

Système Radio pour les objets connectés

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Plan du cours

- Introduction
 - Introduction
 - Architecture d'un système radio
- Antennes
- Smartphone
 - Historique de la téléphone mobile
 - Émetteur-récepteur (modulation analogique et numérique, filtre, interrupteur, amplifier, mixer, oscillateur, PLL)
 - Applications (photo, jeux (accélérateur MEMS), wifi, bluetooth, capteurs, données, etc.)
 - Power management, batterie
- RFID
- Travaux pratiques

Objets Connectés



Un objet connecté est en fait un objet courant (ou futur) doté de capacité électronique pour effectuer des tâches et pour communiquer sans fil avec d'autres via internet, soit directement, soit à travers des relais : smartphones, tablettes, ordinateurs.



Applications :

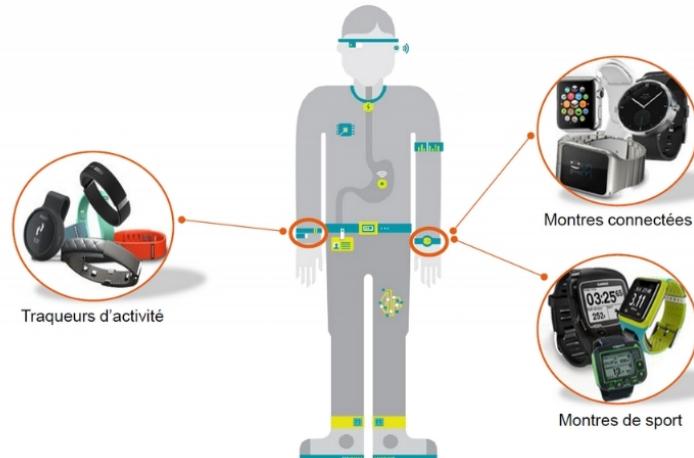
La santé : un des axes importants des objets connectés. On peut désormais facilement connaître ses variables biologiques : suivre son rythme cardiaque, sa tension, sa masse graisseuse.



Le sport : Avec une montre, vous comptabiliser les kilomètres courus ou marchés, vous accédez à des statistiques, à votre historique, vous records, et vous pouvez synchroniser vos résultats sur votre smartphone ou votre tablette avec un coach en ligne. Ce genre d'objet connecté permet de partager vos performances avec vos amis, pour s'étalonner ou se motiver,



QUELS SONT LES PREMIERS SUCCÈS ?



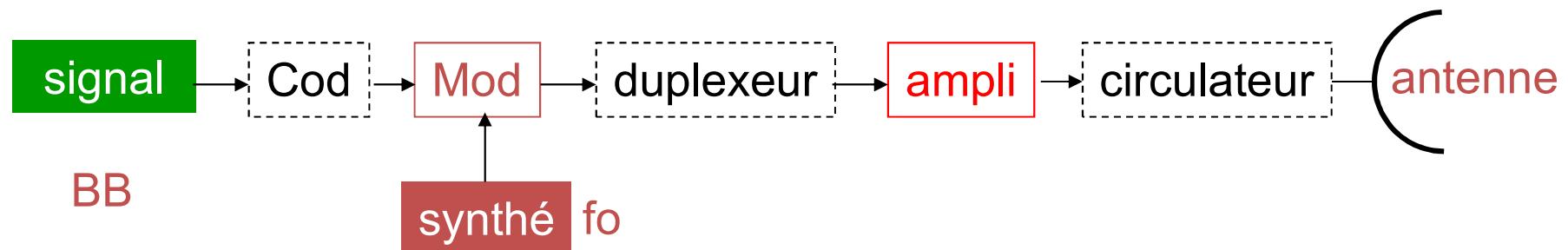
Les loisirs : avec les appareils photo, les caméras, les télévisions ou les montres connectées on peut recevoir ses email, des informations en temps réel, accéder à des contenus multimédias : musique, photos, vidéos, des applications de loisir ou pratiques



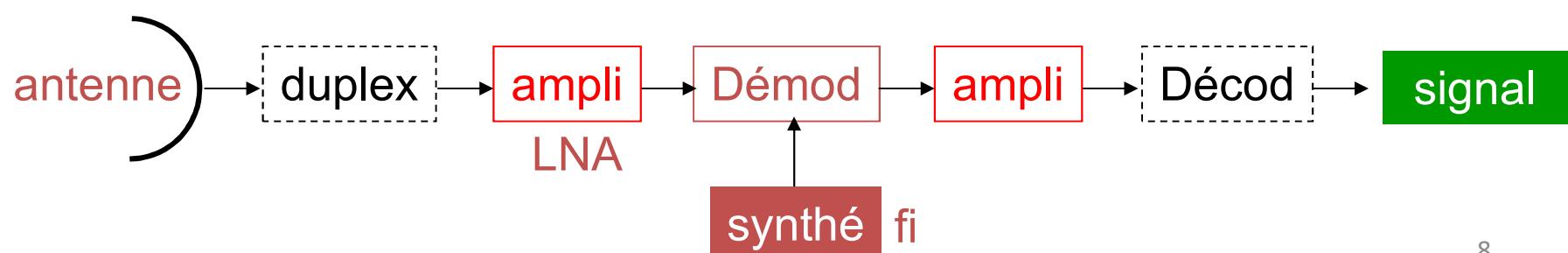


La chaîne de transmission radio

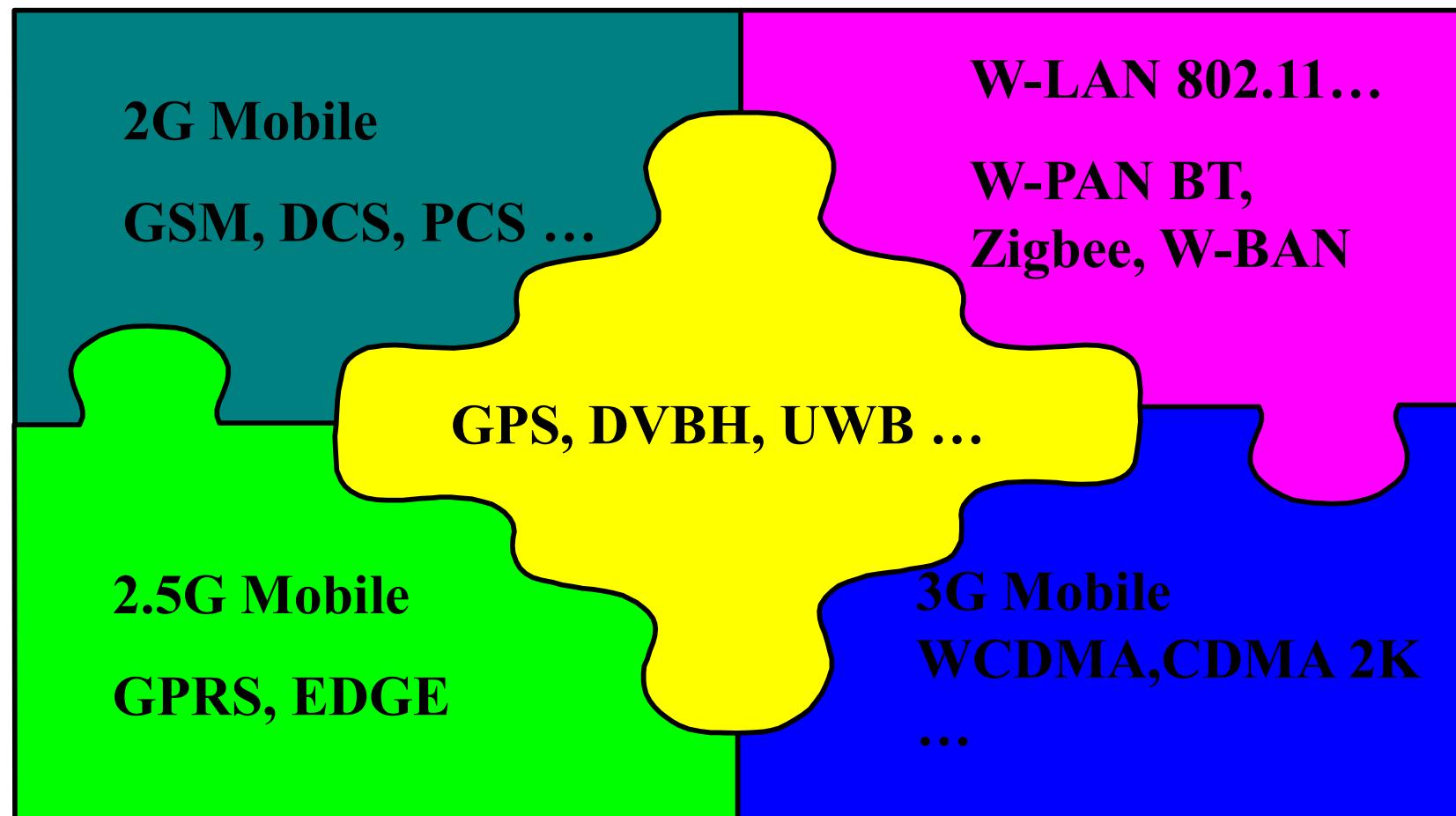
Partie émission :



