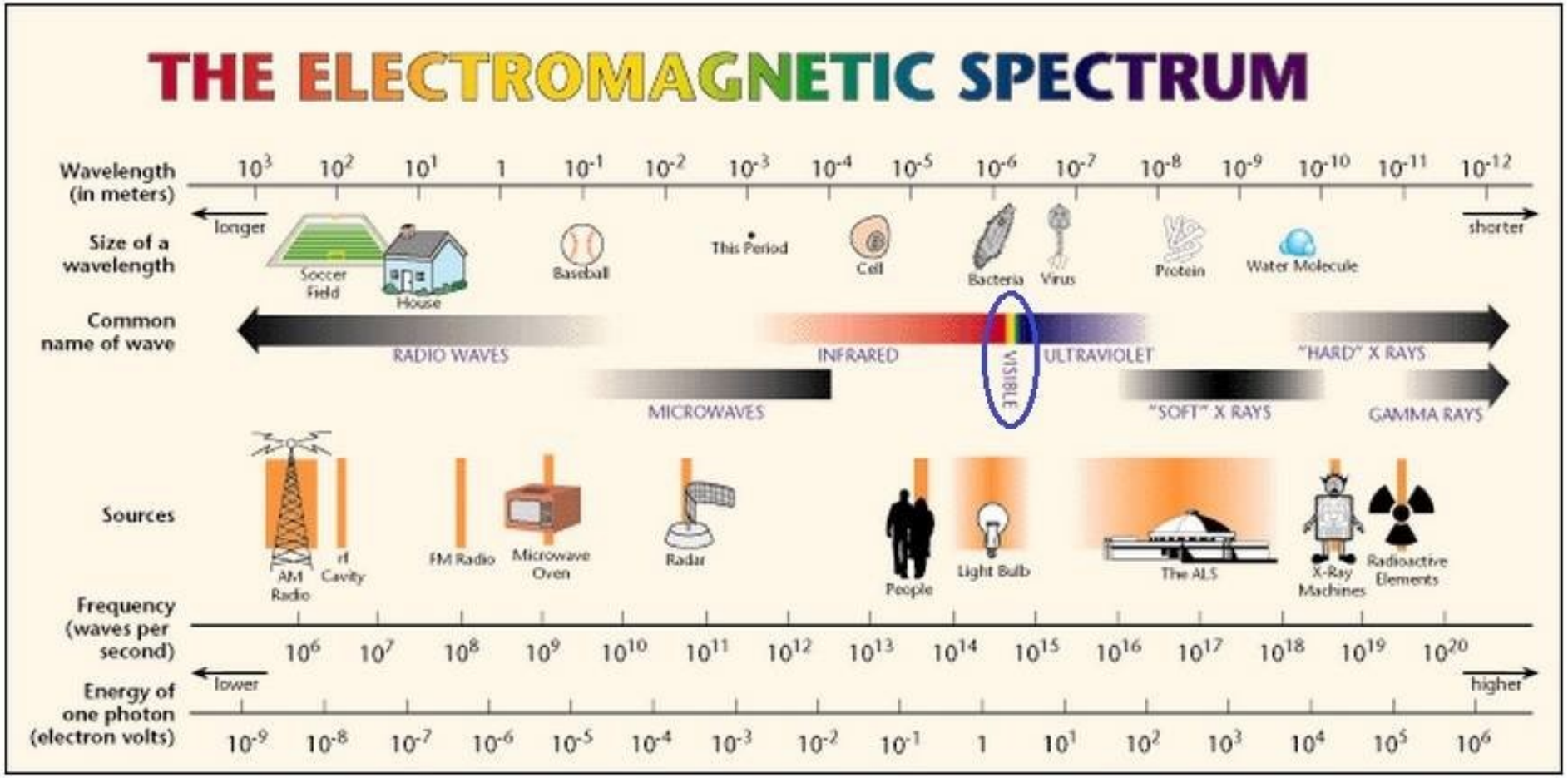
Agenda

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

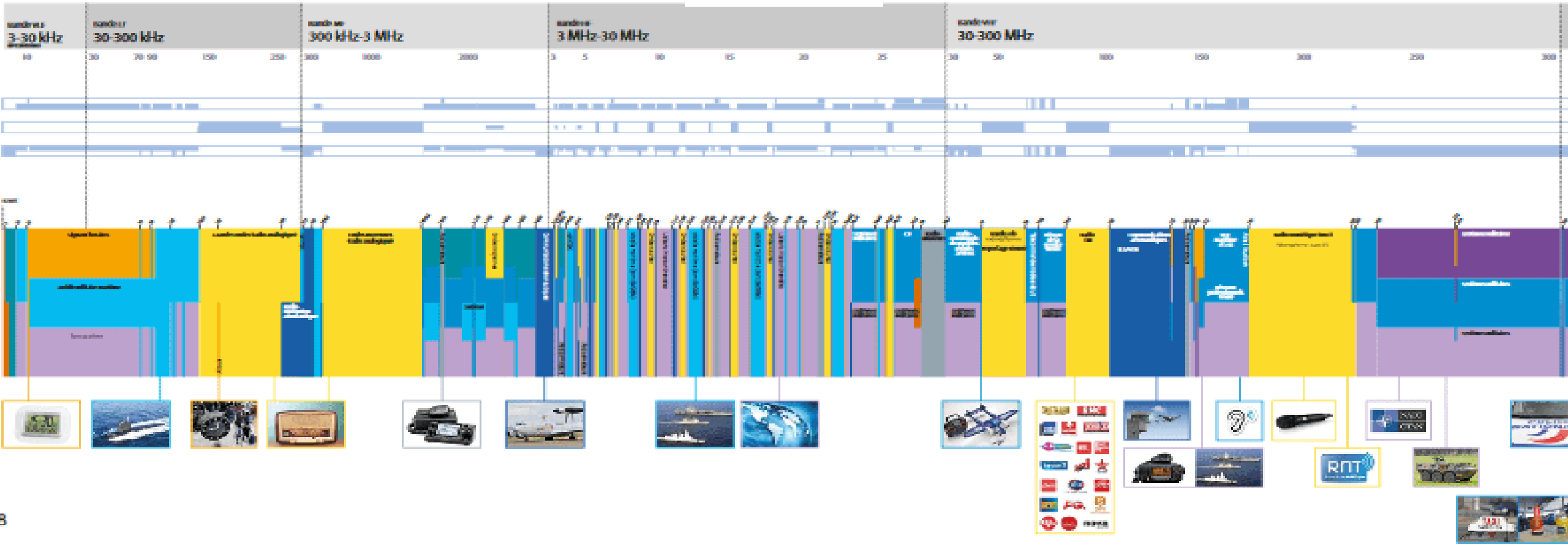
Historique

Le Spectre Electromagnétique



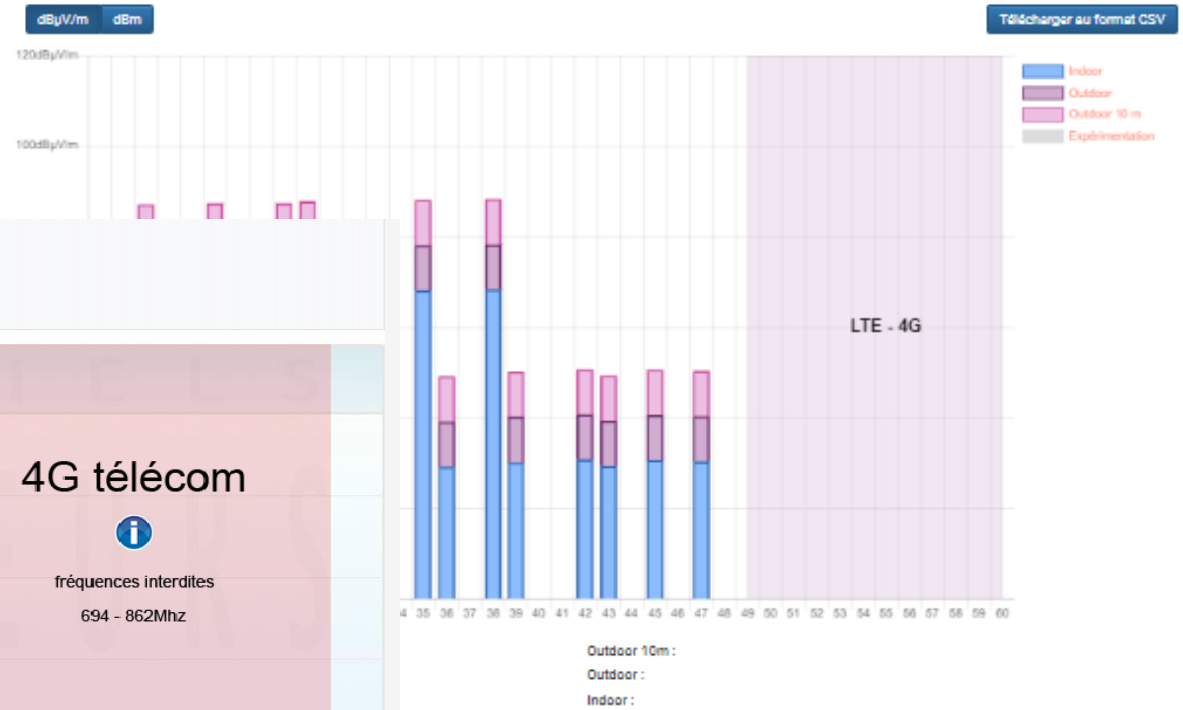
Reglementation

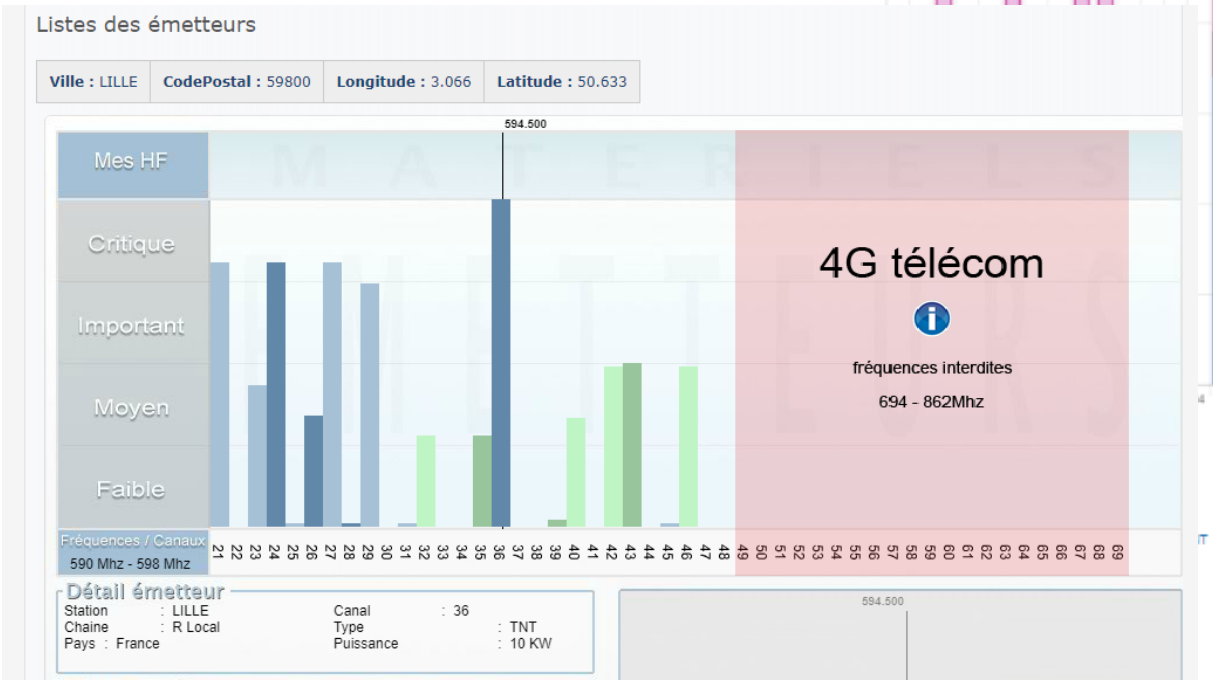
Le Spectre Electromagnétique



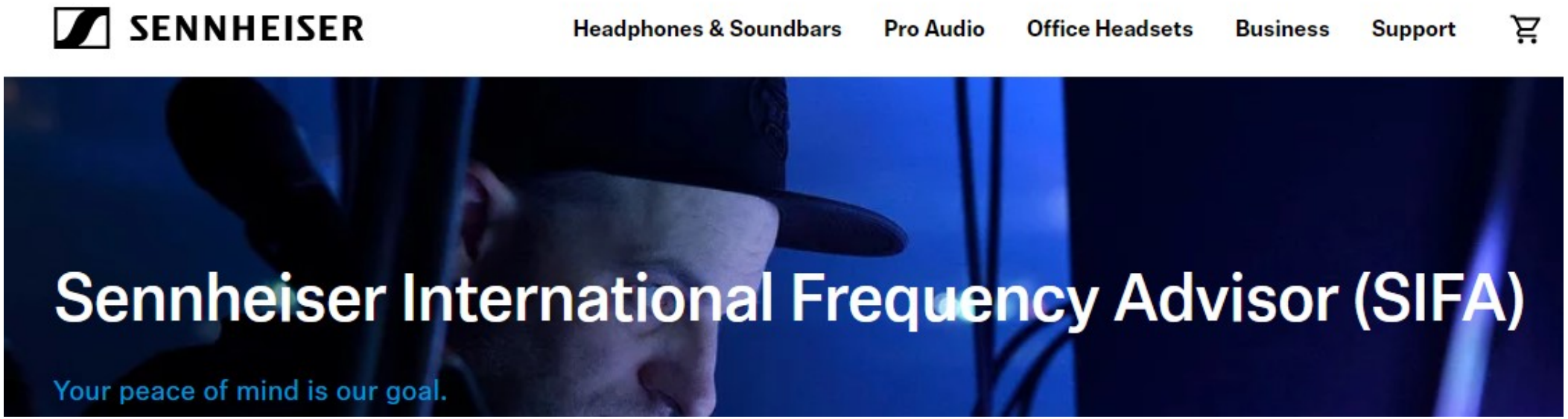
Règlementation - Outils

- ANFR
  - https://scanfrequences.anfr.fr/
- Tapage/DCA
  - http://www.scanzone.fr/





Règlementation



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			View
470.0000 - 694.0000	-	Licence Exempt	50mW ERP			View
823.0000 - 826.0000	-	Licence Exempt	20mW EIRP		Up to 100mW permitted for body-worn equipment.	View
826.0000 - 832.0000	-	Licence Exempt	100mW EIRP			View
1785.0000 - 1800.0000	-	Licence Exempt	20mW EIRP			View

Règlementation - Largeur de bande

Reference
REN/ATTM-0431

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

ETSI

650 Route des Lu
F-06921 Sophia Antipolis Ce

Tel.: +33 4 92 94 42 00 Fax: +

Siret N° 348 623 562 00017
Association à but non lucratif
Sous-Préfecture de Grasse (0

