure métalliques (min 50cm)
- ▶ Espacer suffisamment les antennes de ears entre elles (3m)
- ▶ Ne pas combiner des combineurs.

# Modulation

- ▶ But : Transporter un signal
- ▶ Moyen : Utilisation d'un signal transporteur
- ▶ Comment : Modulation des caractéristiques de la porteuse.
  - Amplitude
  - Fréquence
  - Phase
- ▶ Valeurs discrètes -> modulation numérique
- ▶ Valeurs continues -> modulation analogique



# Modulation

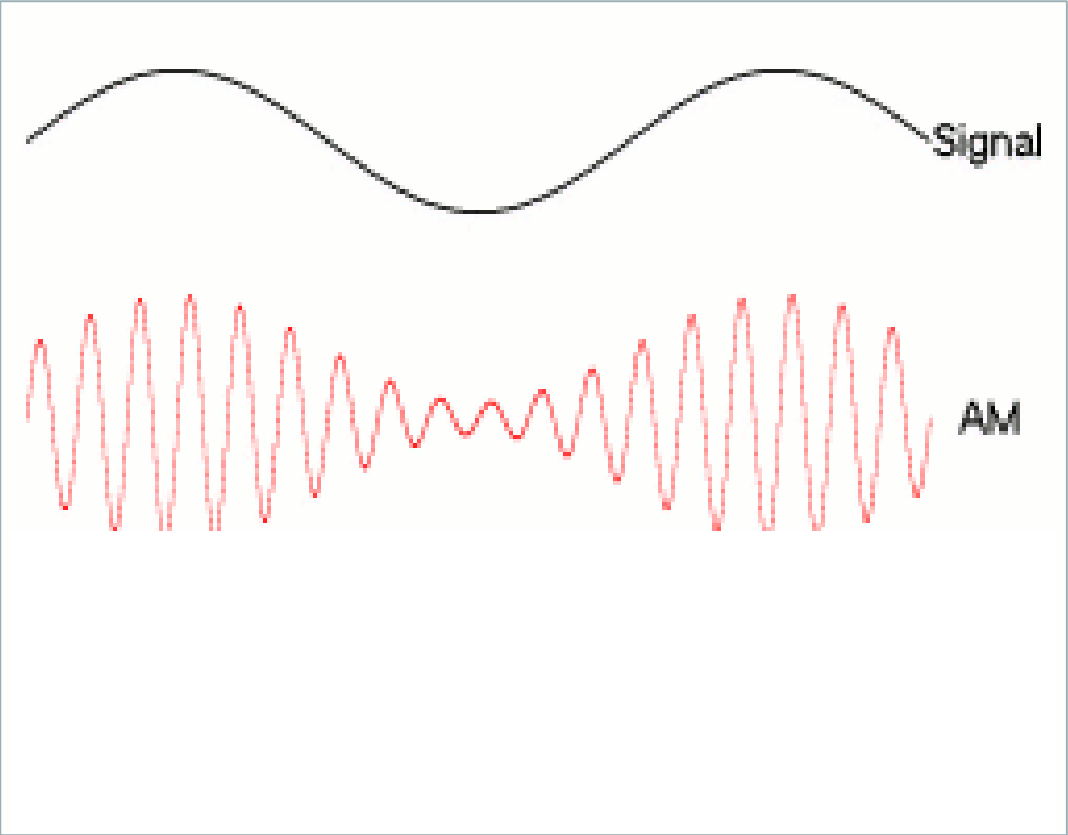




# AMPLITUDE (domaine temporel)

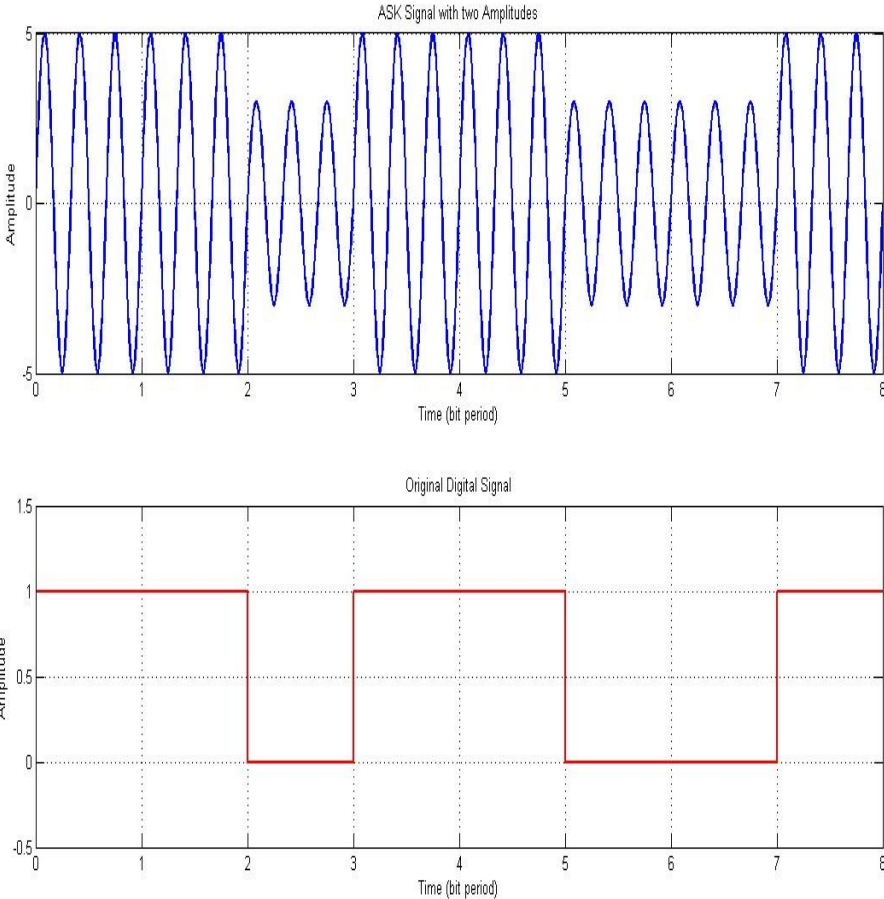
AM

ANALOGIQUE



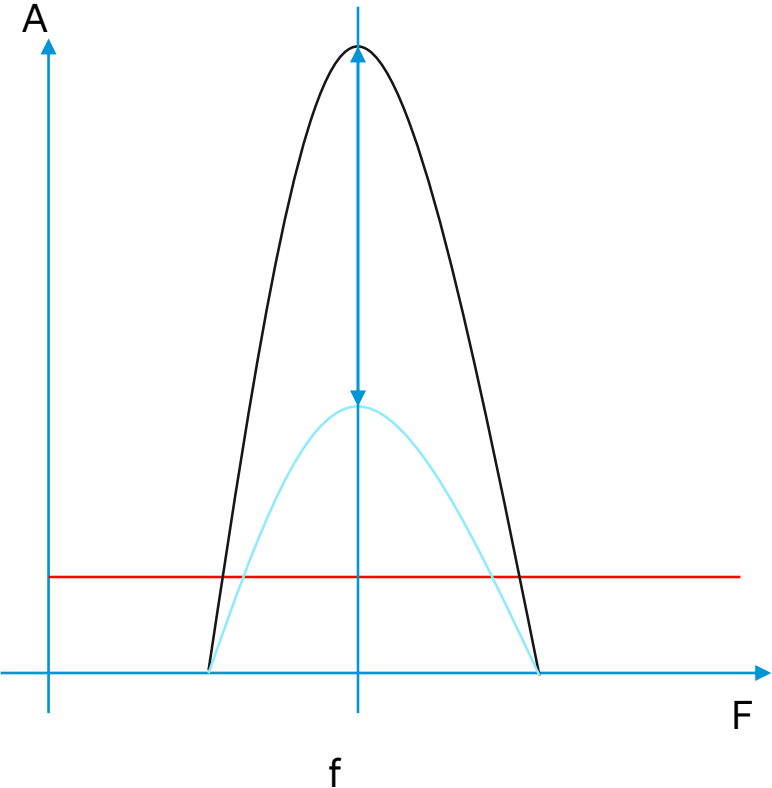
ASK

NUMERIQUE

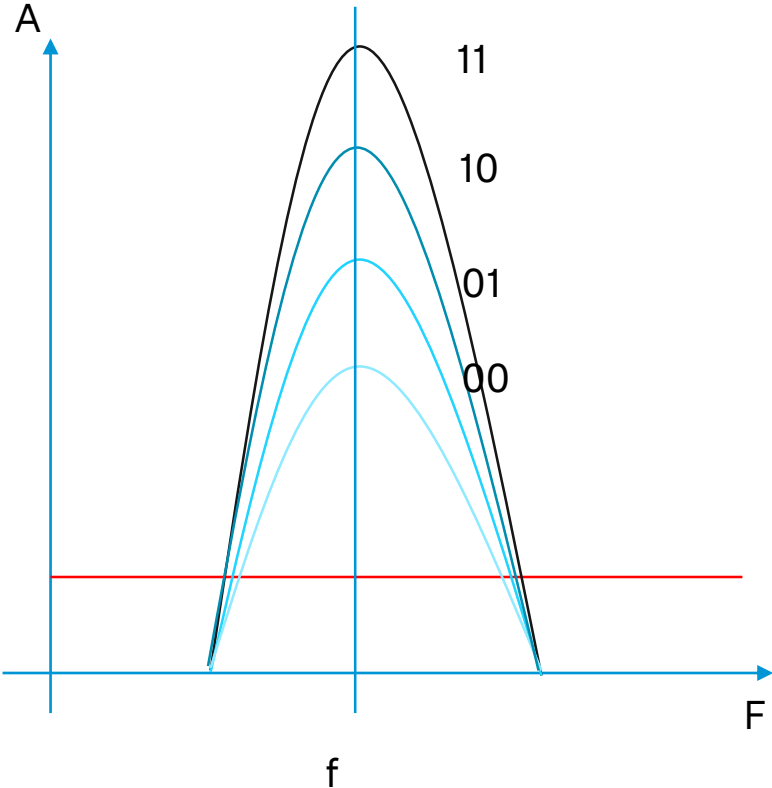


# AMPLITUDE (domaine fréquentiel)

AM ANALOGIQUE