Partie réception :



➤ Standards de communications sans fil



➤ Spécifications des standards

2G & 2.5G

**Carrier frequency < 2GHz, Narrow Band,
Noise sensitive, TDMA, Phase Modulation
except for EDGE, High Power Output**

3GPP

**Carrier frequency @ 2GHz, Wide Band, Noise
sensitive, FDD, CDMA, Polar modulation,
Medium Power Output.**

GPS

**Carrier frequency < 2GHz, Ultra Narrow Band,
Ultra Noise sensitive, Receiver.**

802.11.xxx

**Carrier frequencies 2.5GHz & 5-6GHz,
Wide Band, Noise sensitive, OFDM,
Medium Power Output.**

BT

**Carrier frequency @ 2.5GHz, Wide Band,
phase modulation, Low Power Output.**

DVBH

**Multi-Carrier OFDM, 1GHz, Wide Band
receiver, High linearity, Noise sensitive.**

UWB Pulse

**Ultra Wide Band, 3GHz to 10GHz, Noise
sensitive, Pulsed Time modulation,
Low Power Output.**

UWB MBO

**Multi Carrier, 3GHz- 5GHz? , Ultra Wide Band,
Noise sensitive, OFDM,
Low to Medium Power Output.**

➤ Exemple de standards et spécifications associées

Standard	Transmission (MHz)	Réception (MHz)	Modulation	Bande (MHz)	Largeur de canal (kHz)	Temps d'établissement
GSM	880-915	925-960	GMSK	35	200	200 µs
DCS	1710-1785	1805-1880	GMSK	75	200	200 µs
GPS		1565-1585	PSK	20	20	Non spécifié
Bluetooth	2400-2485.5		GFSK	79	1000	155 µs
802.11b	2400-2483.5 (indoor) 2400-2454 (outdoor)		BPSK QPSK, QAM	83.5 54		150 µs
802.11a	2400-2483.5 (outdoor) 5150-5350 5725-5825		CCK	83.5		150 µs
			BPSK, QPSK QAM, CCK	200 100	25000 25000	

Standard	Distance de la porteuse	Bruit de phase maximum
GSM/DCS	200kHz	-74dBc/Hz
	400kHz	-106dBc/Hz
	600kHz	-121dBc/Hz
	1.6MHz	-131dBc/Hz
	3MHz	-141dBc/Hz
	20MHz	-145dBc/Hz
GPS	10kHz	-70dBc/Hz
	70kHz	-70dBc/Hz
	1MHz	-105dBc/Hz
Bluetooth	1kHz	-78dBc/Hz
	20kHz	-78dBc/Hz
	500kHz	-95dBc/Hz
	1.5MHz	-119dBc/Hz
	2.5MHz	-130dBc/Hz
802.11 WLAN	1kHz	-80dBc/Hz
	15kHz	-80dBc/Hz

Contraintes diverses

Consumer Application

- 2G & 2.5G
- 3GPP
- 802.11.b g
- BT
- UWB Pulse
- DVBH
- GPS

3GPP Mobile « Phones »

RECONFIGURABLE
ULTRA LOW POWER
LOW COST
Transceiver

Frequency: 800MHz To 5 – 10 GHz

Consumer Application

- 802.11.b g
- BT
- UWB Pulse
- UWB MBO

Domestic Local Network

**LOW POWER
&
LOW COST
Transceiver**

Frequency: 2.5GHz To 5 – 10 GHz

Professional Application

- 2.5G
- 3GPP
- 802.11.xxx
- BT
- UWB Pulse
- UWB MBO
- GPS

Nomad Network

**RECONFIGURABLE
LOW POWER
Transceiver**

Frequency: 1.5GHz To 5 – 10 GHz

Professional Application

- 802.11.xxx
- BT
- UWB MBO
- UWB Pulse

Professional Local Network

MEDIUM POWER
Transceiver

Frequency: 2.5GHz To 5 – 10 GHz

The Silicon Processes Offers

- ✓ ***BiCMOS SiGe / SiGeC***
- ✓ ***RF CMOS + Bipolar option***
- ✓ ***RF CMOS & SOI_CMOS***
- ✓ ***VLSI CMOS***
- ✓ ***What About Passives & MEMS***

Décibels

$$dB = 20 \log_{10} V_{\text{out}}/V_{\text{in}}$$

En RF

$$dBV = \text{“décibel volt”} = 20 \log_{10} V$$

$$dB\mu V = \text{“décibel microvolt”} = 20 \log_{10} V + 120dB$$

En Puissance



- dBm = “décibel milliwatt” = $10 \log_{10} (P * 10^3)$
- 1 Watt = 10^3 mW = 30 dBm
- Sous 50Ω , $1\mu V$ donne une puissance de $-137dB$, soit $-107dBm$ ($P = V^2/R$)