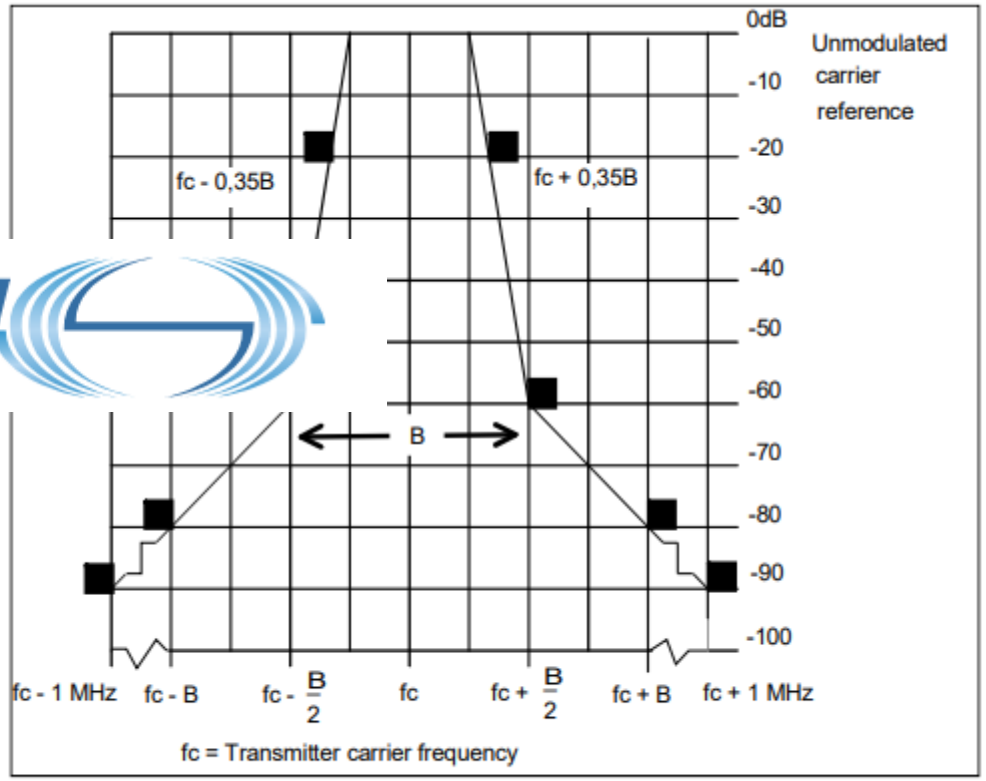


Figure 3: Spectrum mask for analogue systems

Le Spectre Electromagnétique

- Longeur d’onde – Propriétés

F	λ
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 – règlementation – Onde EM

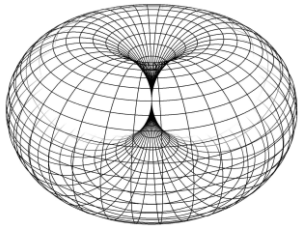
- Spectre UHF

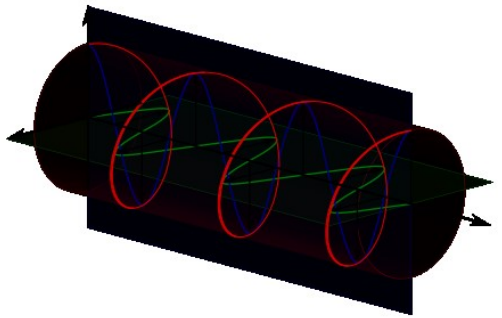
470MHz – 694MHz

Duplex Gap LTE, DECT, Wi-Fi…

- Occupation spectrale – 200KHz
- **Propagation.** La pénétration décroit 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 croit avec la fréquence.