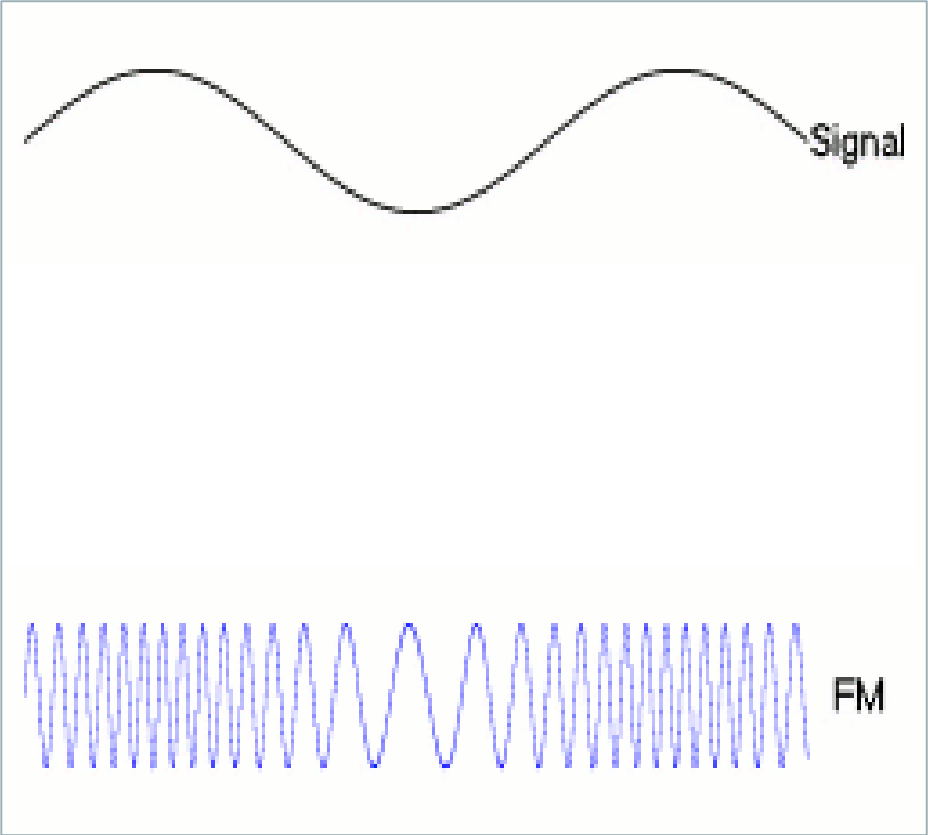
ASK NUMERIQUE



# FREQUENCY (Domain temporel)

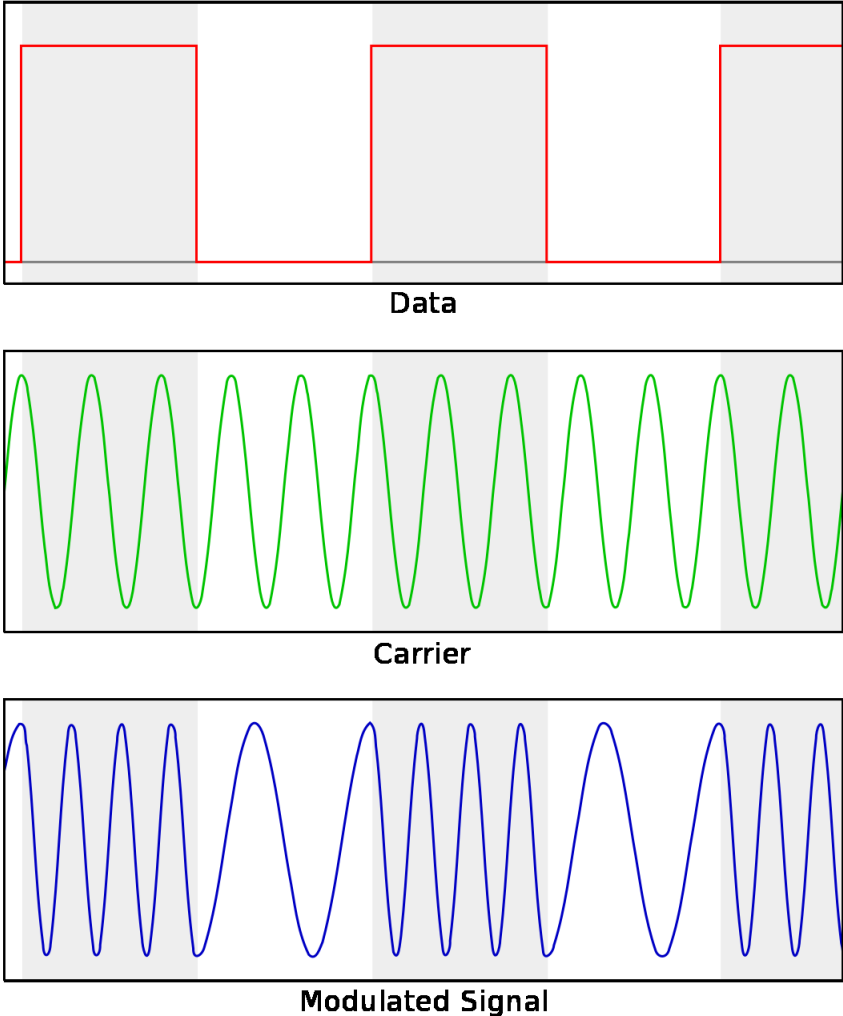
FM

ANALOGIQUE

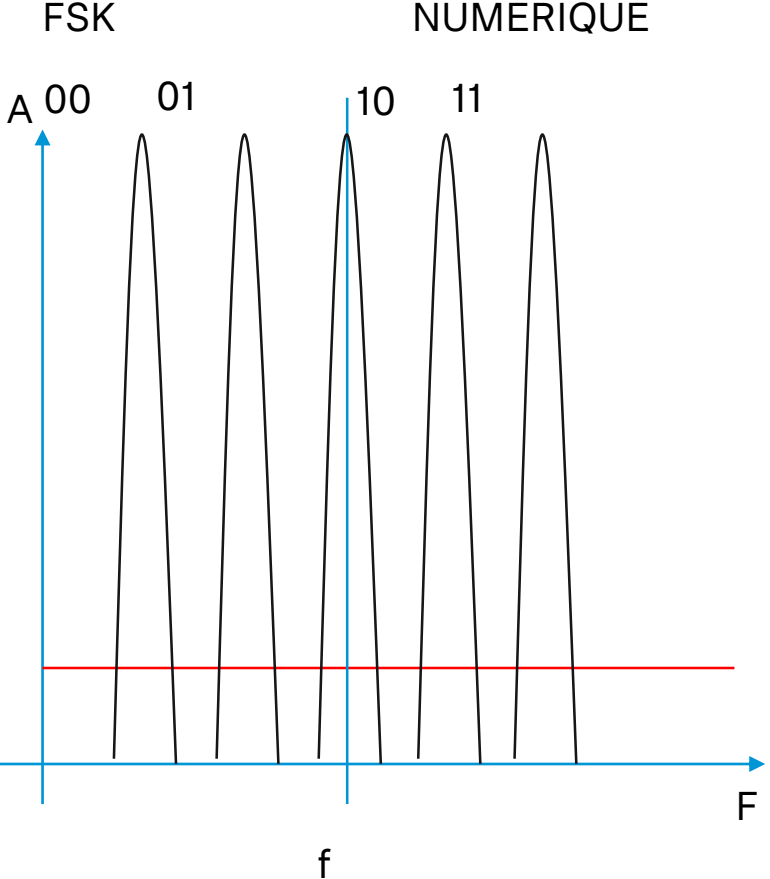
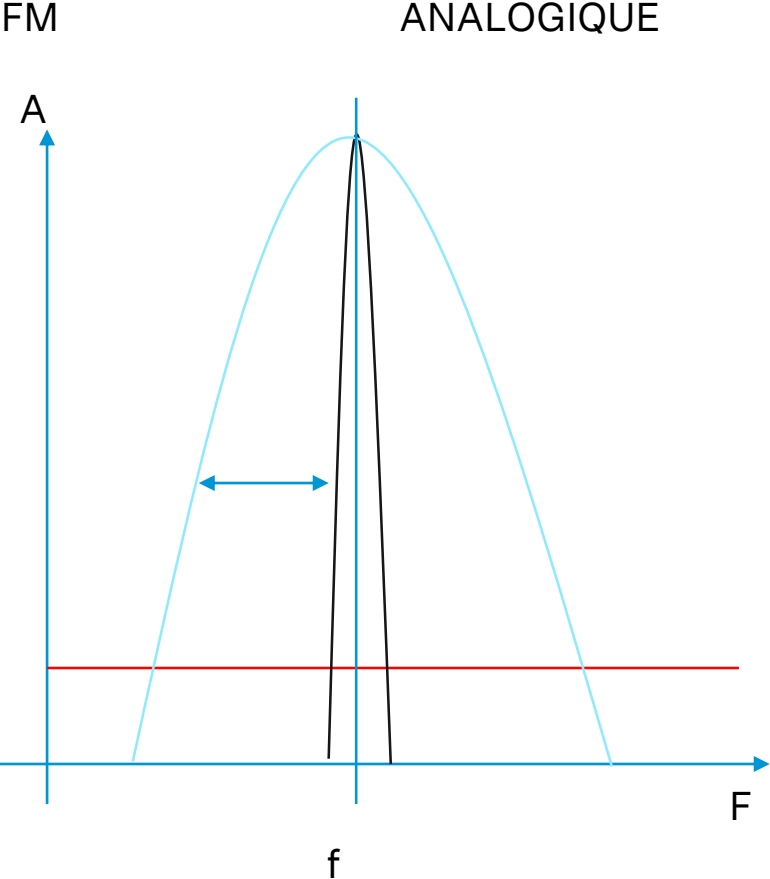


FSK

NUMERIQUE



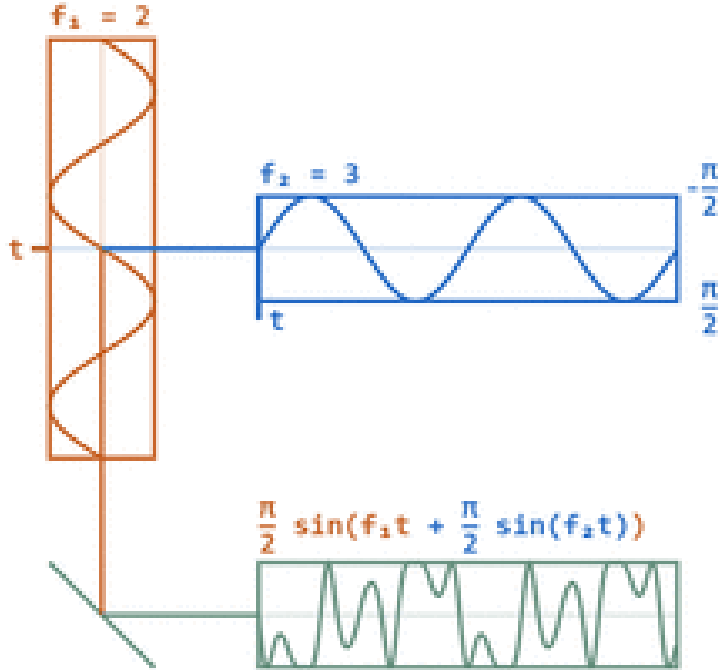
# FREQUENCE (Domaine fréquentiel)