HISTOIRE DE FREQUENCES

$$\lambda = \frac{c}{f}$$

$c = 30000$ km/s,
 f = fréquence en Hz
 λ = longueur d'onde en m

Allongement
fictif



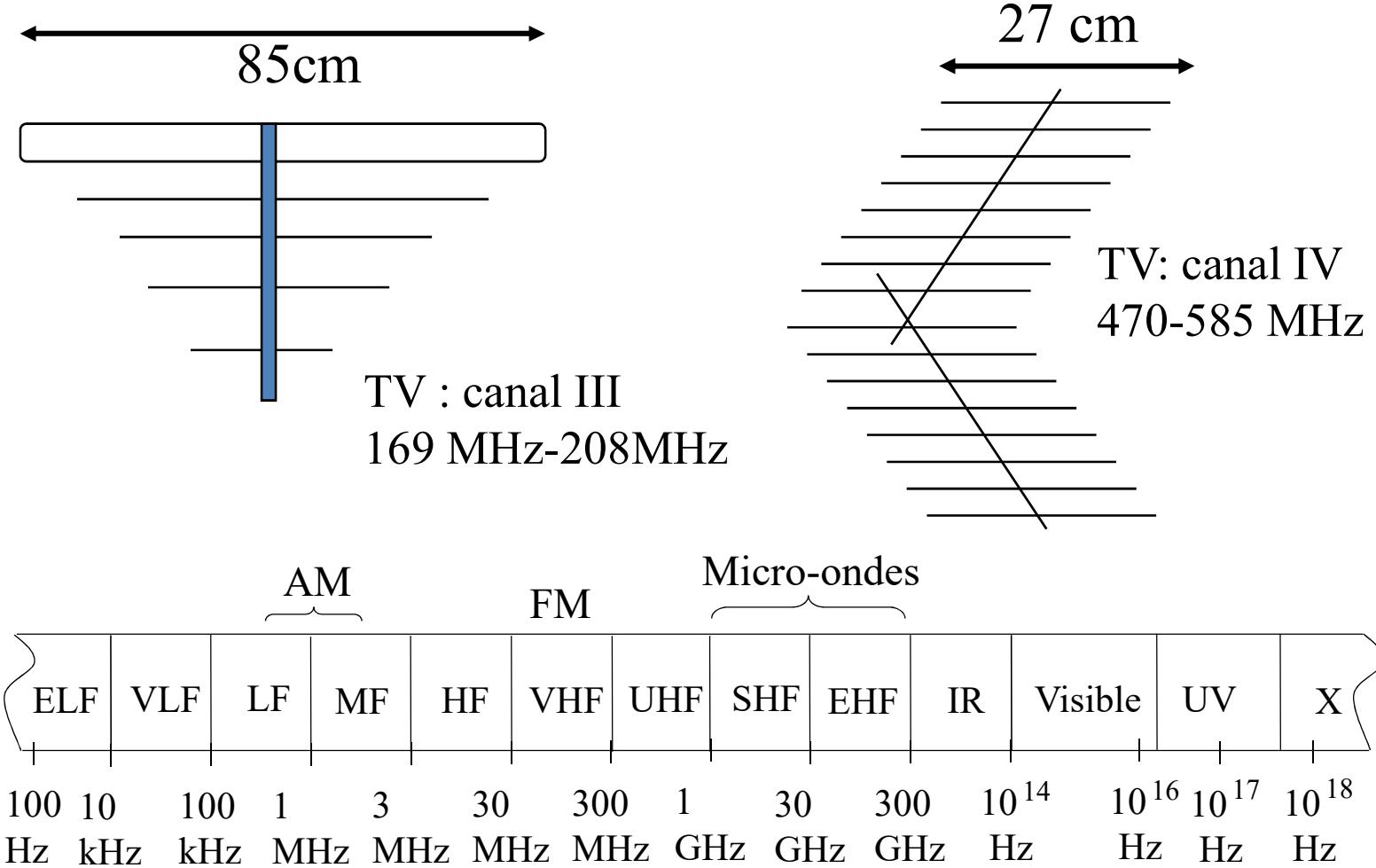
GSM : 930MHz
 $\lambda = 32$ cm
 $\lambda /4 = 8$ cm