Antennes





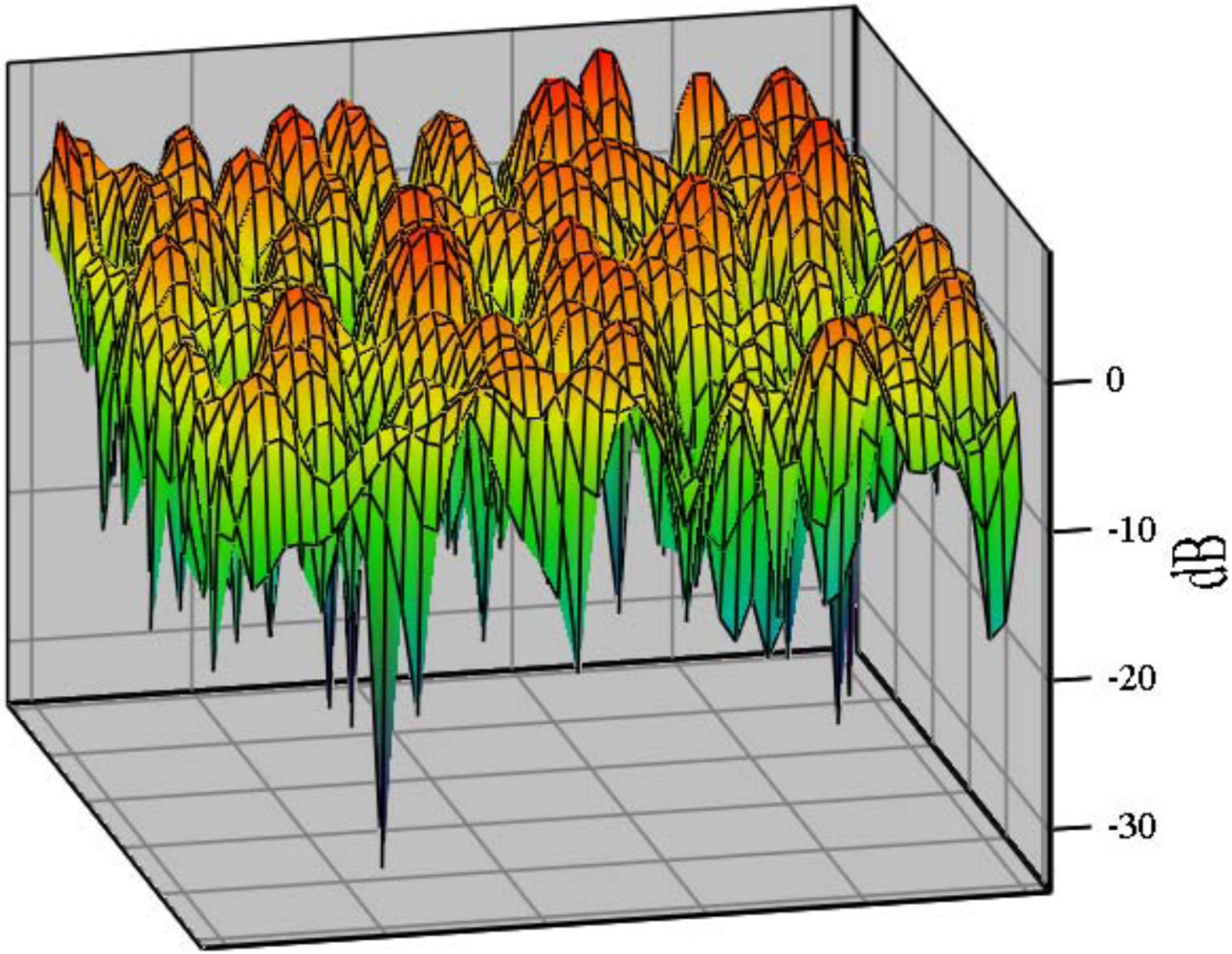
+4dBi

+8dBi

Antenna Polarization

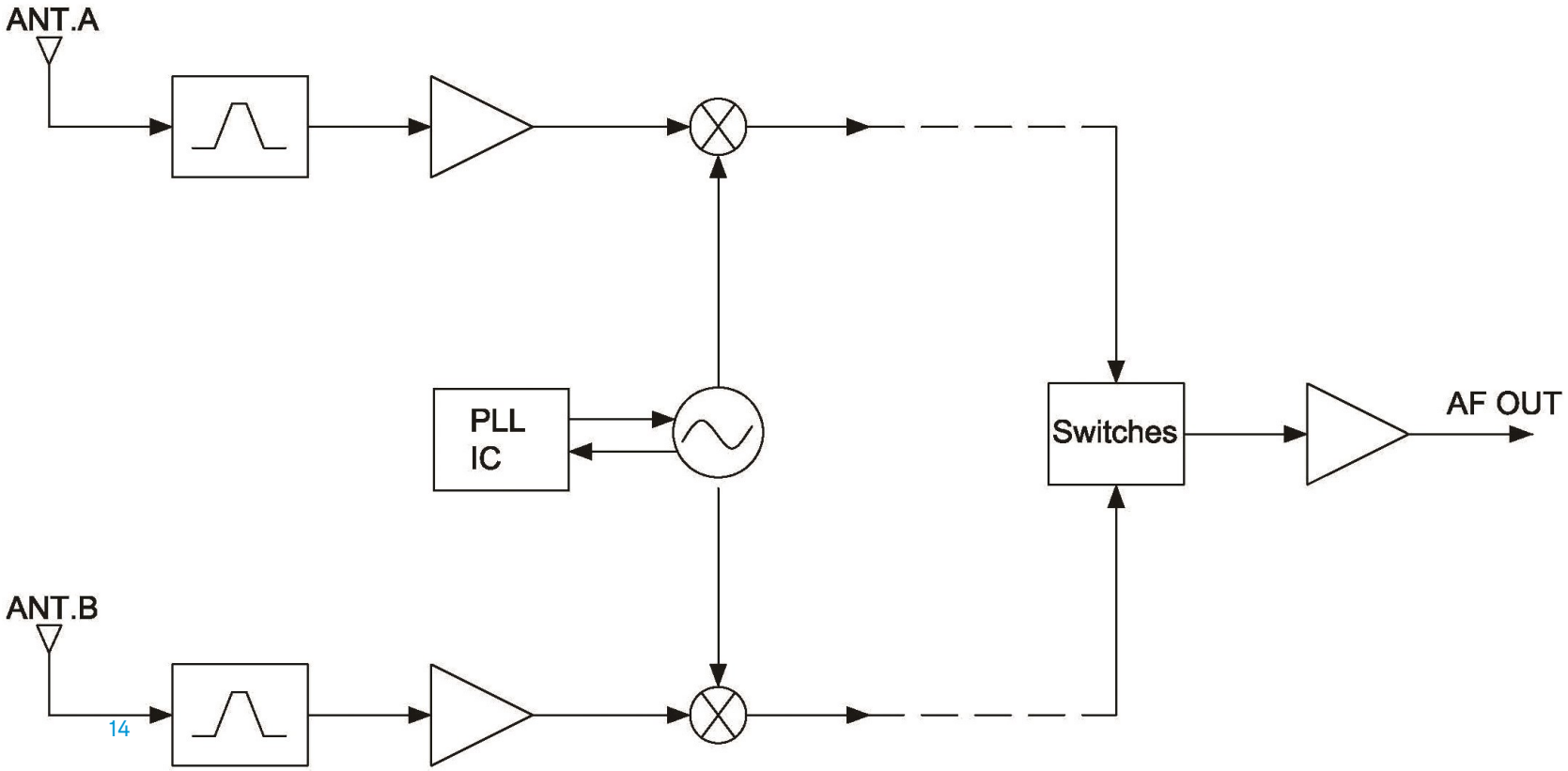
Propagation - Réflexion

- 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



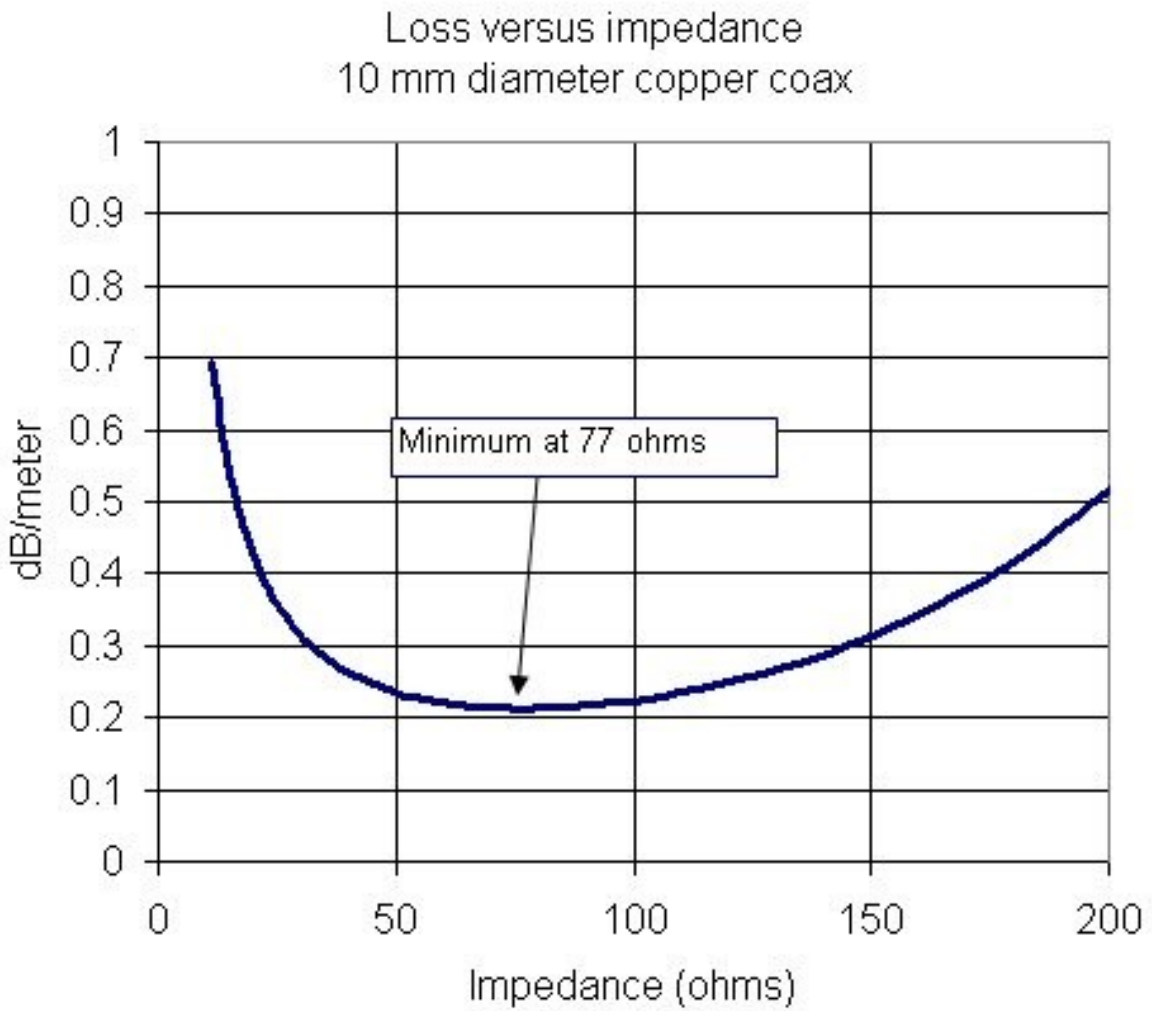
Câblage – Distribution d’antenne

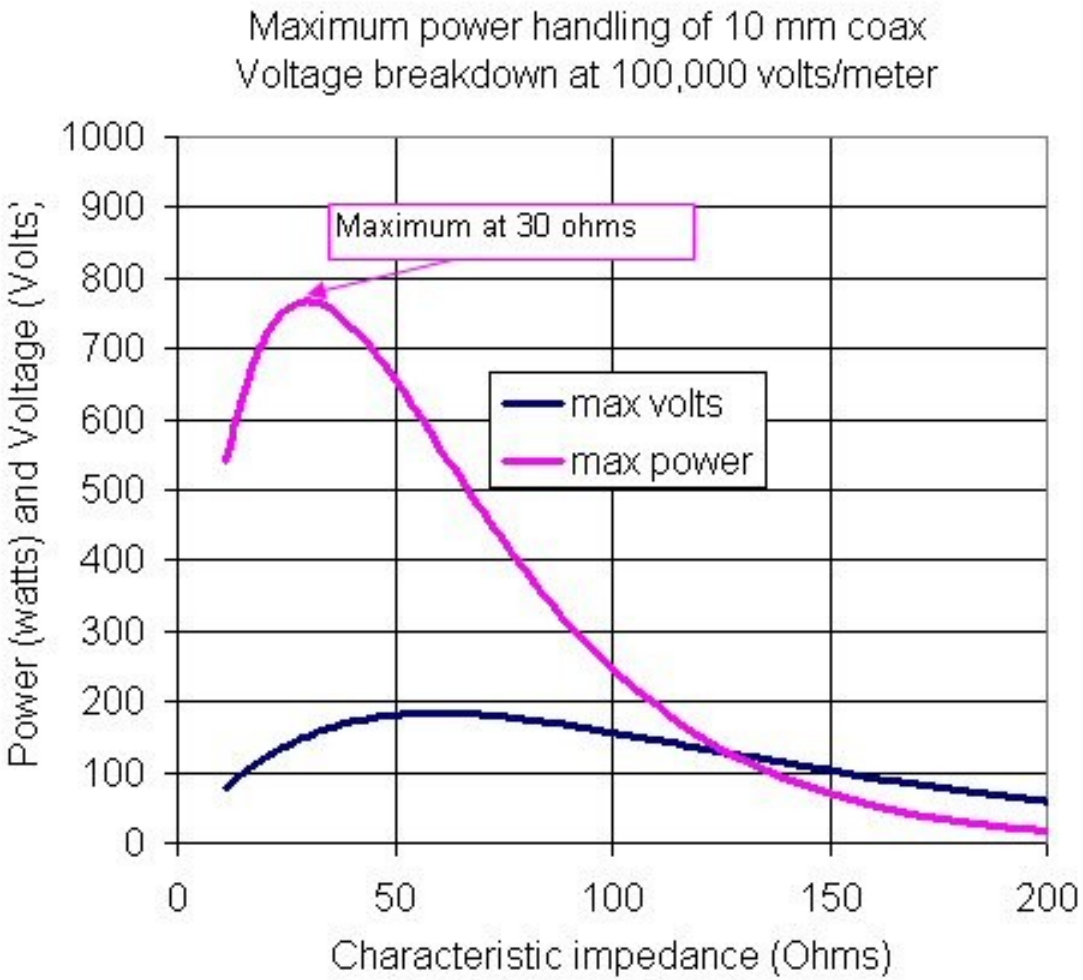
- Puissance / Tension - Ordre de Grandeur
- Perte dans les câbles coaxiaux
- Distribution de signaux / distribution d’antenne

Cablage – Distribution d’antenne

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

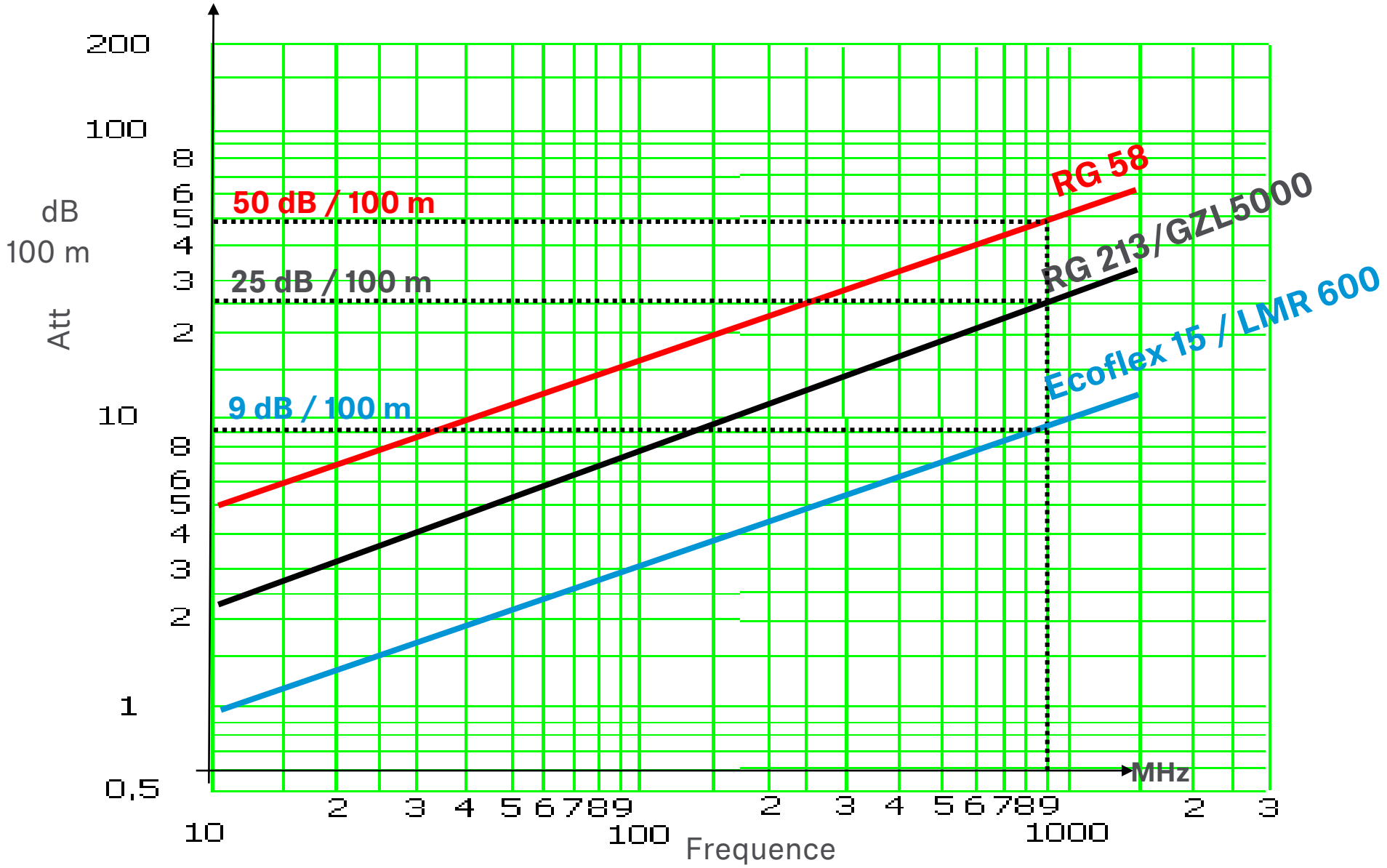
POURQUOI 50 OHMS





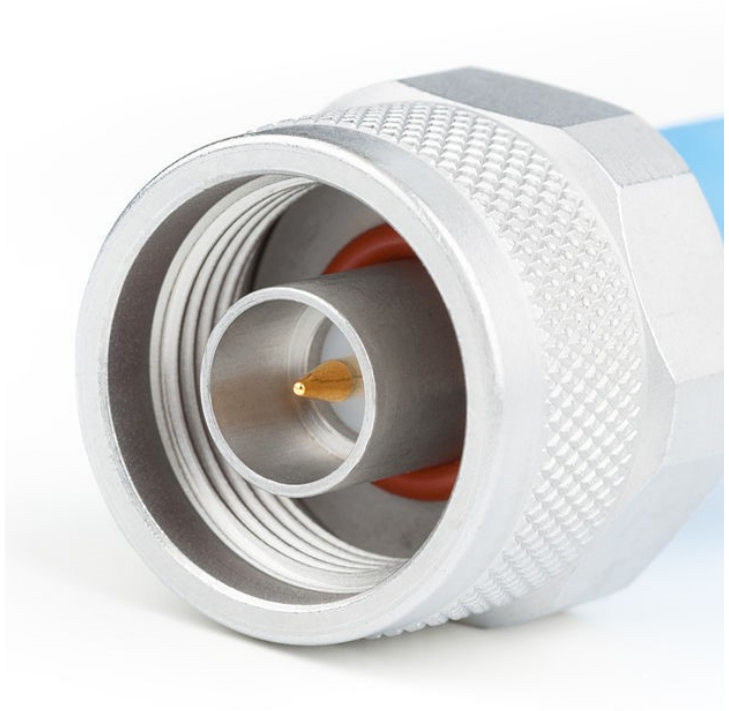
CABLES VIDEO
CABLES WORD CLOCK

Perte dans le cable



CONNECTEURS

CONNECTEURS

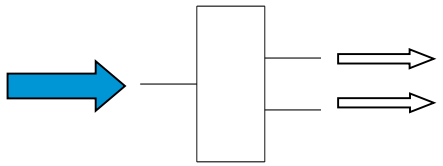


N

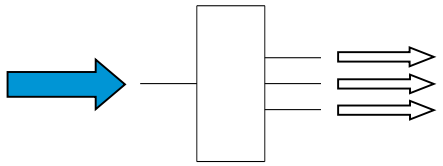
BNC

SMA

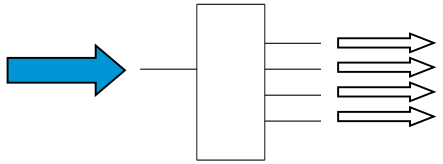
SPLITTERS ET BOOSTERS



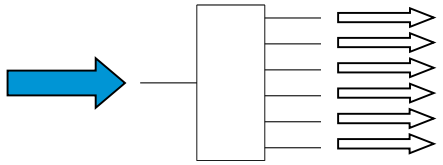
1 : 2 -4 dB



1 : 3 -7 dB



1 : 4 -8 dB

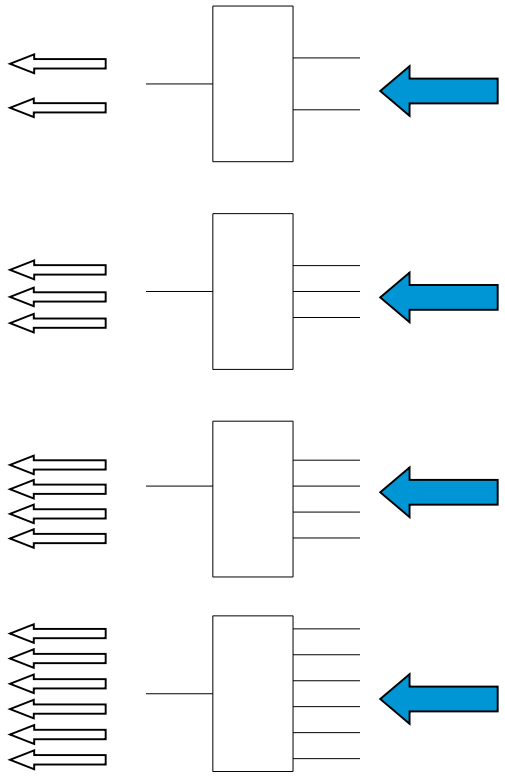


1 : 6 -11 dB

Splitter passif

Un T Vidéo n’est pas un splitter

SPLITTERS ET BOOSTERS



2 : 1 -4 dB

3 : 1 -7 dB

4 : 1 -8 dB

6 : 1 -11 dB

Splitter passif

COMPENSER LES PERTES
Booster - ampli

GAIN AJUSTABLE

AB 3700

Large bande

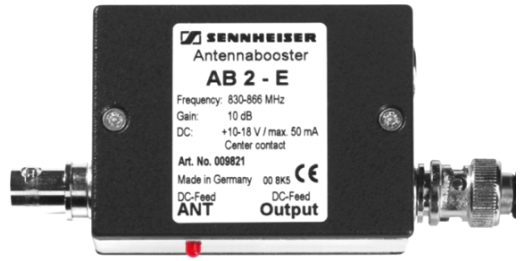
GAIN FIXE

AB 1036 TV

AB 9000

Filtrage Réglable

AB 4



AB 2, AB3

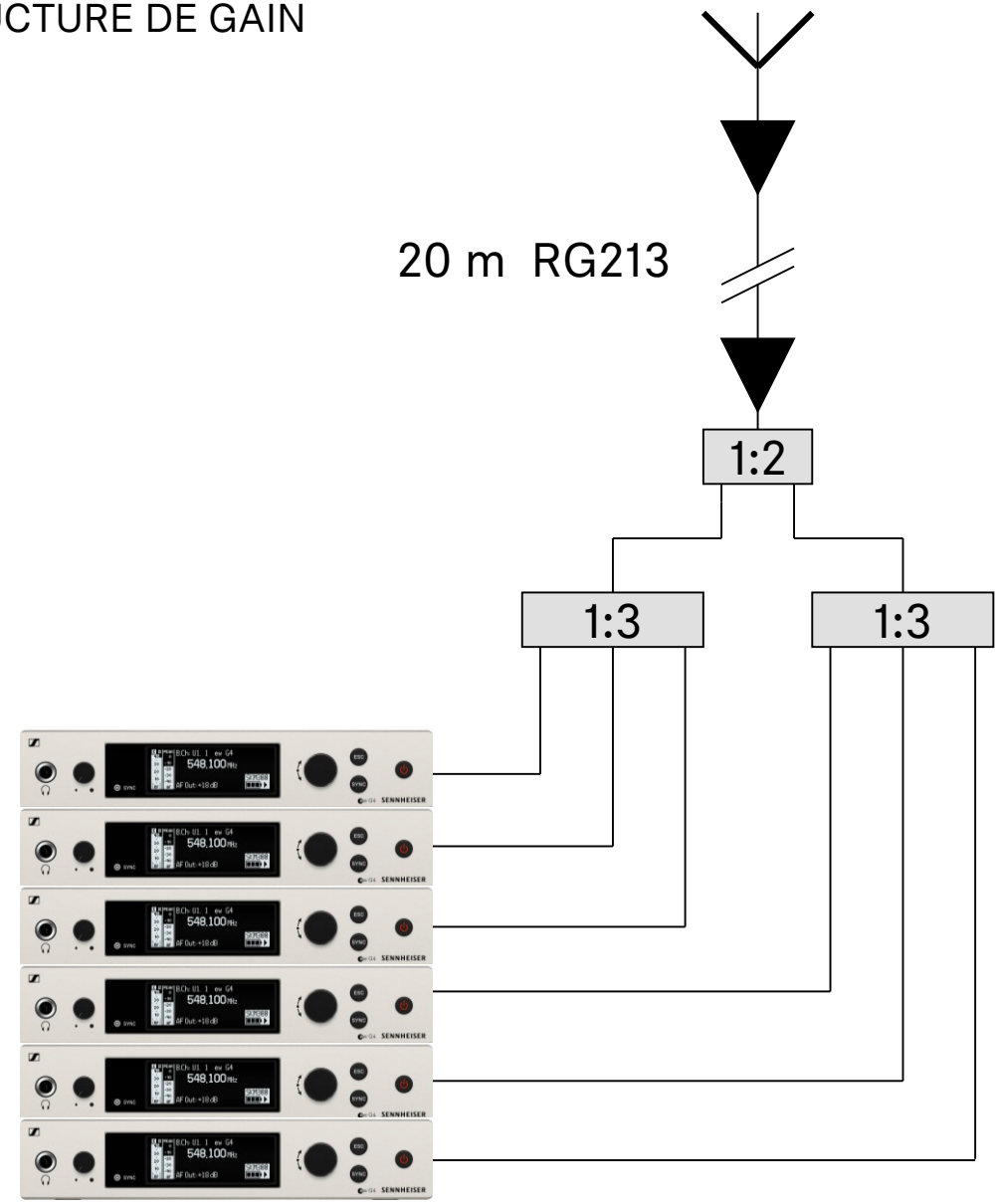
Filtrage Fixe

SPLITTER ACTIFS
BOOSTER + ASP (courant faible)