# PHASE (domain temporel)

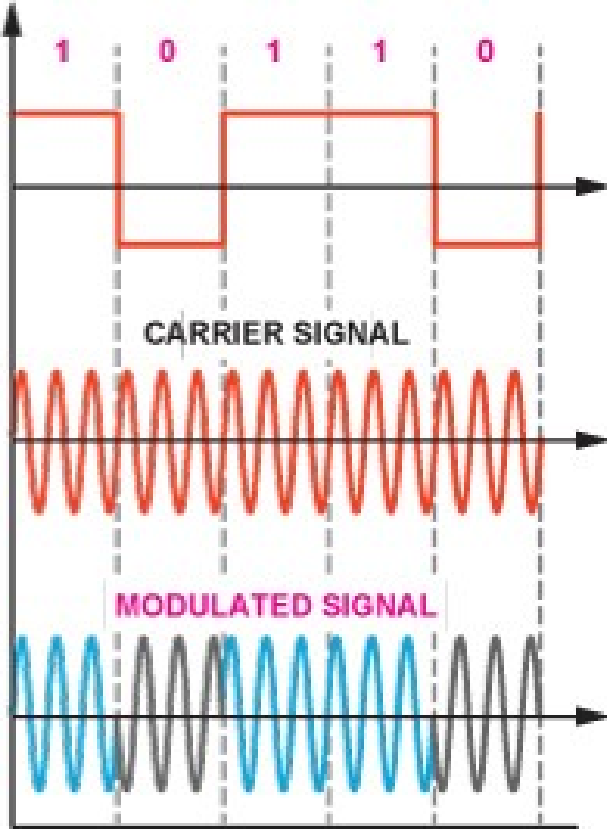
PM

ANALOGIQUE



PSK

NUMERIQUE



(b)

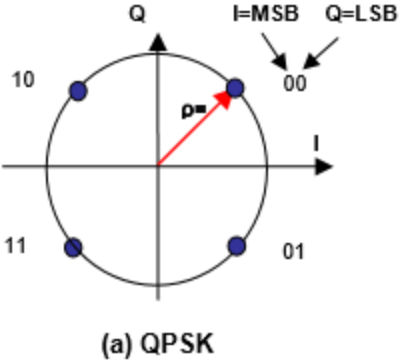
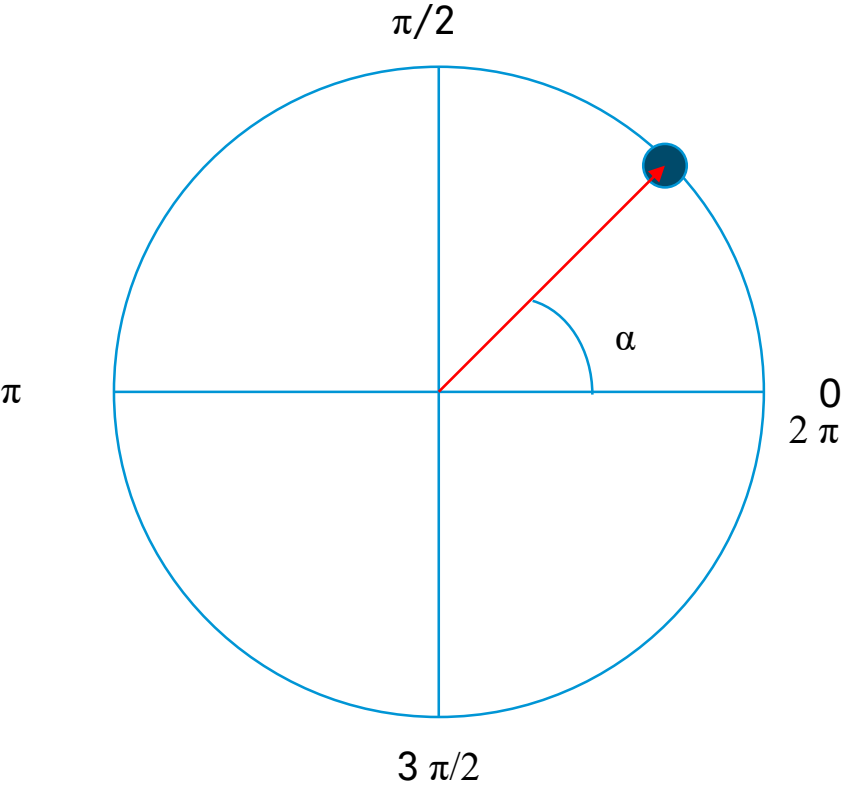
# PHASE (domaine polaire)

PM

ANALOGIQUE

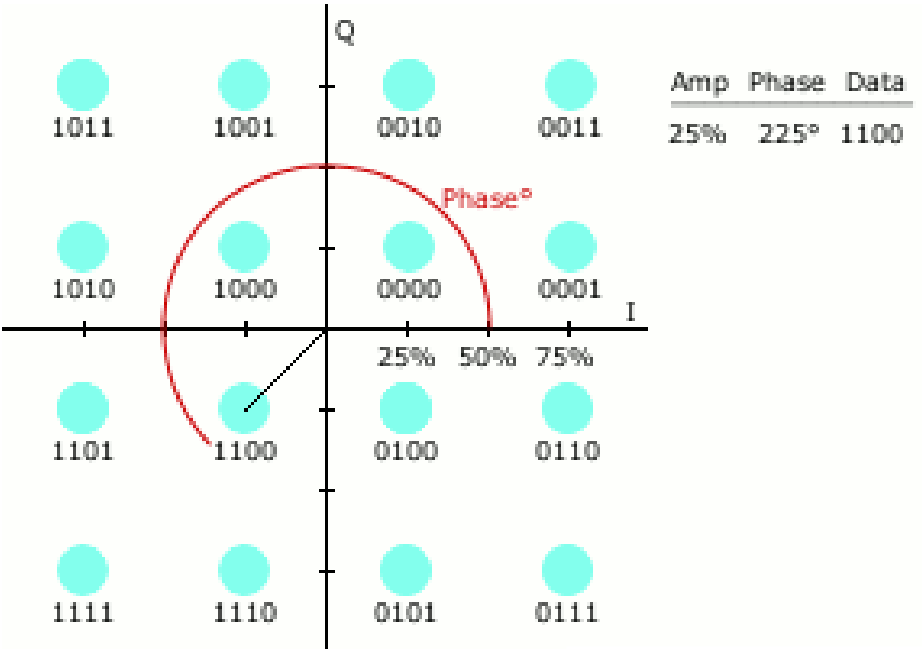
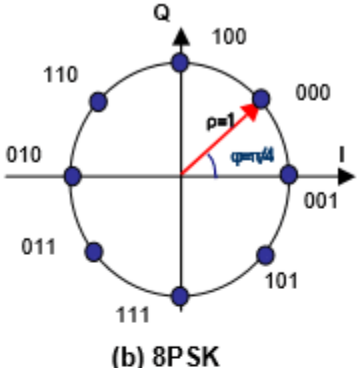
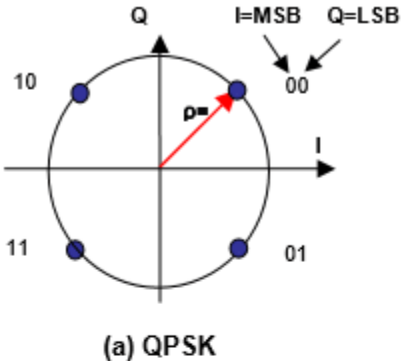
PSK