$$antenne = \frac{\lambda}{4}$$

DCS : 1800MHz
UMTS : 1900 MHz
Amateurs : 3.5, 7, 14, 28 MHz



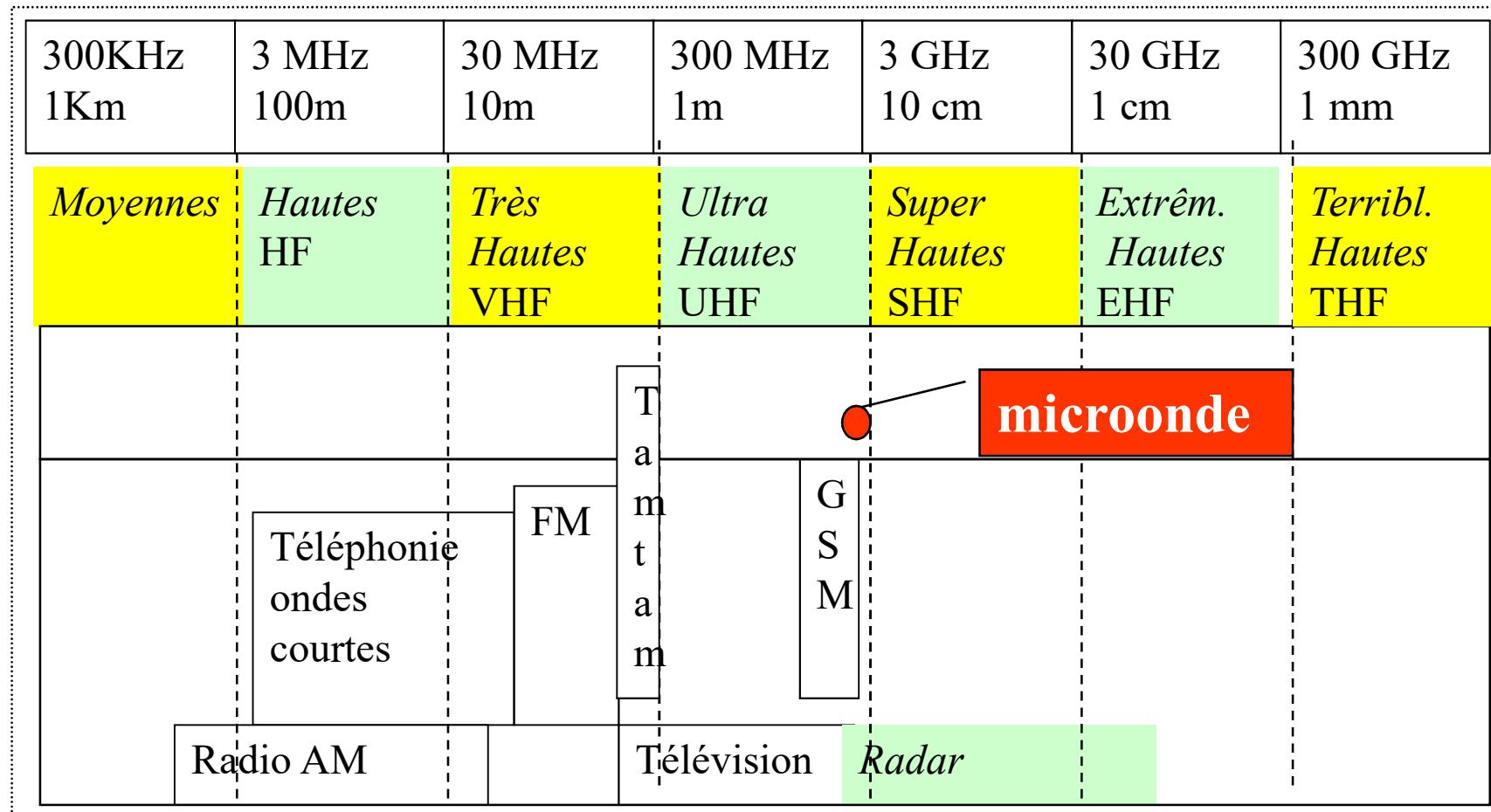
HISTOIRE DE FREQUENCES



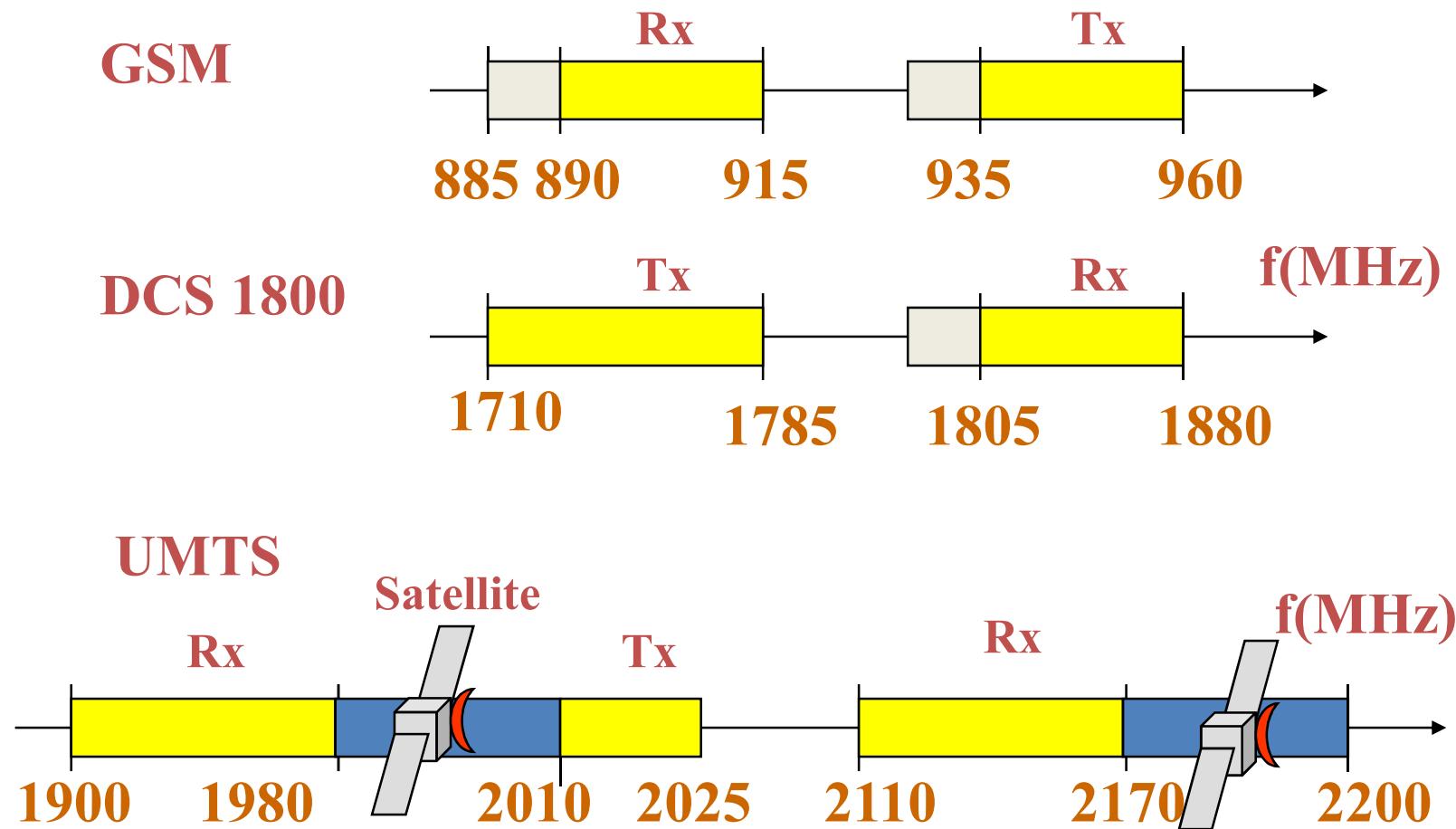
HISTOIRE DE FREQUENCES

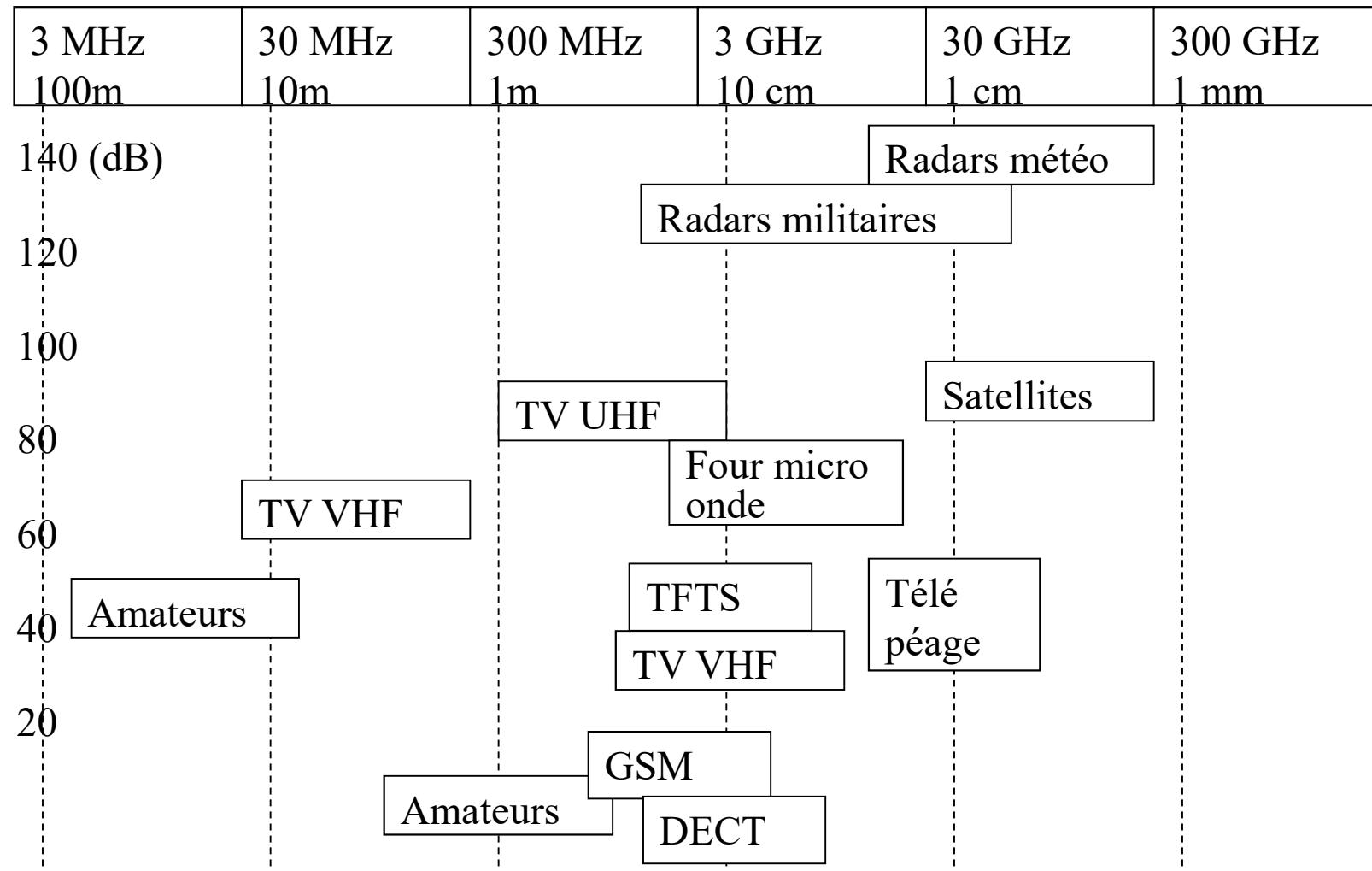
Fréquence	30 Hz	300 Hz	3 KHz	30KHz
Longueur d'onde	10000Km	1000Km	100Km	10Km
Dénomination des plages de fréquence	<i>Audiofréquences</i>			<i>Basses Fréquences</i>
Applications principales	<i>Energie électrique</i>			<i>Chauffage induction</i>
Télé communications		<div style="border: 1px solid black; padding: 5px; text-align: center;">Téléphonie par câble</div>		<div style="border: 1px solid black; padding: 5px; text-align: center;">Téléphonie ondes longues</div>