ASA 214

ASA 3000

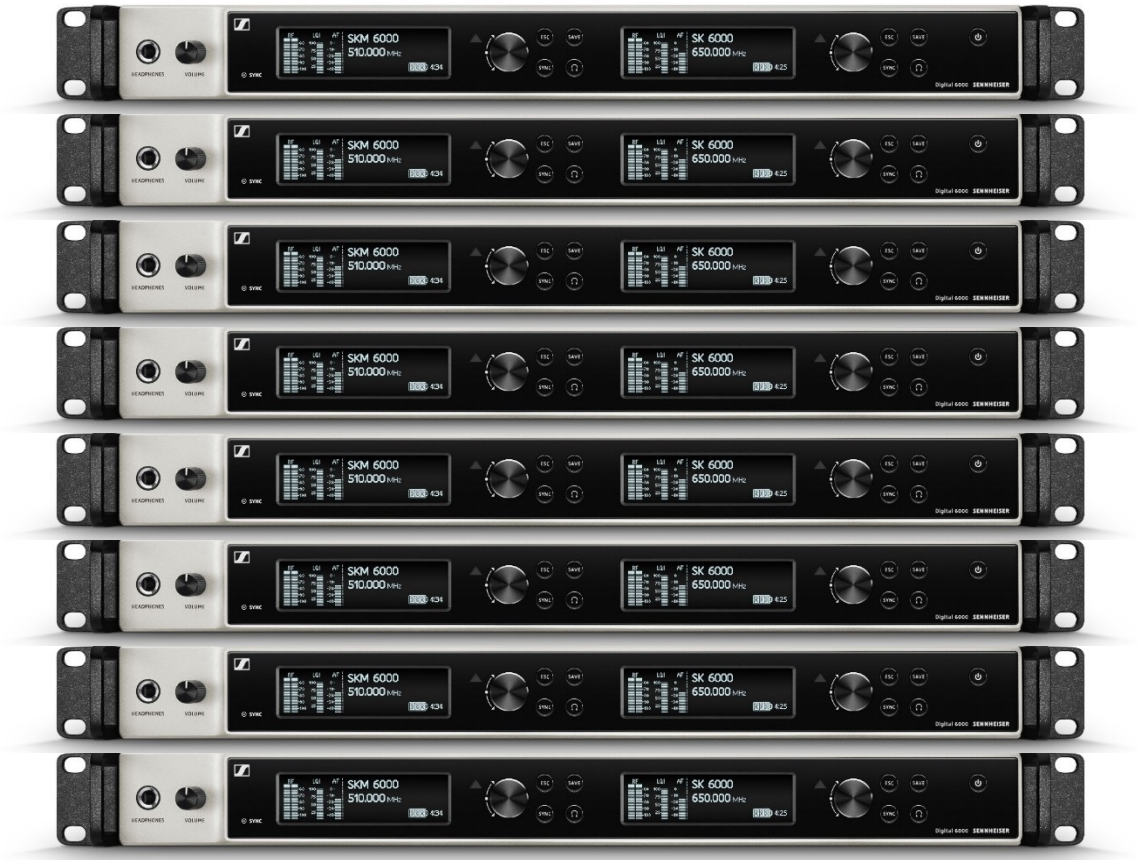
STRUCTURE DE GAIN



AMP	PERTES
+10 dB	
	-6 dB
+10 dB	
	- 4 dB
	- 7 dB
	- 17 dB
+20 dB	

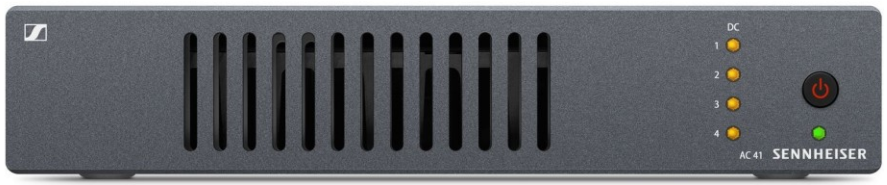
Total +3 dB

Cas des splitters intégrés



128 Channels

COMBINERS
SPLITTER + BOOSTER (puissance!)



AC 41

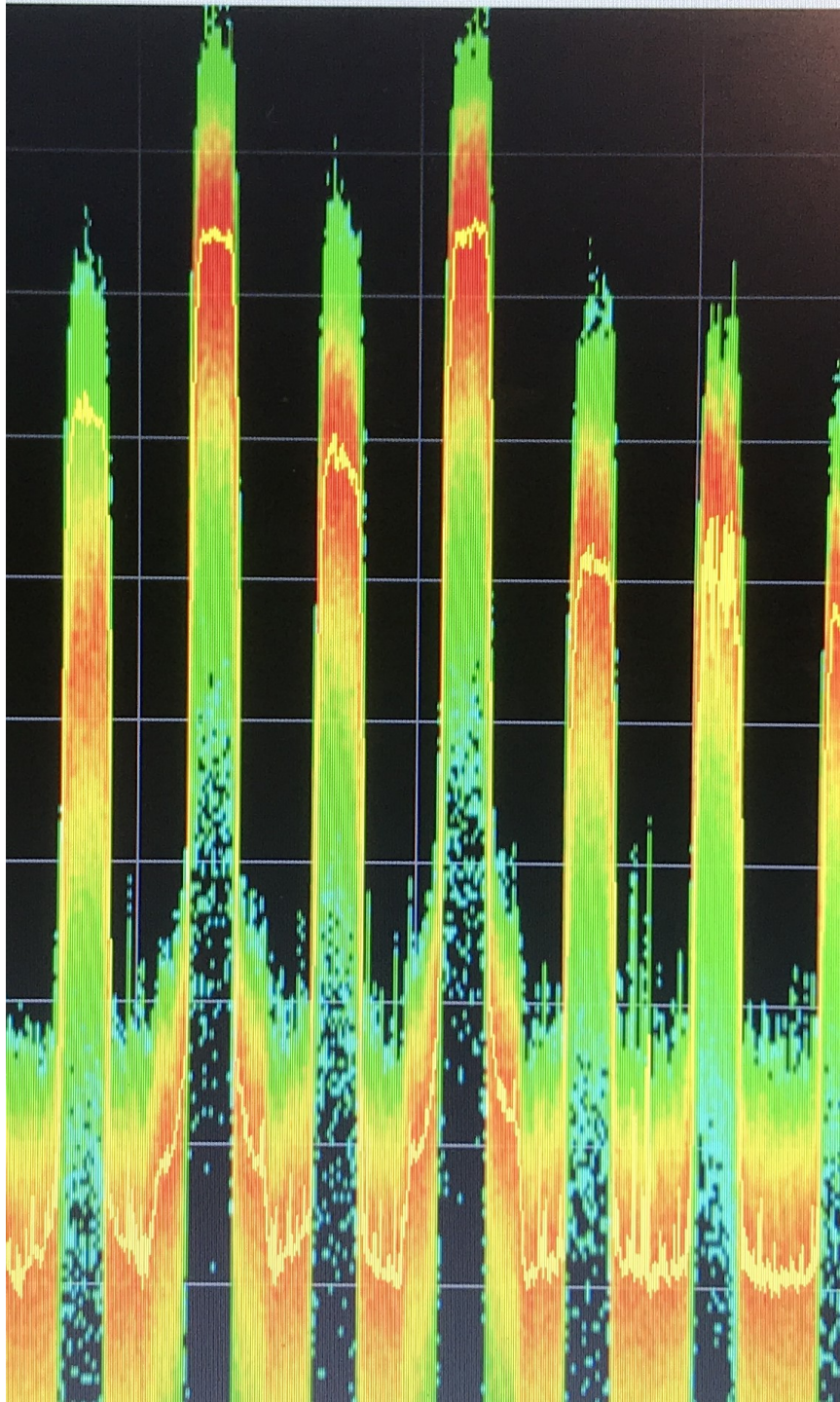
AC 3000, AC 3200, AC 3200 +

Antennes – Diversity – Cablage - Distribution

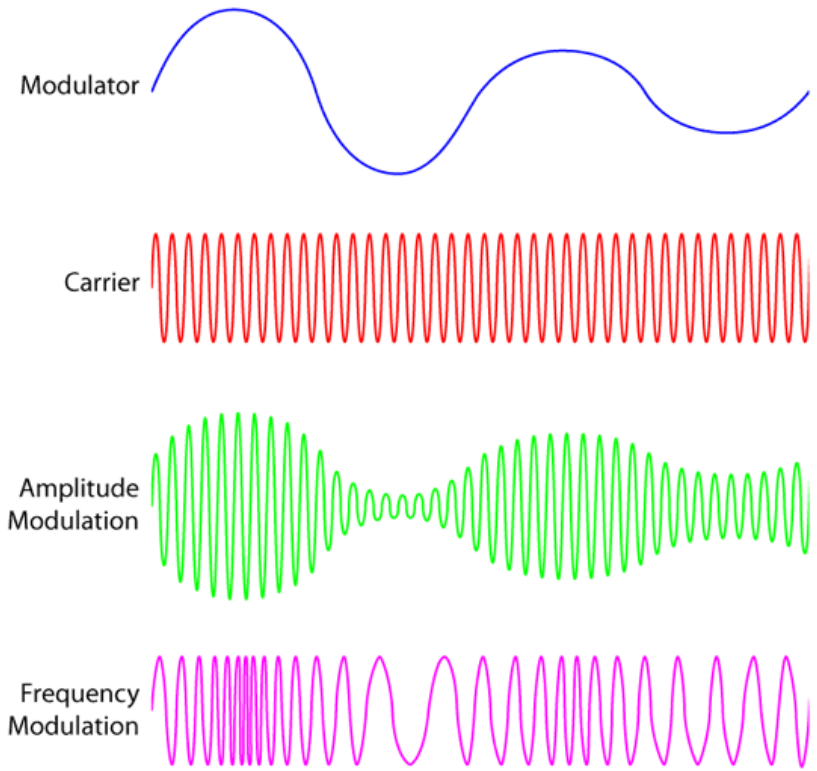
- Les boosters / antennes “actives” ne doivent être envisagés uniquement pour compenser des futures pertes existantes (attenuation dans le cable ou splitter passif).
- Se servir des propriétés directionnelles des antennes. Omni en interieur, directionnelle pour attenuer une source de pollution HF.
-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