NUMERIQUE

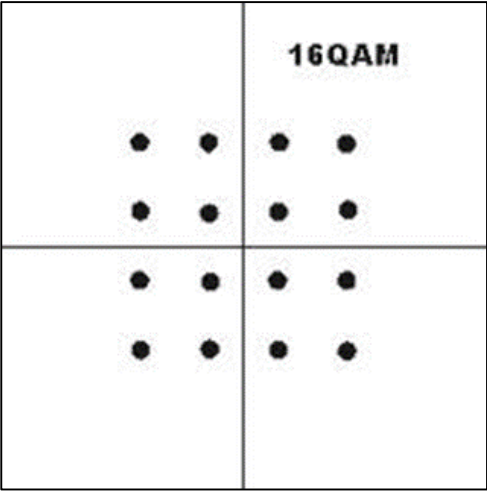


# MODULATIONS COMPLEXES (domaine polaire)

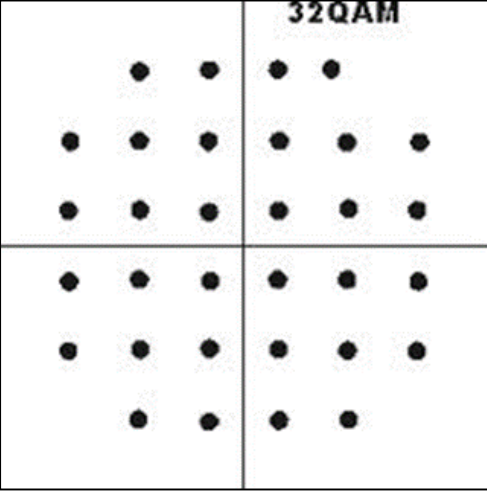
NUMERIQUE



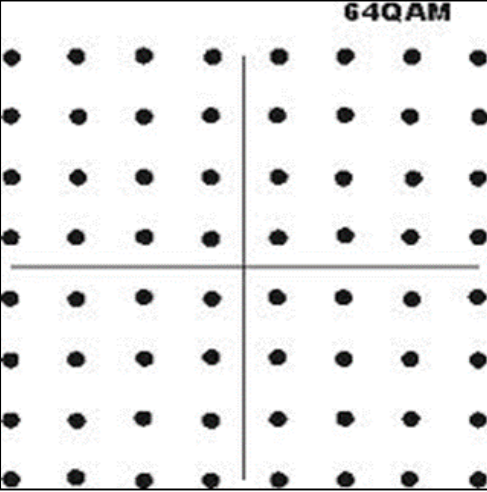
**DIAGRAMES DE CONSTELLATION (QAM)**



4 bits/symbol ( $2^4$  CPs)



5 bits/symbol ( $2^5$  CPs)



6 bits/symbol ( $2^6$  CPs)



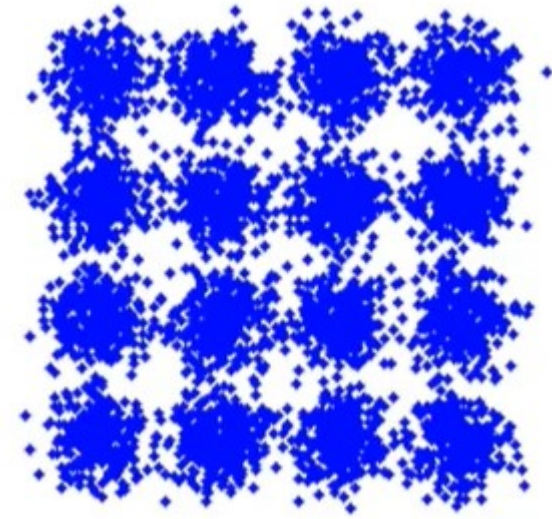
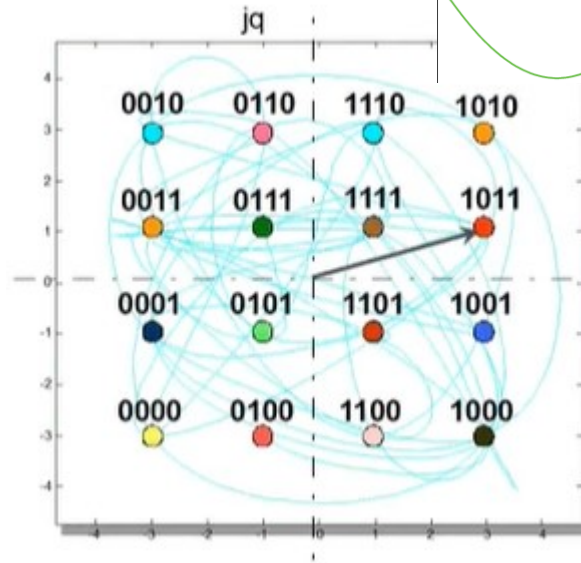
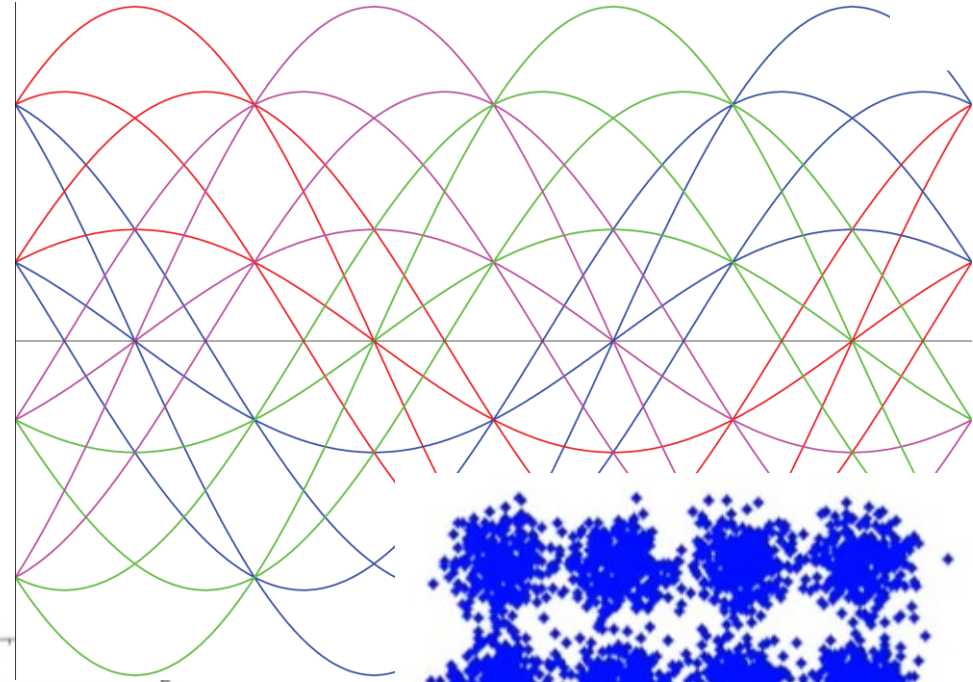
# LES PRINCIPES HF – Modulation Numérique

Signal discret

Codec / Cas du D9000

QAM / Pourquoi pas +0V / -5V ?