HISTOIRE DE FREQUENCES



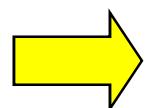
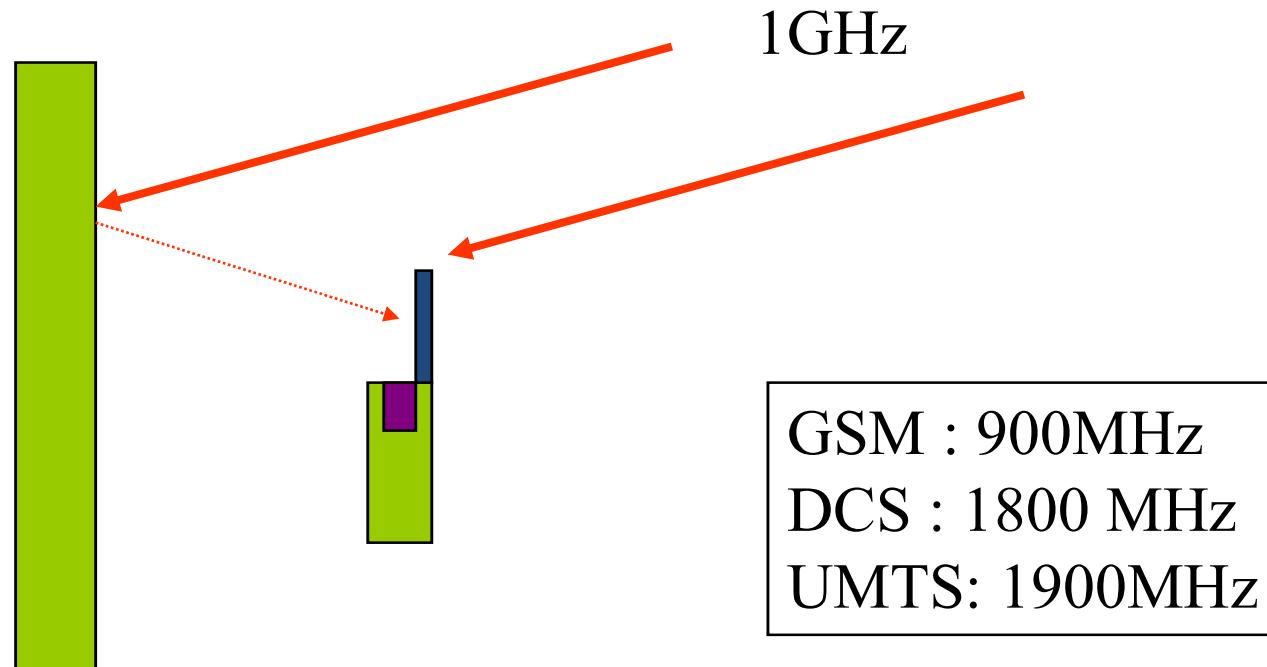
HISTOIRE DE FREQUENCES





PROPAGATION

➤ Canal de propagation



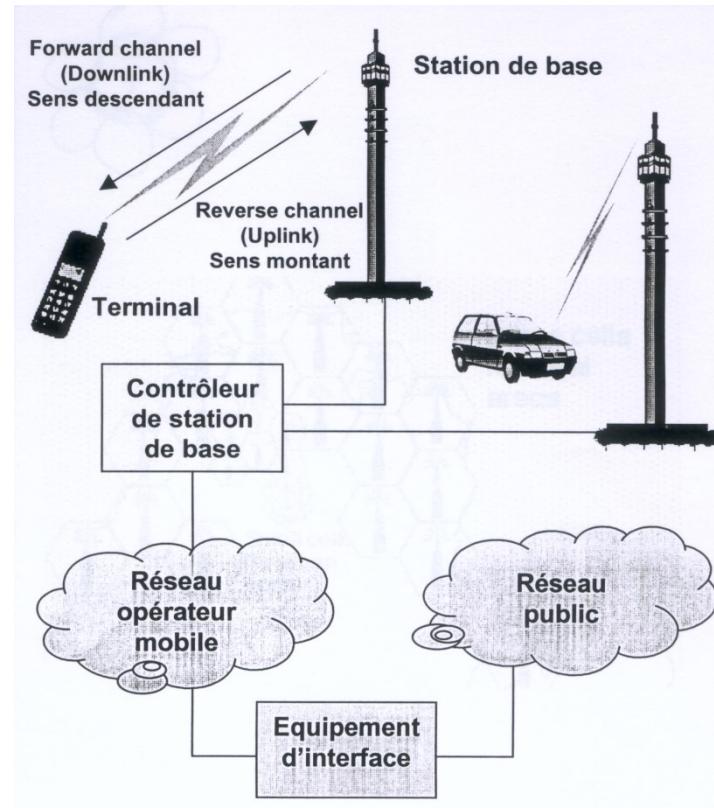
Le GSM doit traiter le phénomène d'écho

SYSTEMES DE COMMUNICATION RADIOMOBILE

➤ Principe de base

➤ Réseau de relais radio

- Stations de base permettant d'assurer la couverture du service
- Protocole d'accès aux ressources radio avec contrôle par le réseau
- Gestion de la mobilité et de l'usager



Smartphone

Histoire



Bell Laboratories

Bell Labs proposes hexagonal cells for mobile phones, with the three sided antenna we know today. It sucked, because it was all theoretical.

1947



1950

1960

1965

1980

1983



1954

Linus Larrabee (Humphrey Bogart) uses a real mobile phone from his car in Billy Wilder's Sabrina (played by Audrey Hepburn.)



First fully automatic mobile phone (Mobiltelefonisystem A or MTA) system launched in Sweden by Ericsson. Each handset, pictured above, was 90 pounds (40 kg.)

1956



Bell Laboratories

Automatic "call handoff" system is invented, allowing mobile phones to move through several cell areas during a single conversation without loss of conversation.

1970



1971

ARP, the first successful commercial cellphone network, is launched in Finland. You couldn't move from cell to cell seamlessly. It was 0G (Zero G.)

April 3, 1973: Motorola's Dr. Martin Cooper calls Joel Engel, head of research at AT&T's Bell Labs, while walking in New York City using the first Motorola DynaTAC prototype. The beginning of 1G networks.