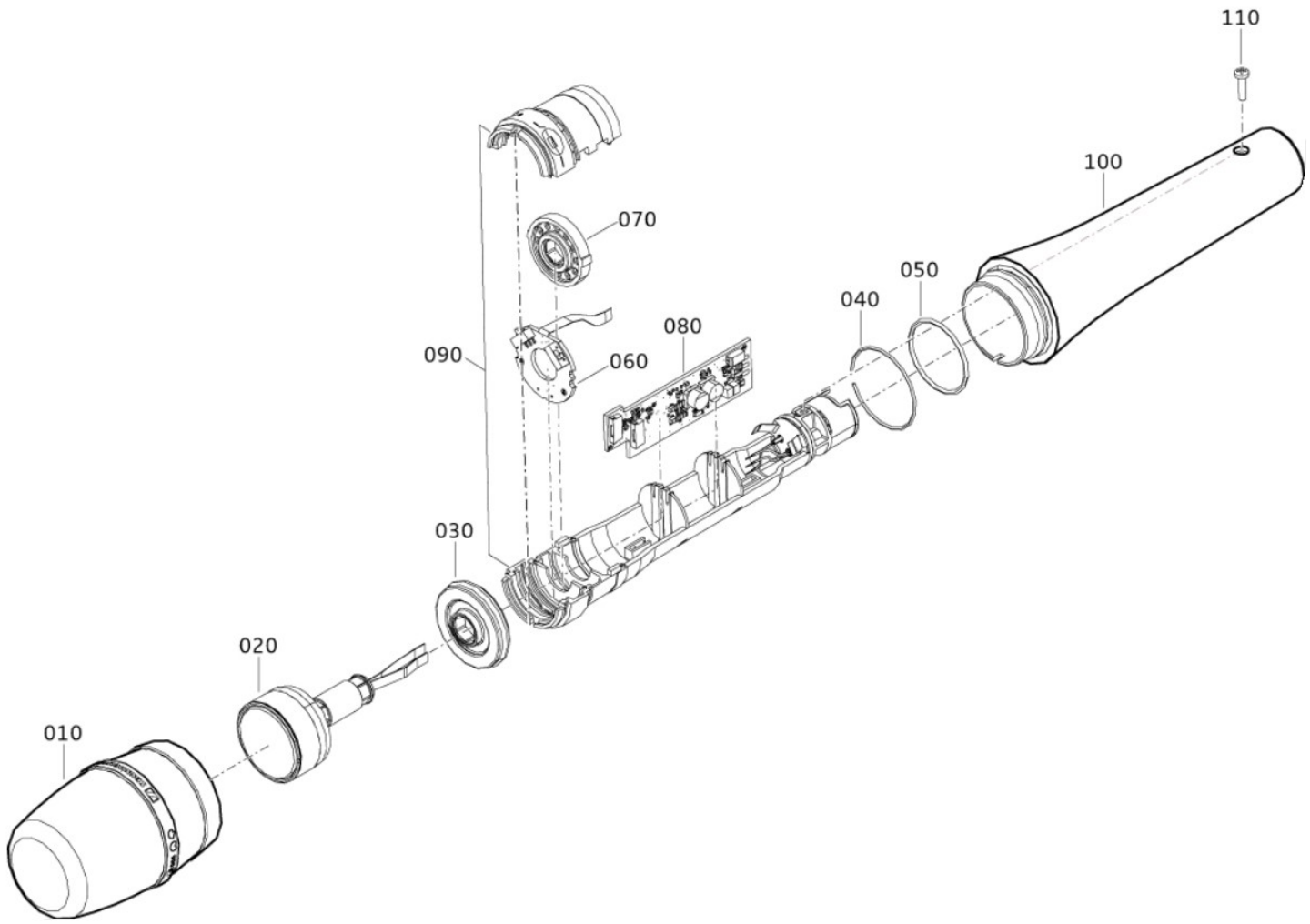
Modulation

- 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



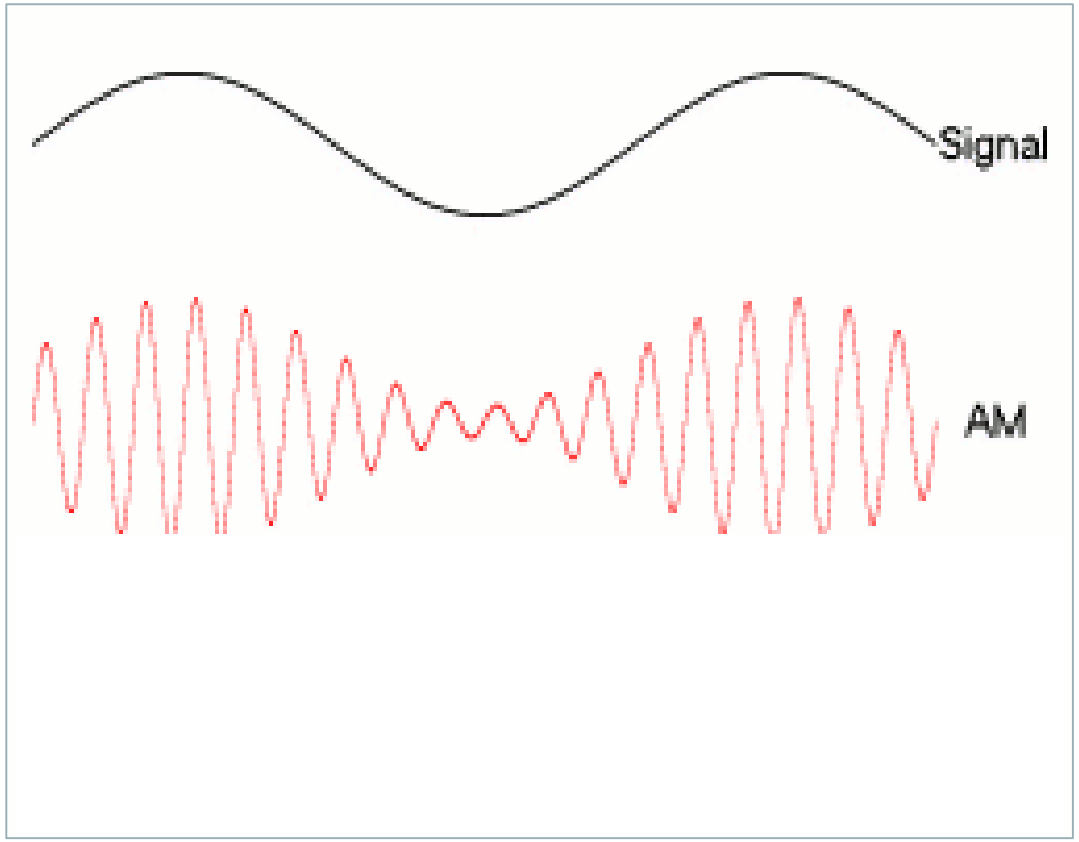
Modulation


Modulator
Carrier
Amplitude Modulation
Frequency Modulation

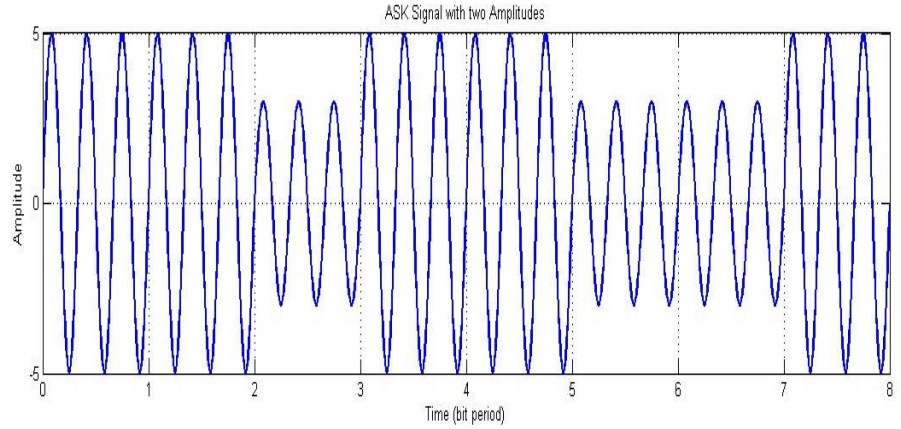

110
100
070
050
040
080
090
060
030
020
010

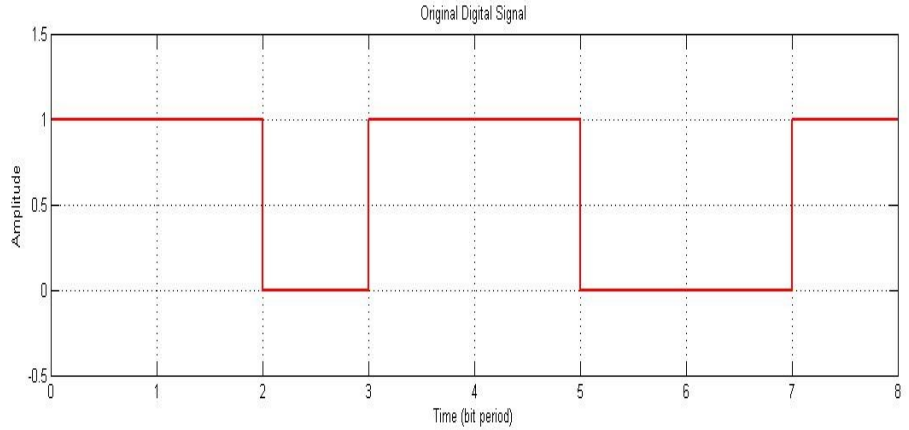
AMPLITUDE (domaine temporel)

AM ANALOGIQUE



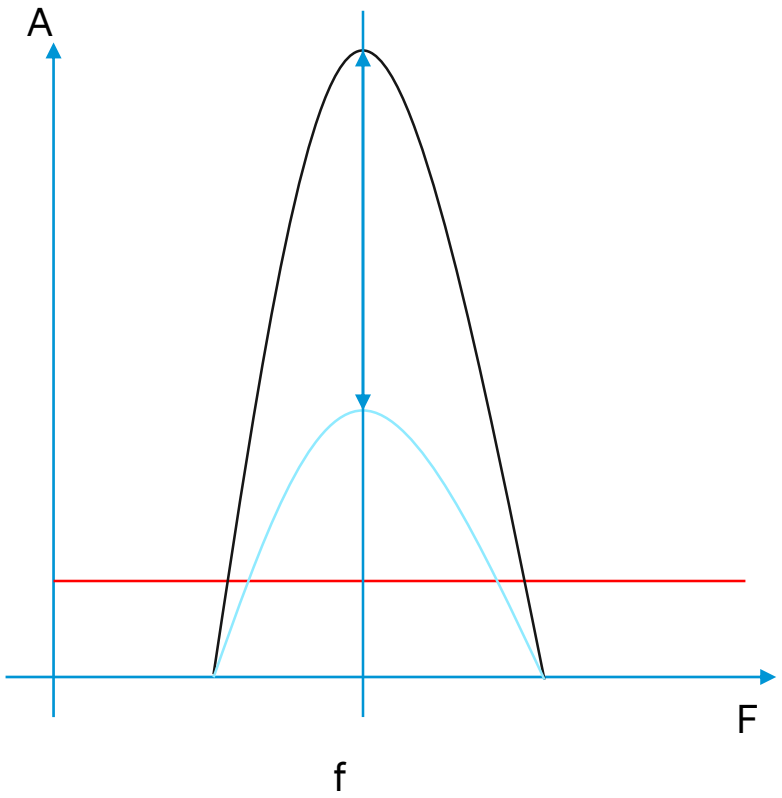
ASK NUMERIQUE



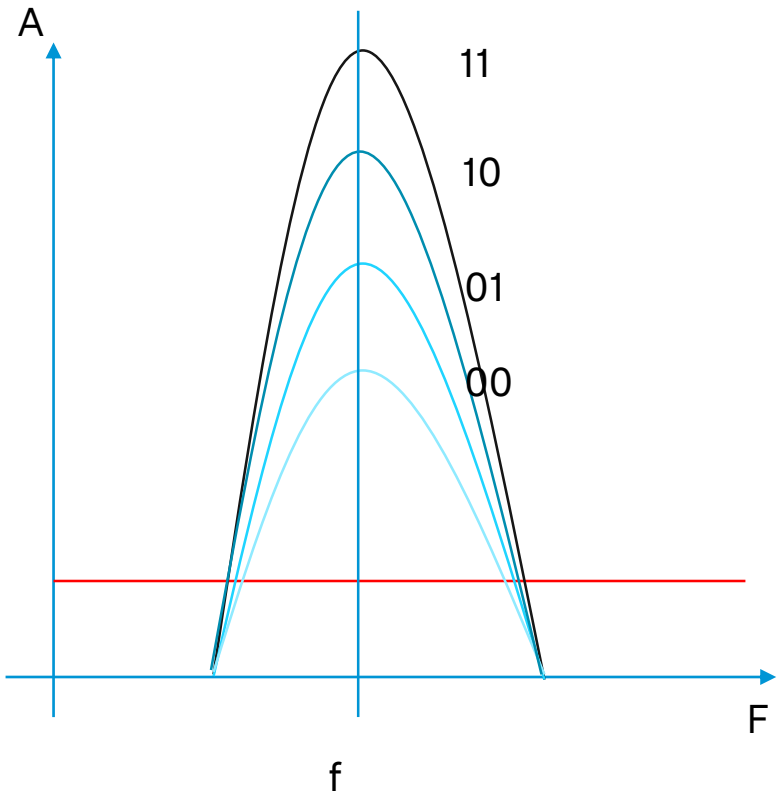


AMPLITUDE (domaine fréquentiel)

AM ANALOGIQUE

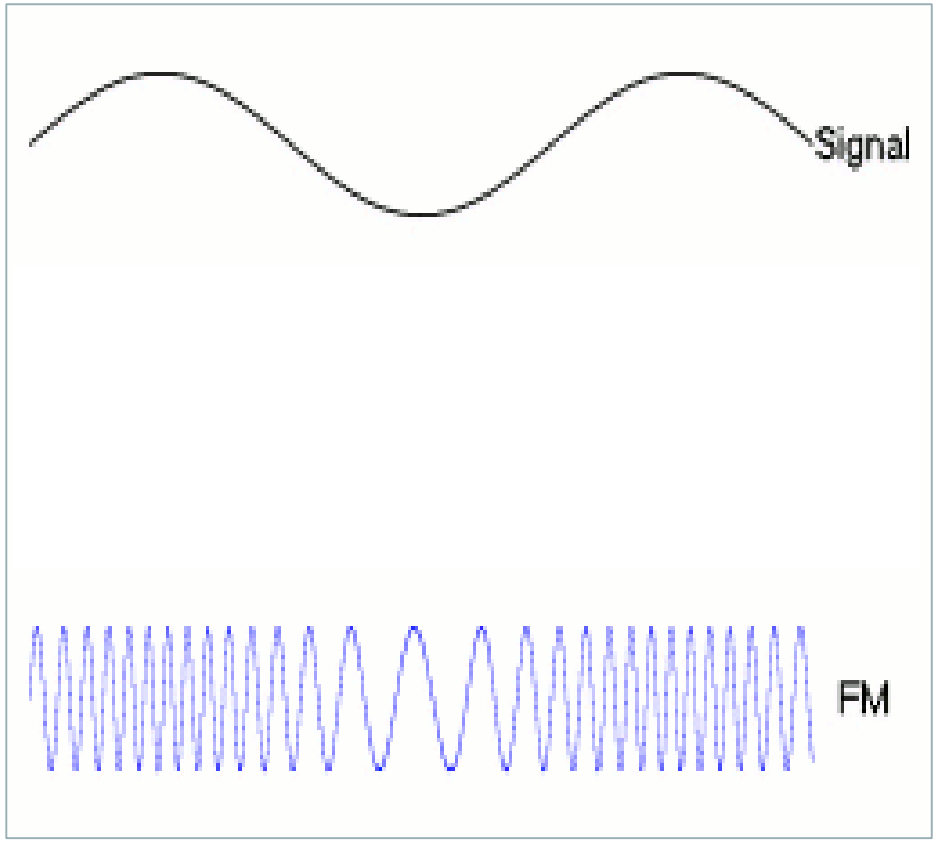


ASK NUMERIQUE

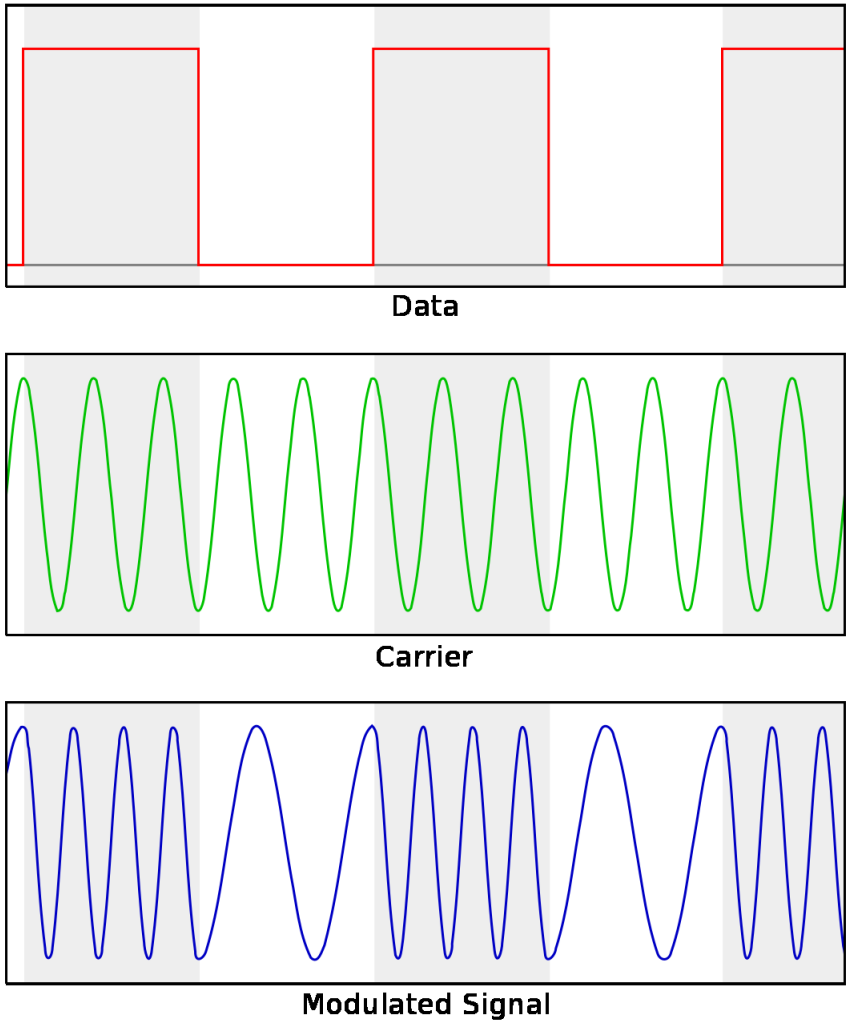


FREQUENCE (Domaine temporel)