Des produits applicatifs



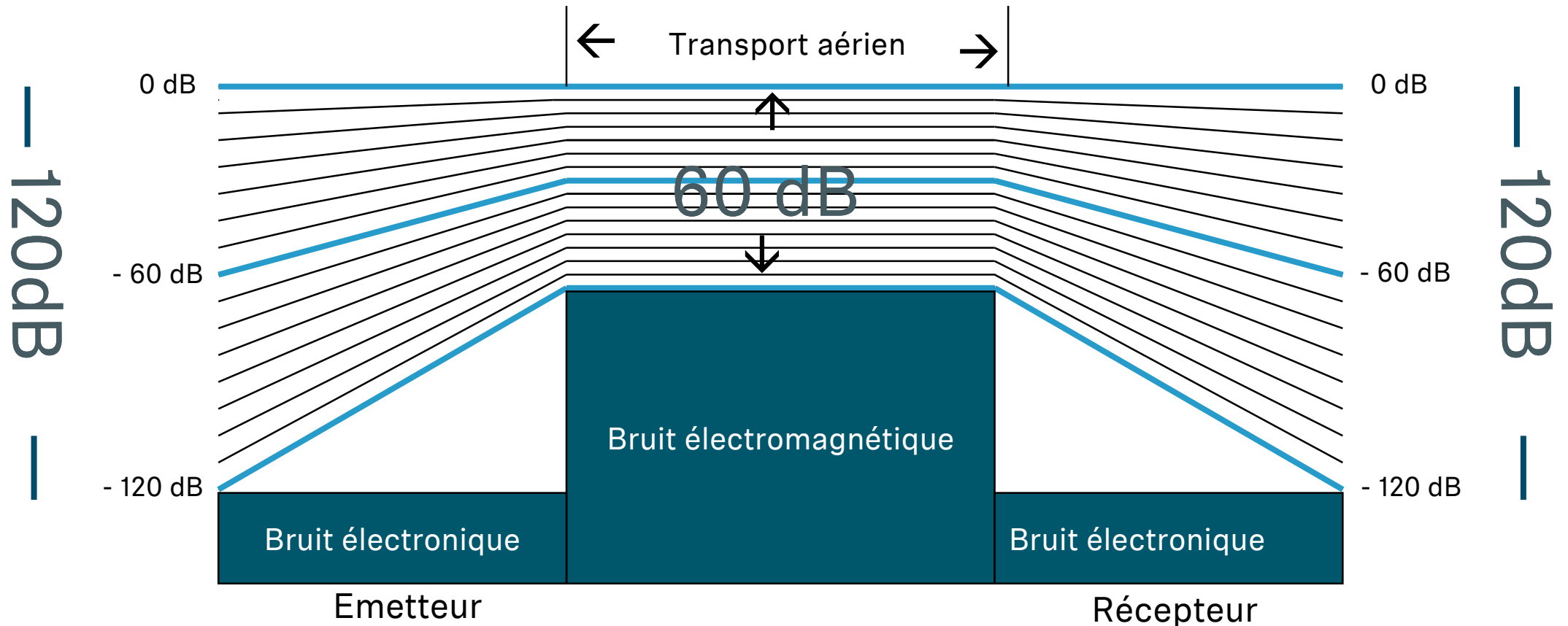
# LES PRINCIPES HF – Modulation Numérique

1110100101001100011101101110000110101011011011110010001101011100100111000111011000101011101010110001110110  
1101110101110001001011100011101001010011000111011011100001101010110110111100101100011101001010011000111011  
1100100011010111001001110001110110001010111010101100011011011101111010100010010001110111010111000100101110  
1101110000110101011011011110010001101011100100111000111011000101011101010110001110110111011110101000100100  
0011010111001001110001110110001010111010101100011101101110111101010001001000111011101011100010010111000111  
1000011010101101101111001000110101110010011100011101100010101110101011000111100011101001010011000111011011  
0100011010111001001110001110110001010111010101100011110001110100101001100011101101110000110101011011011110  
011101100010101110101011000111100011101001010011000111011111000011010101101101111001000110101110010011100  
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We transmit digital data  
On Analog waves