1973



Nokia introduces their first cellphor the analog Mobira Senator

FCC approves the analog-based Advanced Mobile Phone Service (AMPS) and assigns frequencies in the 824-894 MHz band.

1982



MTB shuts down, still with 600 clients.

1978
Bell launches first trial commercial cellular network in Chicago.

Evolution du Portable

					1993	1995
					Digital system (800MHz)	
					 	
Model	802B:500cc 750g	803B:400cc 640g	Mova:150cc 230g	Digital 150cc Mova : 240g	Ultra-compact 100cc mobile station:150g	
Antenna technology	<ul style="list-style-type: none"> Bottom end feeding 1/2λ Side-mounted built-in reverse-F antenna Small diversity antenna 	<ul style="list-style-type: none"> Bottom end feeding 3/8λwt Retractable whip antenna on the side Reverse-F antenna Integrated with filter Built-in reverse-F antenna installed at the back 			 nna	 small nna

http://www.privateline.com/mt_digitalbasics/

Nokia 8120 79 g

30

Génération et Normes

0G ([MTS, MTA, MTB, OLT, ...](#))

1946

- Système cellulaire analogique

1G ([AMPS, NMT, TACS, ...](#))

1981

- Système cellulaire analogique

2G ([GSM, IS-54, PDC, cdmaOne](#))

1991

- Cellulaire numérique
- Voix numérique, données à faible vitesse ([9.6 Kbps](#)), SMS

2.5G ([GPRS, cdmaOne](#))

1999 - 00

- Introduction de données par paquets
- Amélioration de la voix, données à vitesse moyenne ([~100 Kbps](#)), SMS amélioré

3G ([WCDMA, cdma2000 \(1X, 3X\), EDGE, ...\)](#) **2002 - 03**

- Amélioration de la voix, données à haut vitesse ([384Kbps - 2 Mbps](#))
- Amélioration de l'efficacité spectrale et la capacité
- Applications multimédias

Génération et Normes

3.5G (HSPDA) 2005

- 3G+ ou turbo 3G
- Vitesse et capacité de transfert de données plus élevés (**1.8 Mbps - 14.4 Mbps**)
- MIMO (Multiple-Input, Multiple-Output)

4G (LTE) 2010?

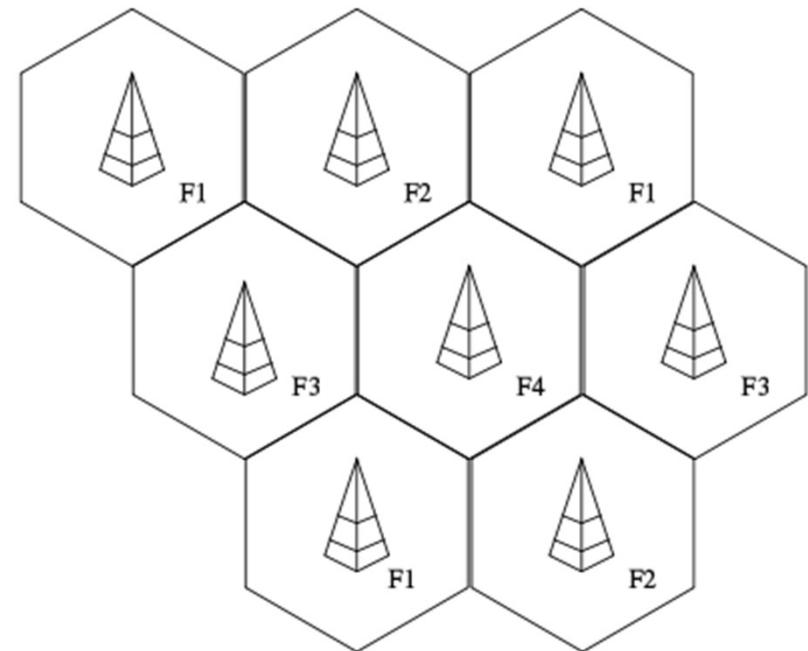
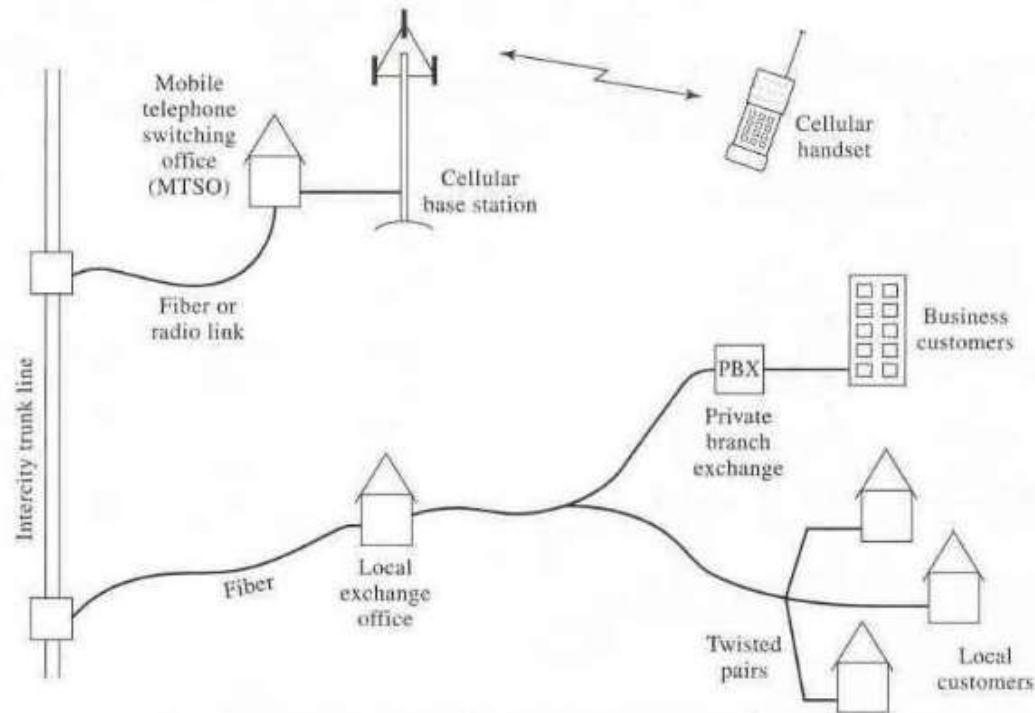
- Haut vitesse de transfert de données (**100 Mb/s downlink et 50 Mb/s uplink**)
- Orthogonal Frequency Division Multiple Access (OFDMA)