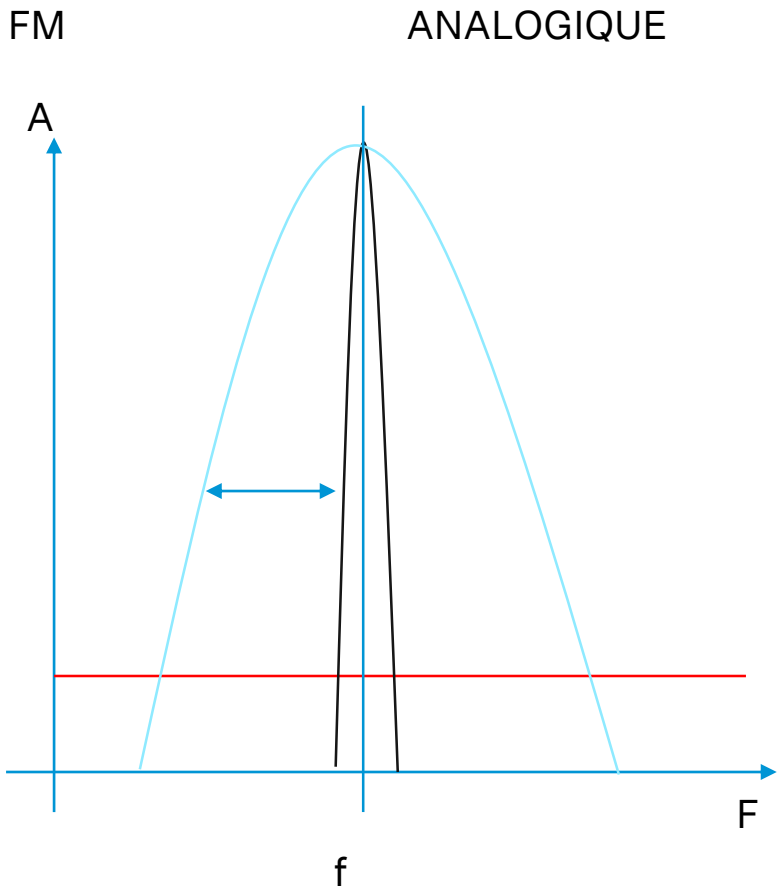
FM ANALOGIQUE

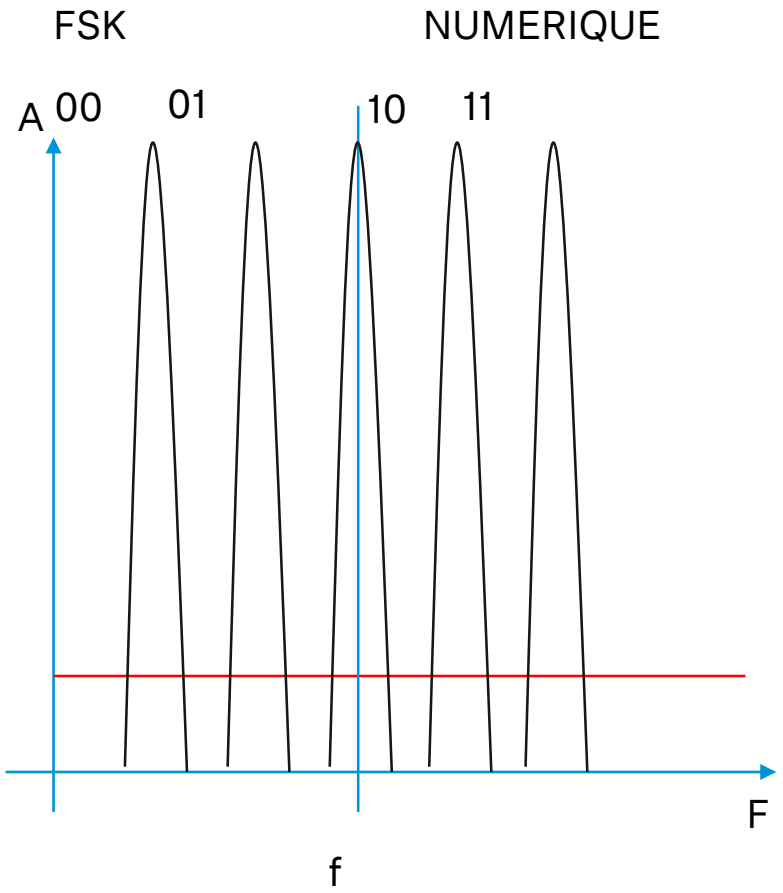


FSK NUMERIQUE



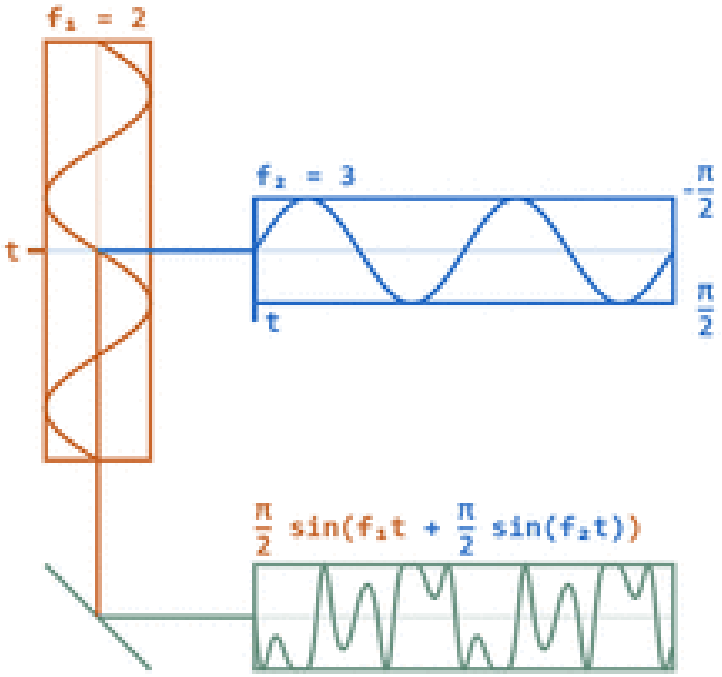
FREQUENCE (Domaine fréquentiel)



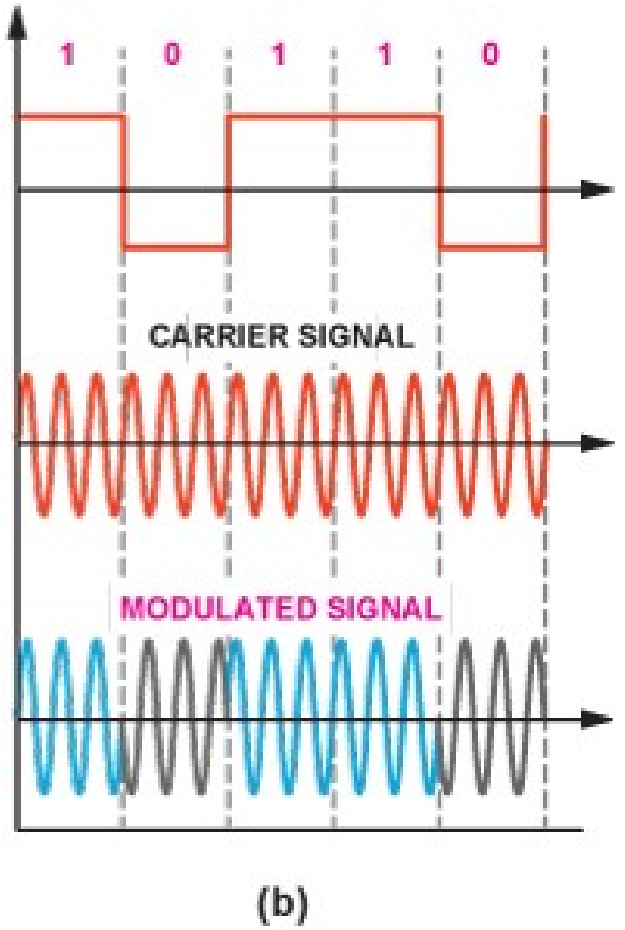


PHASE (domaine temporel)

PM ANALOGIQUE

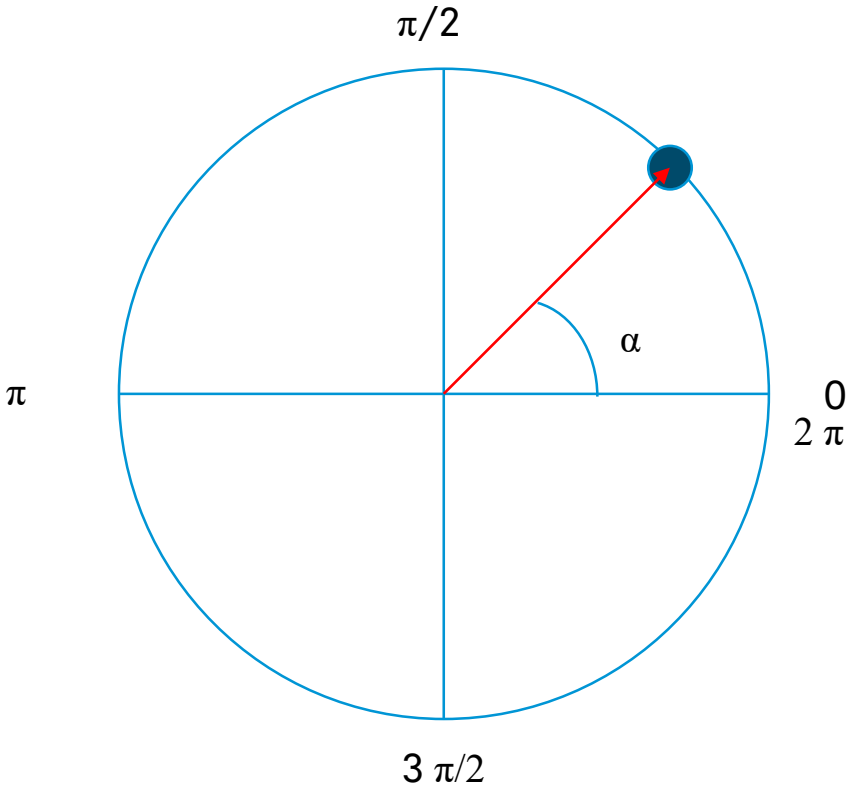


PSK NUMERIQUE

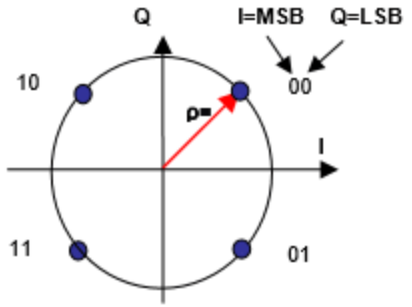


PHASE (domaine polaire)

PM ANALOGIQUE



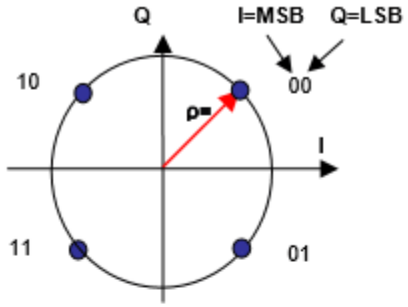
PSK NUMERIQUE



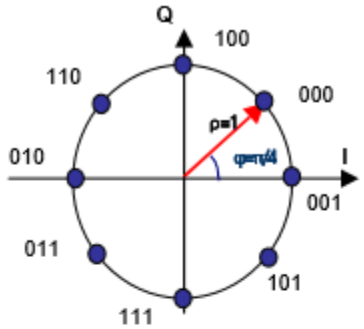
(a) QPSK

MODULATIONS COMPLEXES (domaine polaire)