# TRAITEMENT AUDIO ANALOGIQUE

## Compandeur



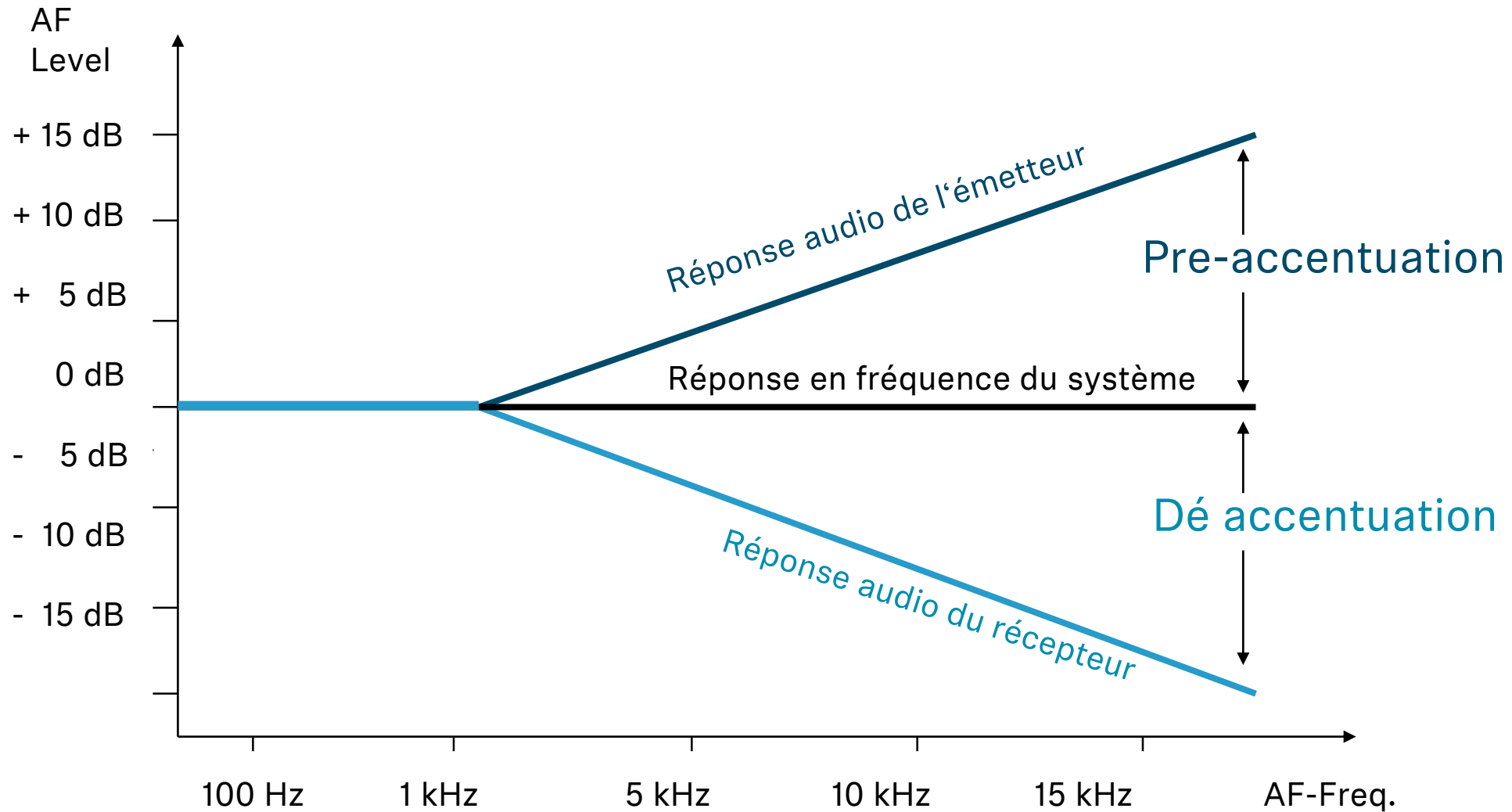
Compresseur 2 : 1

Expandeur 1 : 2

Compandeur

# TRAITEMENT AUDIO ANALOGIQUE

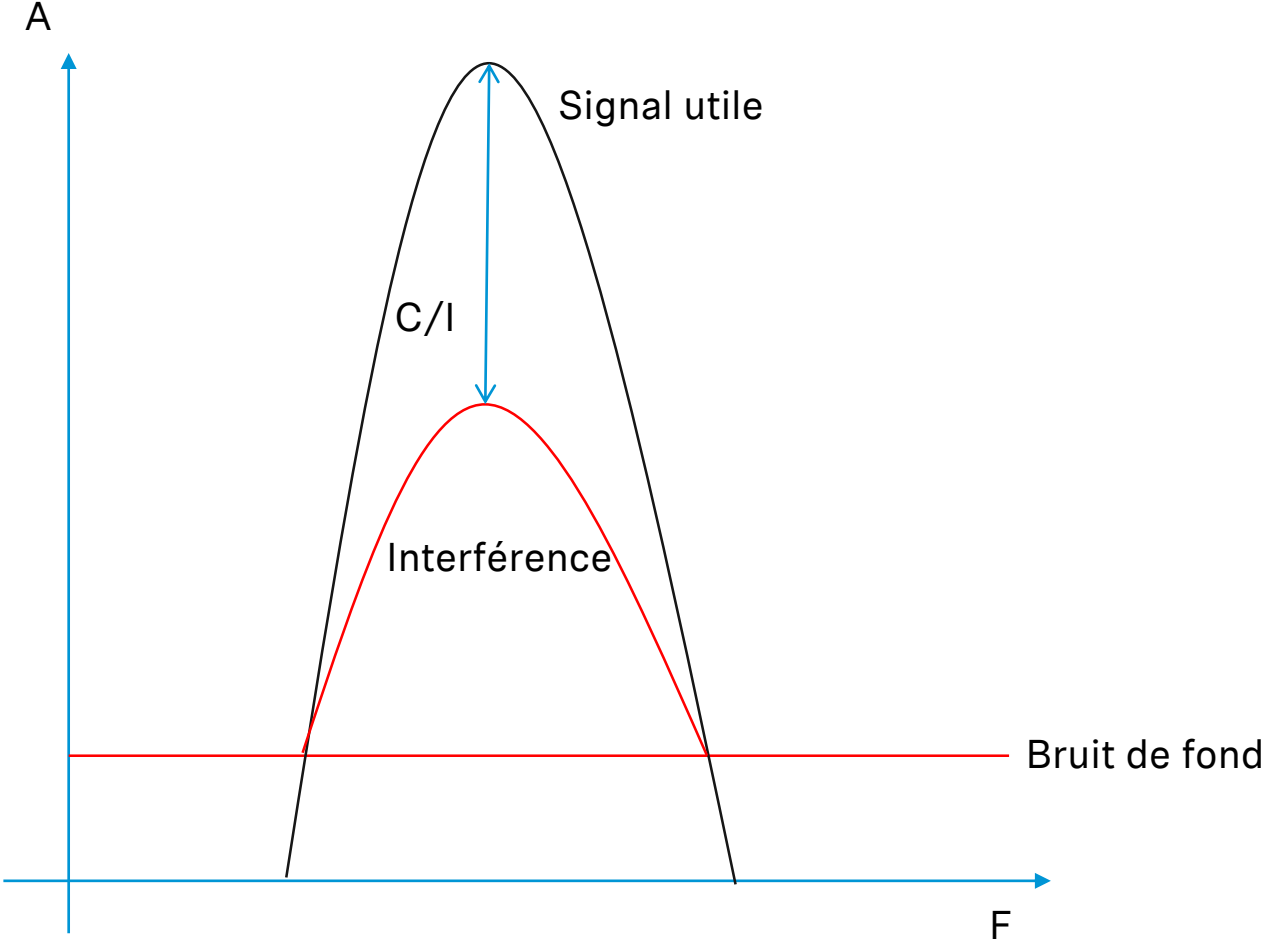
## Pre accentuation



## Modulation – Audio

- ▶ En modulation analogique (FM), utiliser au maximum la déviation pour avoir un maximum de dynamique.
- ▶ Plus d'effet de compandeur sur les liaisons numériques
- ▶ L'intermodulation n'est pas en lien avec le type de modulation
- ▶ Utilisation de codec audio en transmission numérique (sauf D9000 HD)

# Rapport Signal/Bruit





The image features a vibrant, futuristic cityscape at night, with numerous skyscrapers and lights. Overlaid on this scene is a complex network of glowing blue lines and nodes, resembling a global communication or data network. In the center, a large, semi-transparent globe is visible, with the letters '5G' prominently displayed in a white, stylized font. The overall color palette is dominated by deep blues and bright yellows/golds, creating a high-tech, digital atmosphere.


**NON, la 5G n'a rien à voir la dedans...**

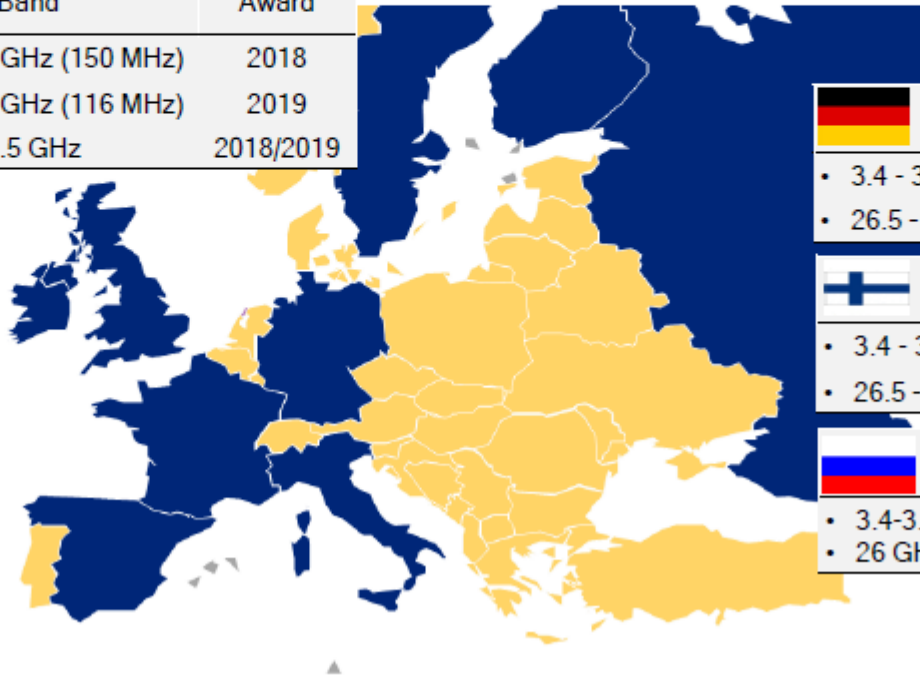
# Les sources d'interférences


## 5G Spectrum in Europe

Focus on mid-band (3.4-3.8 GHz) and 26 GHz (24.25-27.5 GHz) for 2018+

	Band	Award
	<ul style="list-style-type: none"> <li>3.4 - 3.8 GHz (350 Mhz)</li> <li>26 GHz</li> </ul>	2017 2018
	Band	Award
	<ul style="list-style-type: none"> <li>3.46 - 3.8 GHz</li> <li>26 GHz</li> </ul>	2018 2019
	Band	Award
	<ul style="list-style-type: none"> <li>3.4-3.8 GHz</li> <li>26.5 - 27.5 GHz</li> </ul>	2019/2020 2019/2020
	Band	Award
	<ul style="list-style-type: none"> <li>3.6 - 3.8 GHz</li> <li>26.5 - 27.5 GHz</li> </ul>	2018 2018

	Band	Award
	<ul style="list-style-type: none"> <li>3.4 - 3.6 GHz (150 MHz)</li> <li>3.6 - 3.8 GHz (116 MHz)</li> <li>26.5 - 27.5 GHz</li> </ul>	2018 2019 2018/2019



	Band	Award
	<ul style="list-style-type: none"> <li>3.4 - 3.8 GHz</li> <li>26.5 - 27.5 GHz</li> </ul>	2018 2018?
	Band	Award
	<ul style="list-style-type: none"> <li>3.4 - 3.8 GHz</li> <li>26.5 - 27.5 GHz</li> </ul>	2018 2020
	Band	Award
	<ul style="list-style-type: none"> <li>3.4-3.8 GHz</li> <li>26 GHz</li> </ul>	2019/20* 2020+*