Le Réseau

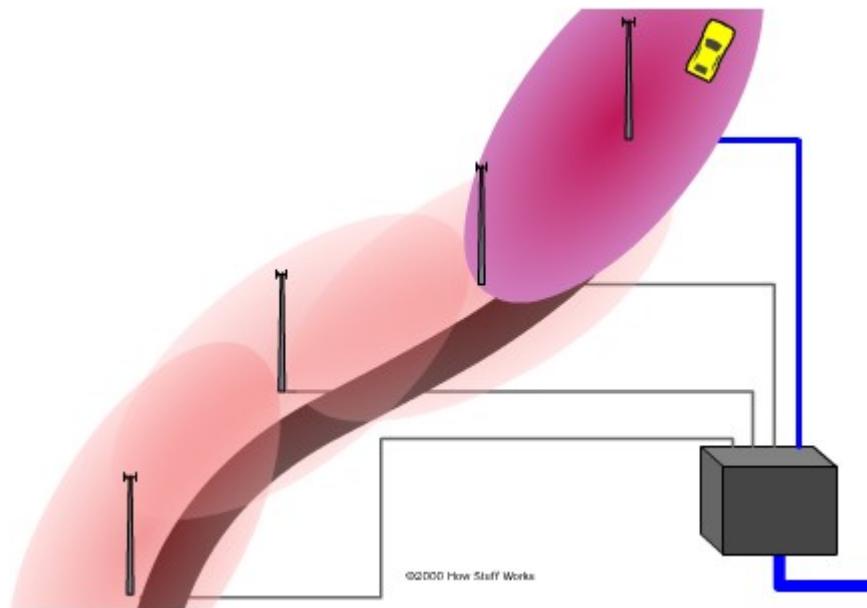


- réparties sur le territoire selon un schéma de cellules
- réutilisation des fréquences et *hand-offs (hand overs)*



Le Réseau

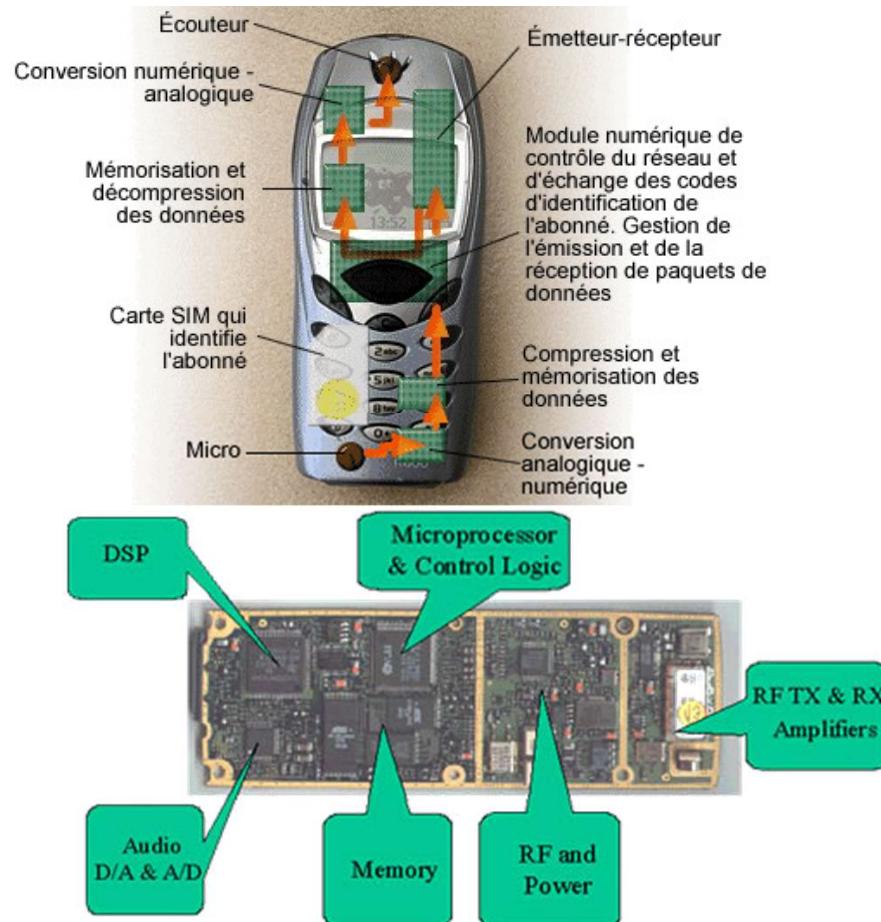
Fréquences *hand-offs*



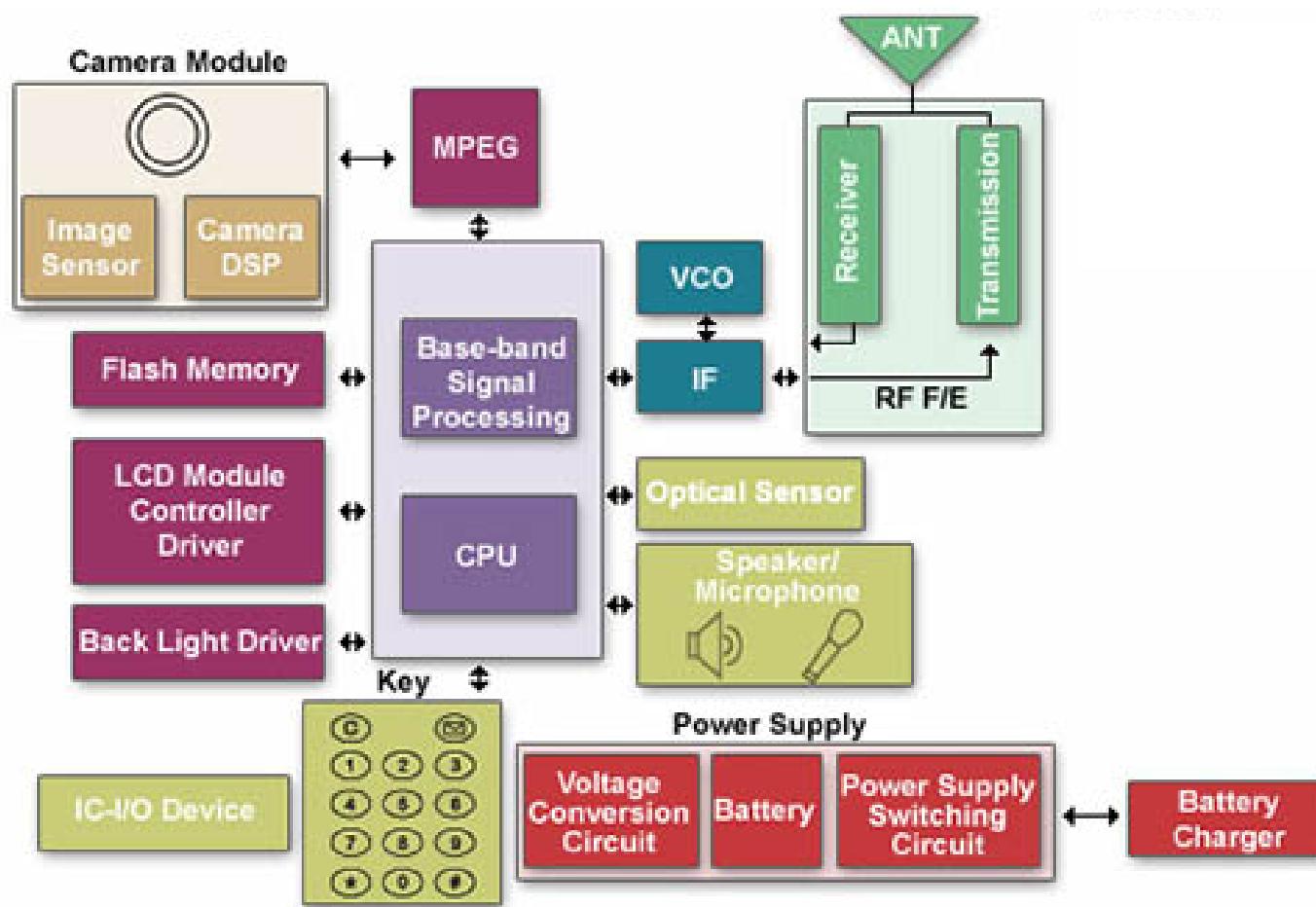
Fréquence

Actuel / Prévues Technologies	Band	Fréquence (MHz)
<u>SMR</u> <u>iDEN</u>	800	806-824 and 851-869
<u>AMPS</u> , <u>GSM</u> , <u>IS-95</u> (CDMA), <u>IS-136</u> (D-AMPS), <u>3G</u>	Cellular	824-849, 869-894, 896-901, 935-940
<u>GSM</u> , <u>IS-95</u> (CDMA), <u>IS-136</u> (D-AMPS), <u>3G</u>	PCS	1850-1910 and 1930-1990
<u>3G</u> , <u>4G</u> , <u>MediaFlo</u> , <u>DVB-H</u>	700 MHz	698-806
Unknown	1.4 GHz	1392-1395 and 1432-1435
<u>3G</u> , <u>4G</u>	AWS	1710-1755 and 2110-2170
<u>4G</u>	BRS/EBS	2500-2690