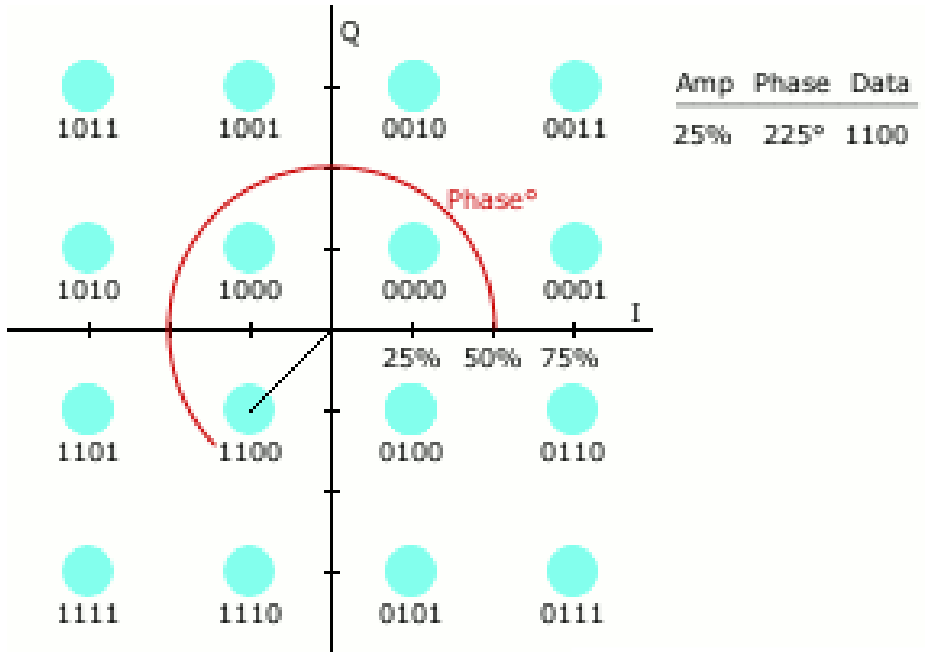
NUMERIQUE



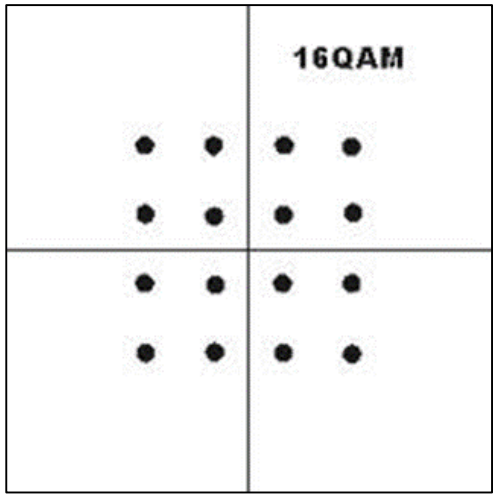
(a) QPSK



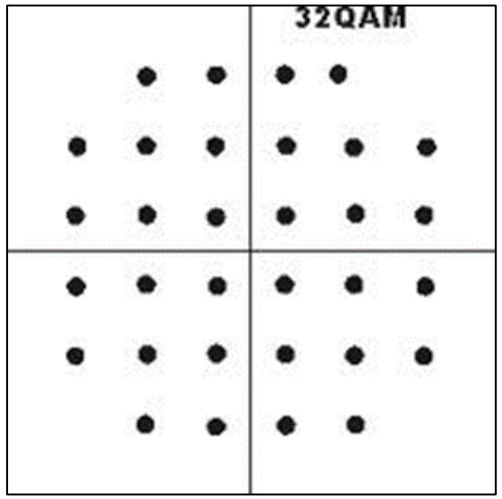
(b) 8PSK



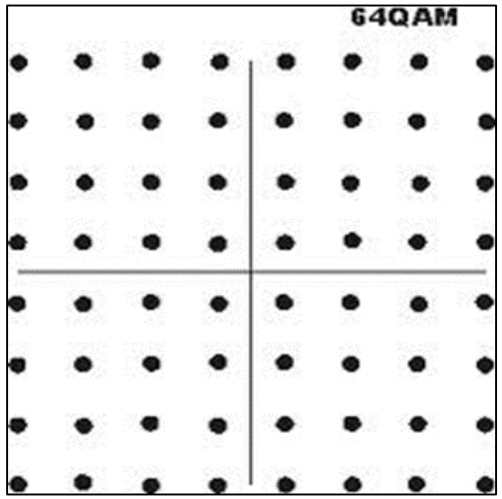
DIAGRAMES DE CONSTELLATION (QAM)



4 bits/symbol (2^4 CPs)



5 bits/symbol (2^5 CPs)



6 bits/symbol (2^6 CPs)