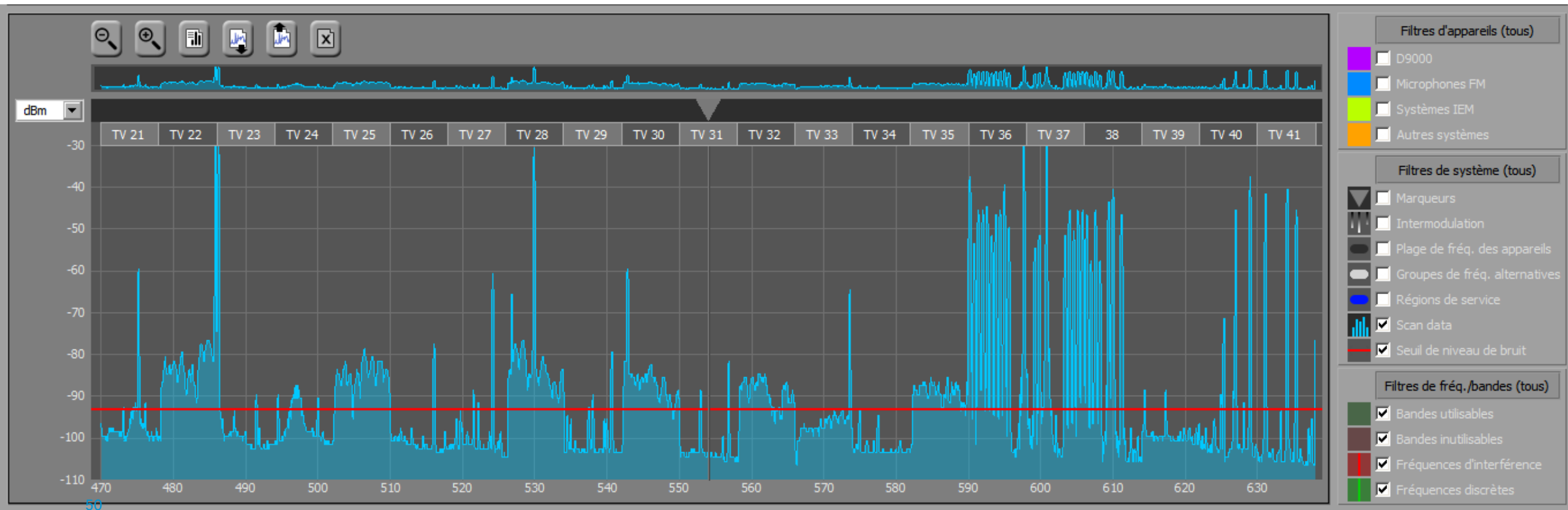
# Les sources d'interférences

- ▶ Tous les équipements fonctionnant à haute fréquence. Les alimentations à découpage, certains switch, matériel video, HDMI.
- ▶ Eviter les antennes  $\frac{1}{4}$  onde à l'intérieur des baies à proximité de ces éléments.
- ▶ Si les antennes sont déportées, s'assurer qu'aucune source de pollution ne soit trop proche.



# SQUELCH

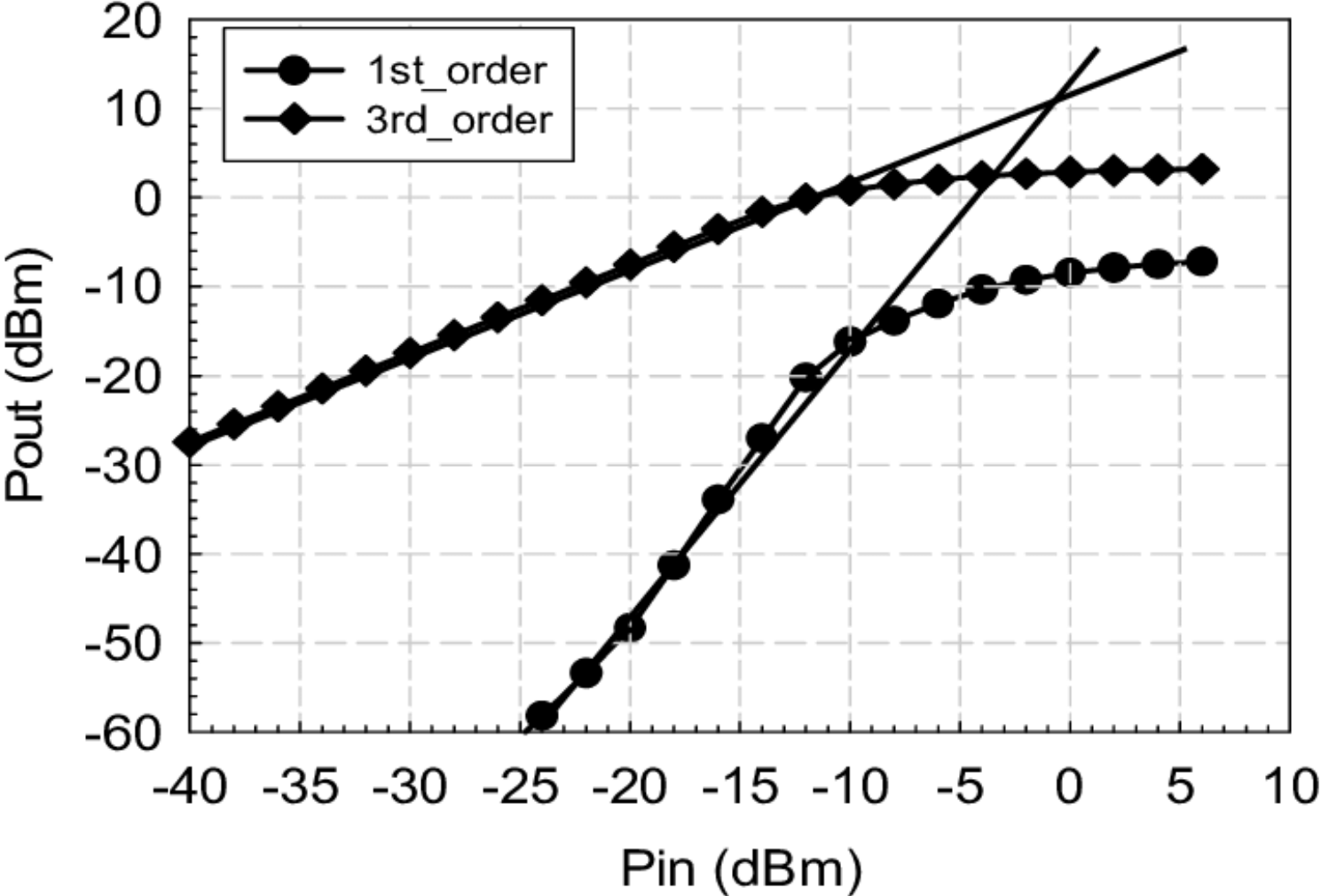
- ▶ C'est un gate audio contrôlé en HF.



## Interférences – C/N - Squelch

- ▶ Le réglage du squelch influence la portée
- ▶ Le squelch intervient également en recherche de fréquence (Easy setup)
- ▶ En FM l'audio se dégrade en limite de portée ( $C/N < 25\text{dB}$ )
- ▶ Identifier les sources d'interférences et les éloigner des antennes.
- ▶ Placement des équipements

# Linéarité - intermodulation



## Linéarité - intermodulation

- ▶ Low power mode pour créer moins de produits d'intermodulation
- ▶ Le rapprochement d'une certaine quantité d'émetteurs augmente les PIM.