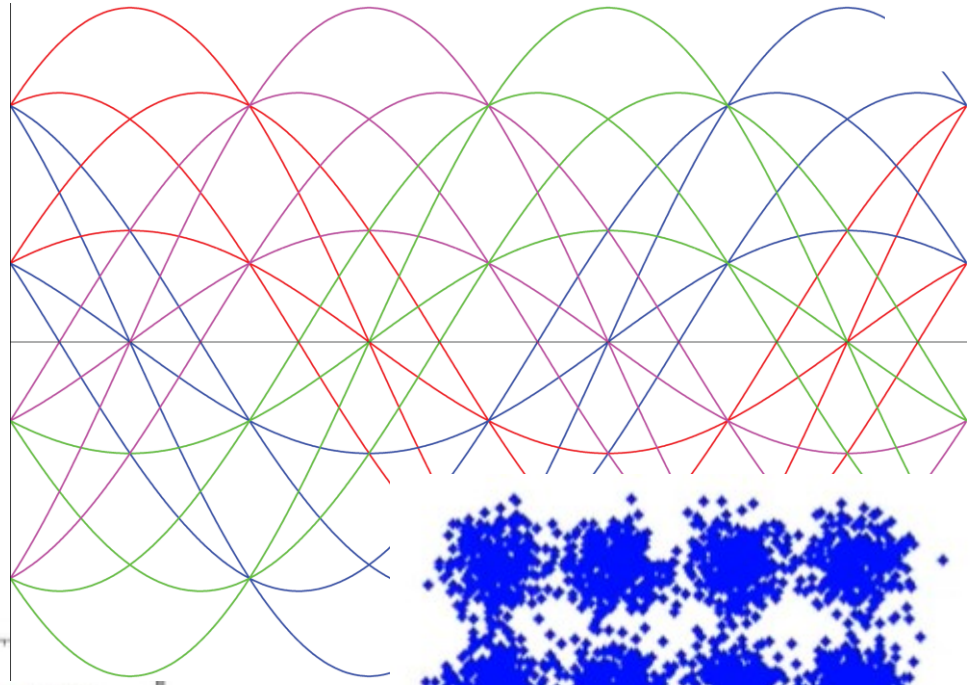
LES PRINCIPES HF – Modulation Numérique

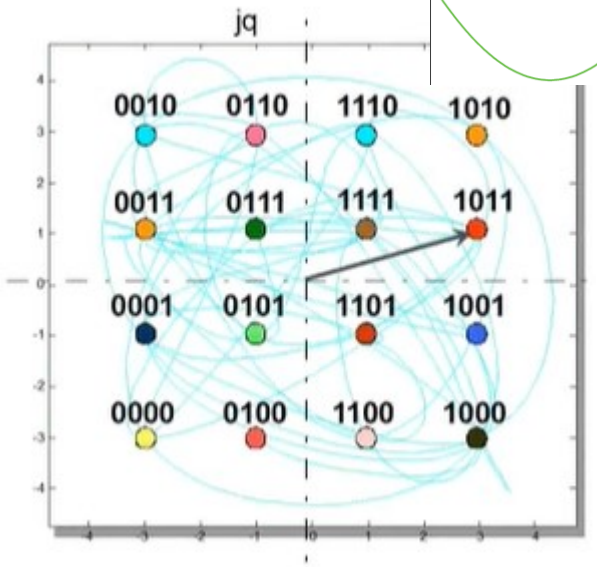
Signal discret

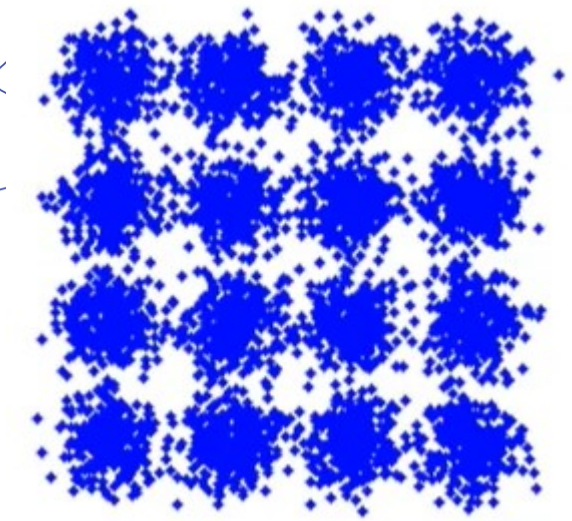
Codec / Cas du D9000

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

Des produits applicatifs





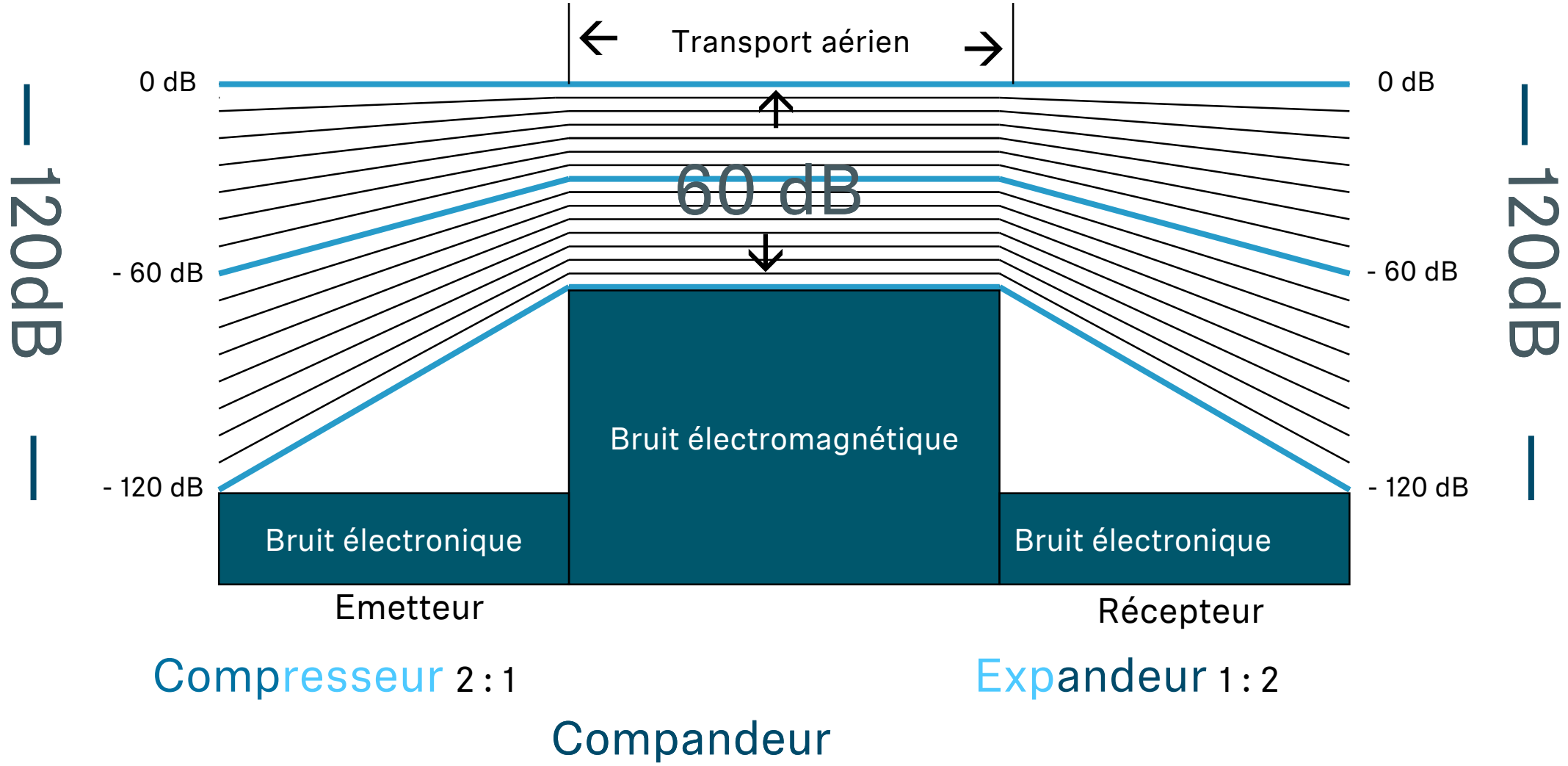


LES PRINCIPES HF – Modulation Numérique

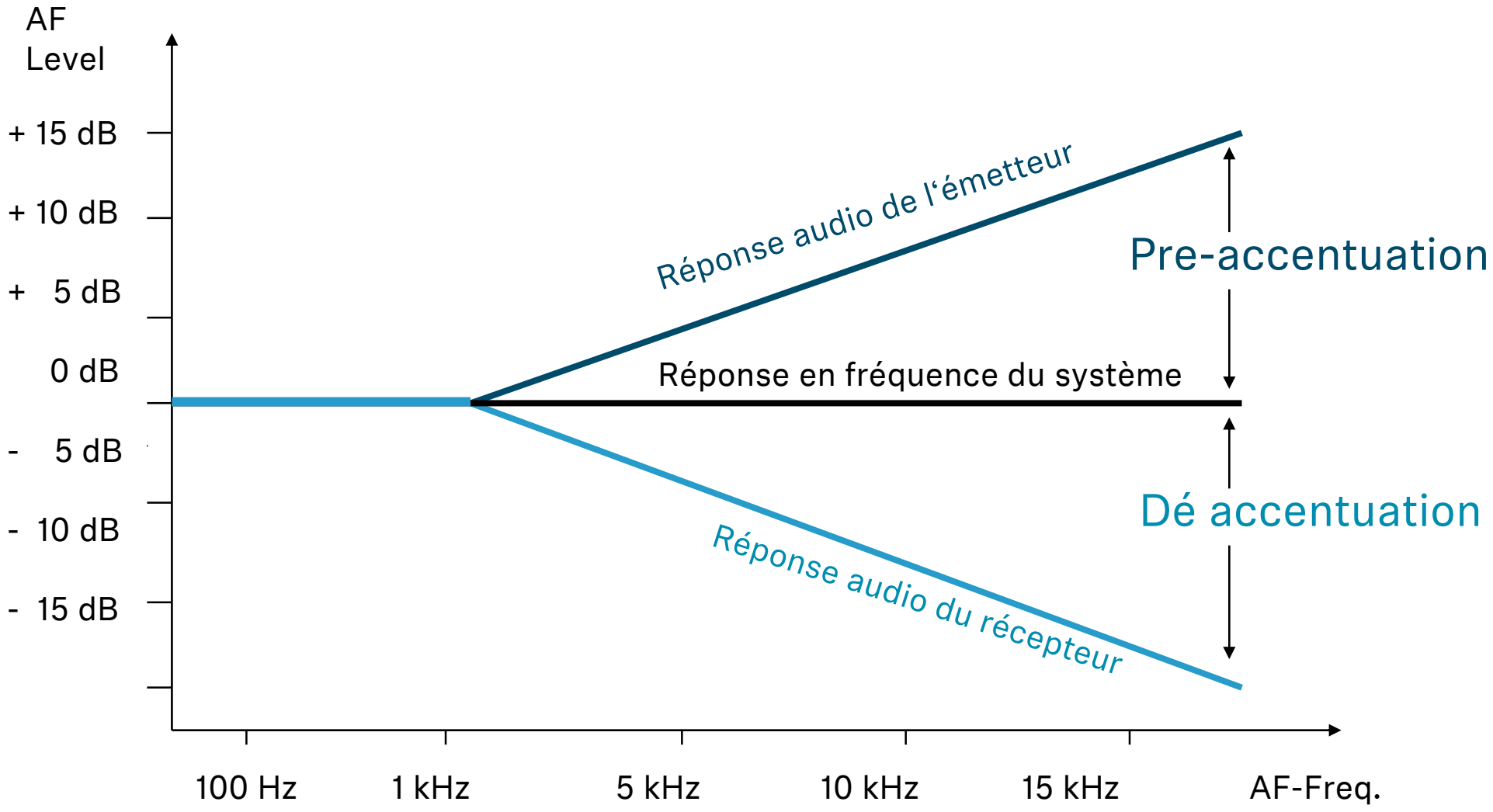
We transmit digital data

On Analog waves

TRAITEMENT AUDIO ANALOGIQUE
Compandeur



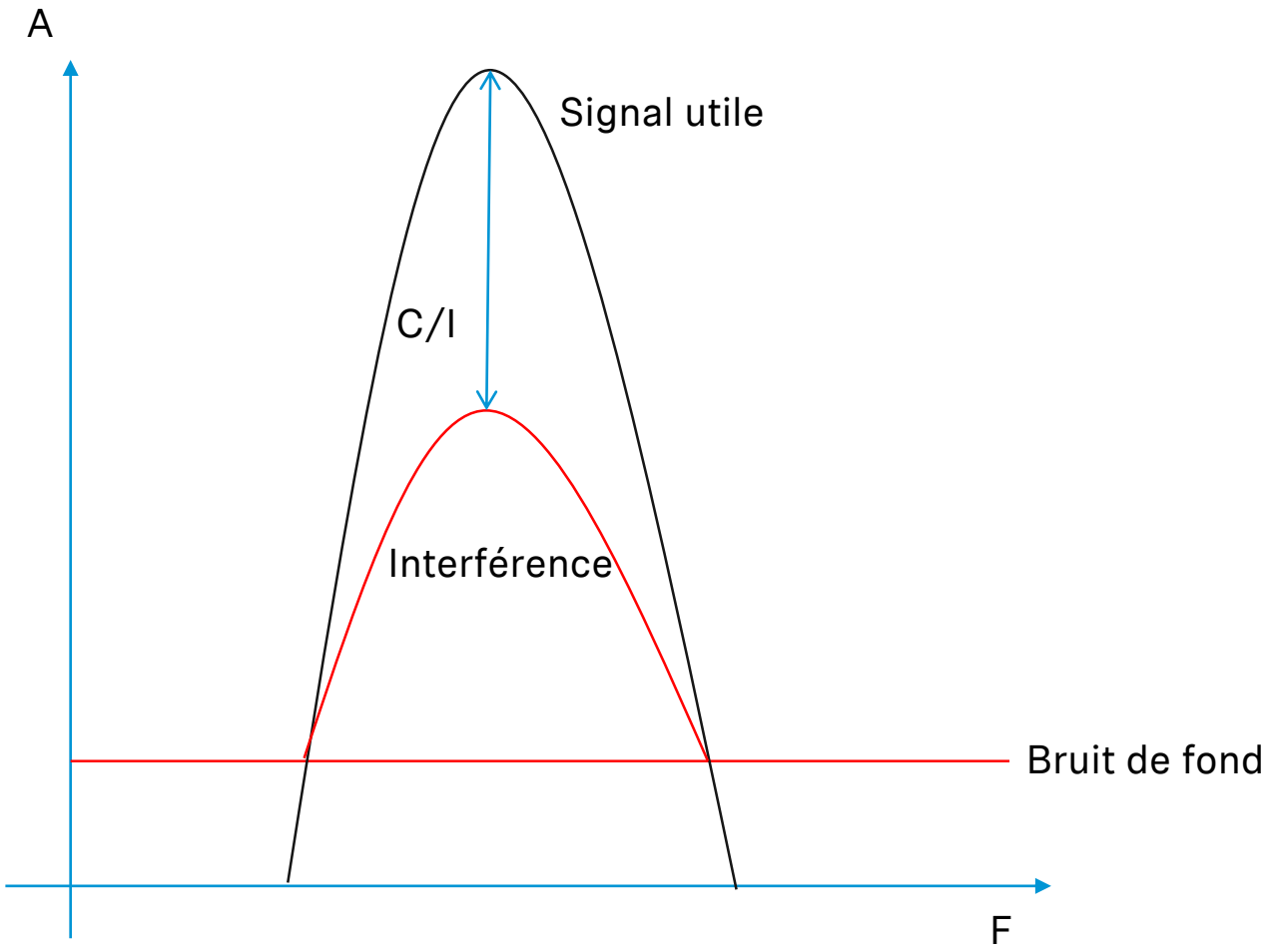
TRAITEMENT AUDIO ANALOGIQUE
Pre accentuation



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




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+

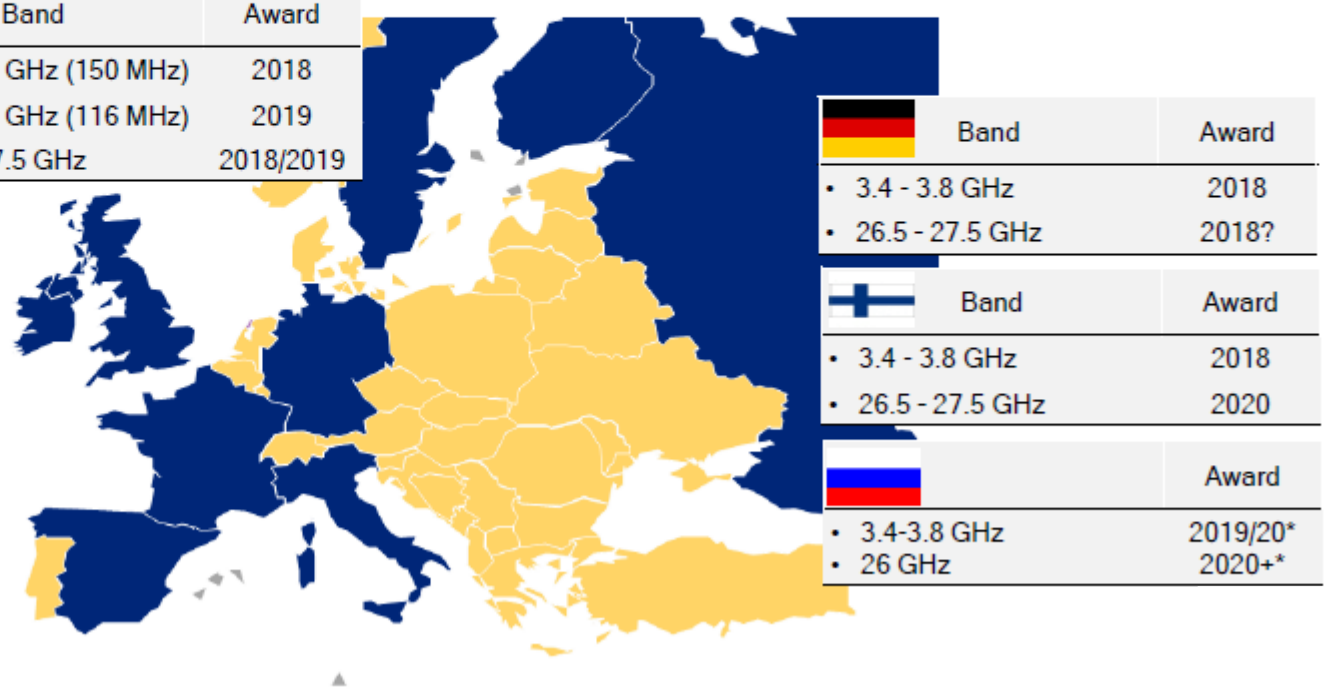
Band	Award
• 3.4 - 3.8 GHz (350 Mhz)	2017
• 26 GHz	2018

Band	Award
• 3.46 - 3.8 GHz	2018
• 26 GHz	2019

Band	Award
• 3.4-3.8 GHz	2019/2020
• 26.5 - 27.5 GHz	2019/2020

Band	Award
• 3.6 - 3.8 GHz	2018
• 26.5 - 27.5 GHz	2018

Band	Award
• 3.4 - 3.6 GHz (150 MHz)	2018
• 3.6 - 3.8 GHz (116 MHz)	2019
• 26.5 - 27.5 GHz	2018/2019



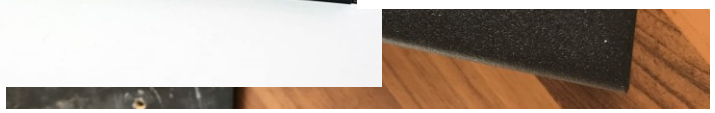
Band	Award
• 3.4 - 3.8 GHz	2018
• 26.5 - 27.5 GHz	2018?

Band	Award
• 3.4 - 3.8 GHz	2018
• 26.5 - 27.5 GHz	2020

	Award
• 3.4-3.8 GHz	2019/20*
• 26 GHz	2020+*

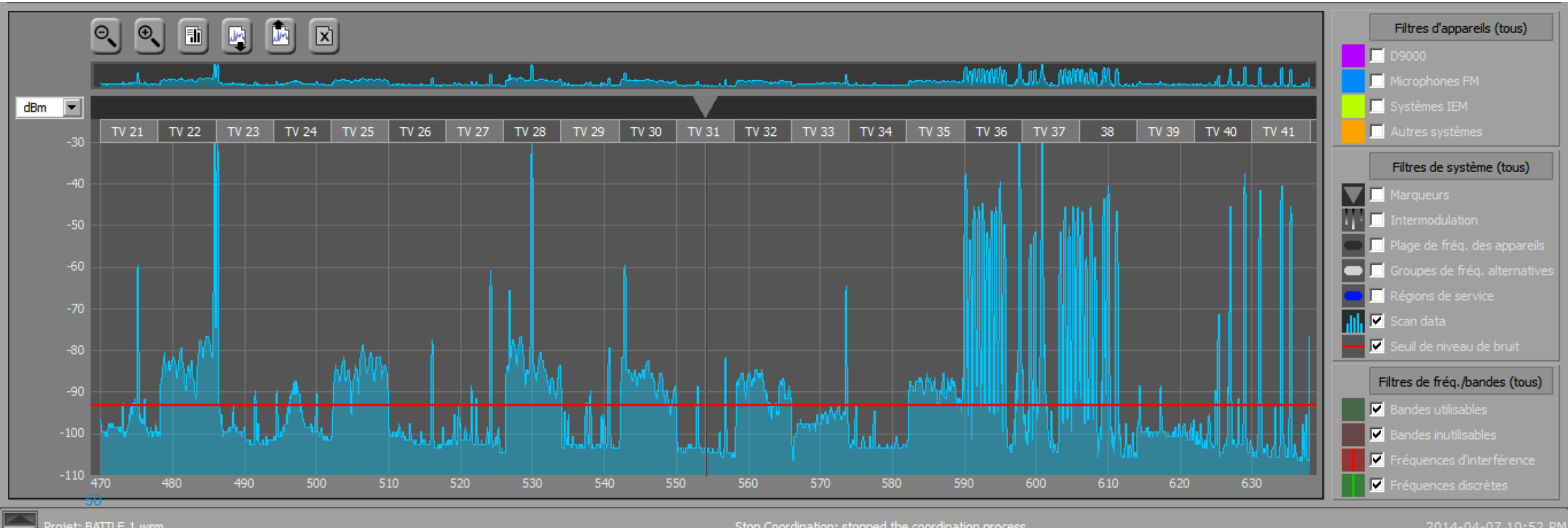
Les sources d’interférences

- Tous les équipements fonctionnant à haute fréquence. Les alimentations à découpage, certains switch, materiel video, HDMI.
- Eviter les antennes ¼ onde à l’interieur des baies à proximité de ces élements.
- Si les antennes sont déportées, s’assurer qu’aucune source de pollution ne soit trop proche.



SQUELCH

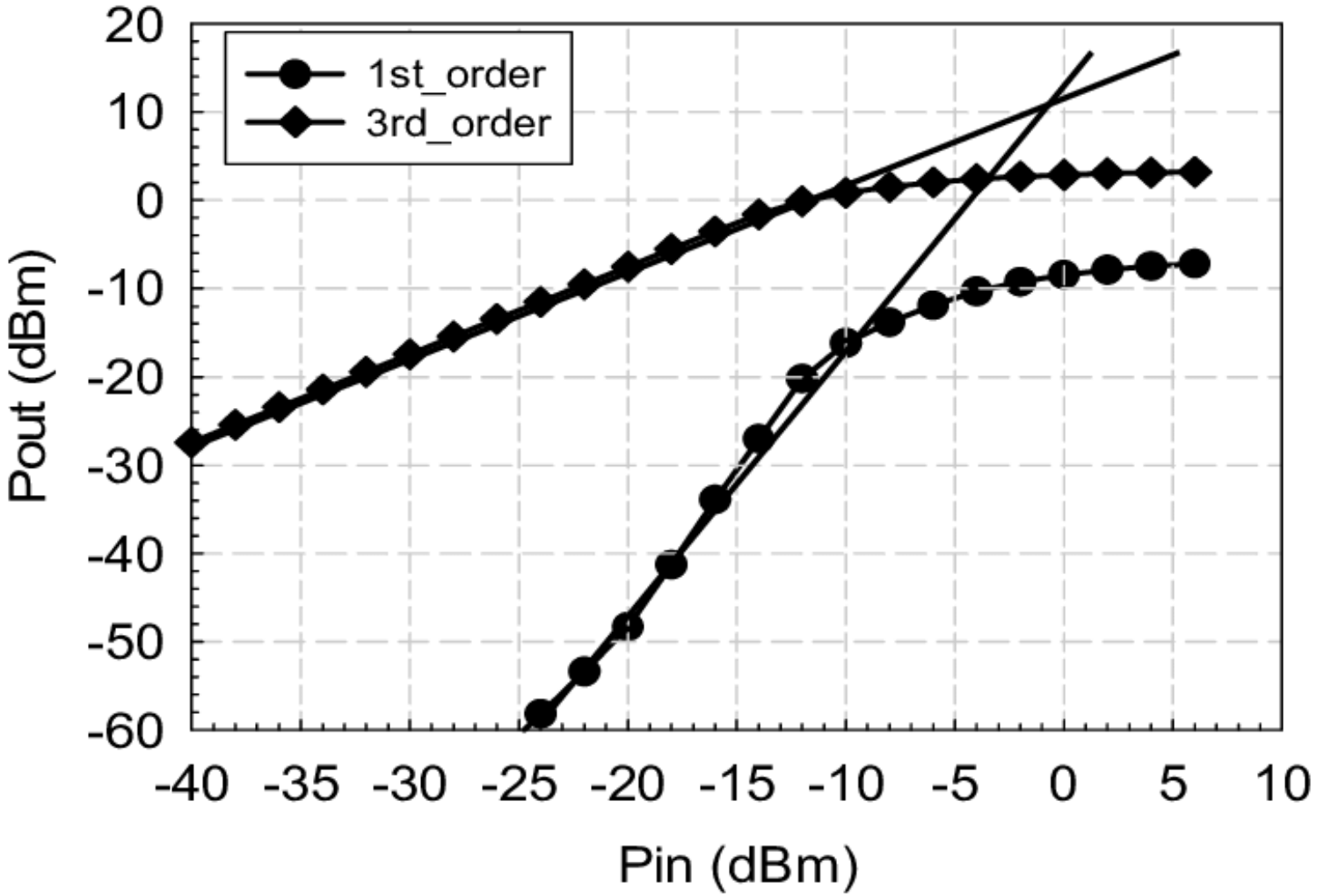
- C’est un gate audio controlé en HF.



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 degrade en limite de portée (C/N < 25dB)
- Identifier les sources d’interferences et les éloigner les 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.