L'Architecture du Mobile

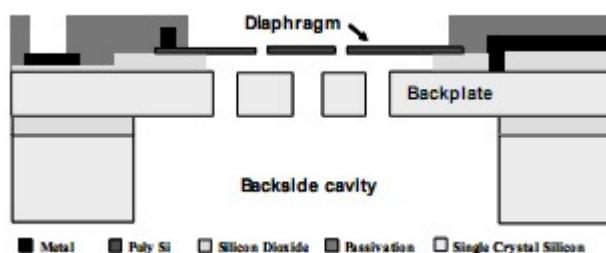


Bloc Fonctionnel du Mobile

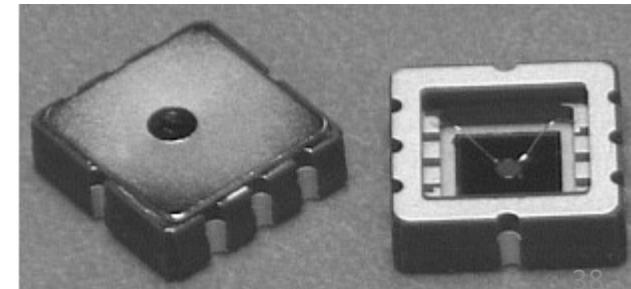
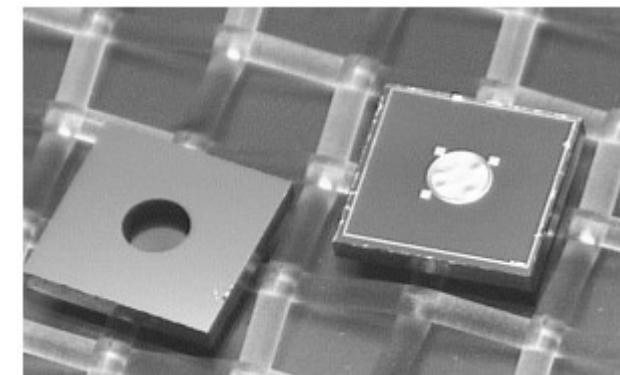
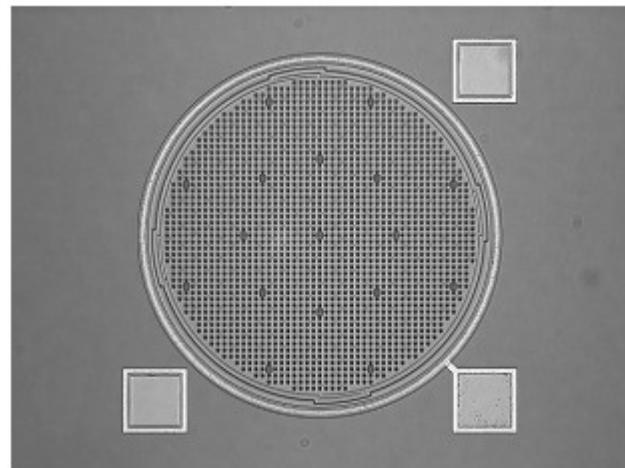


Transducteurs

Microphone – MEMS Condensateur



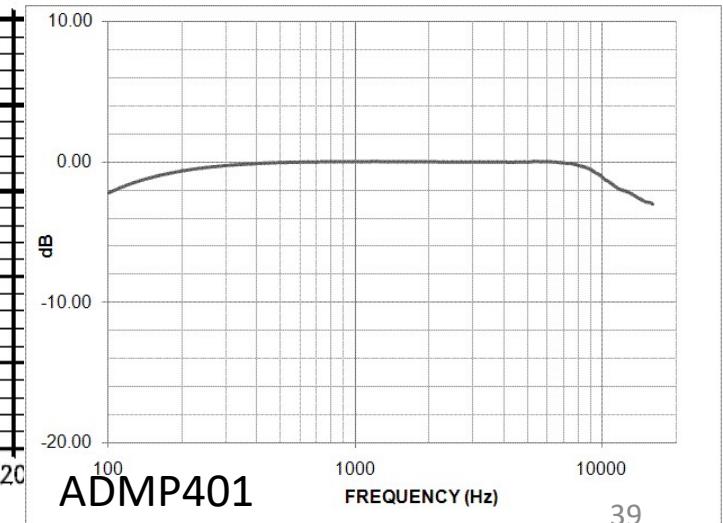
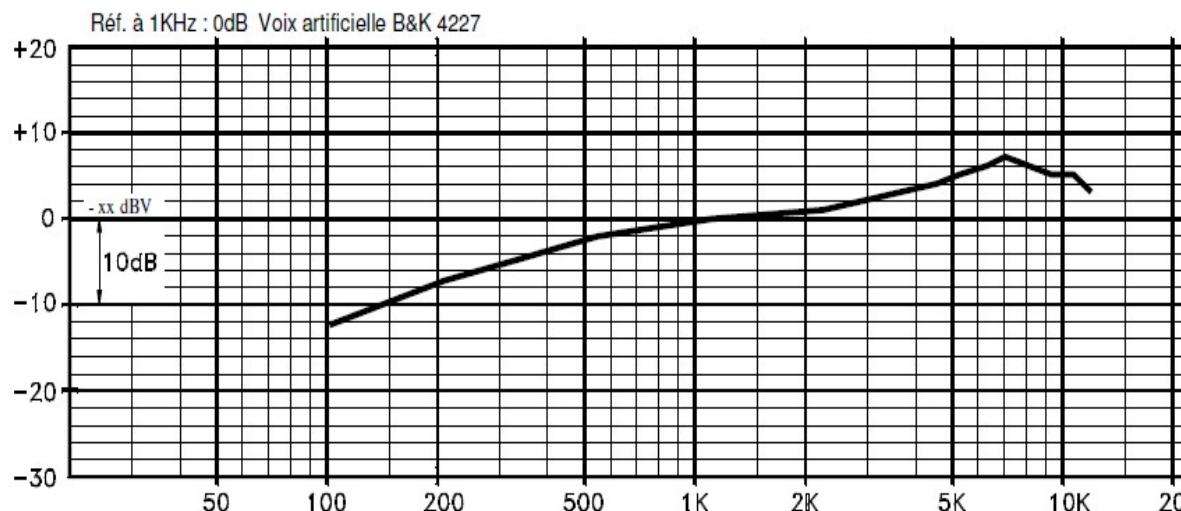
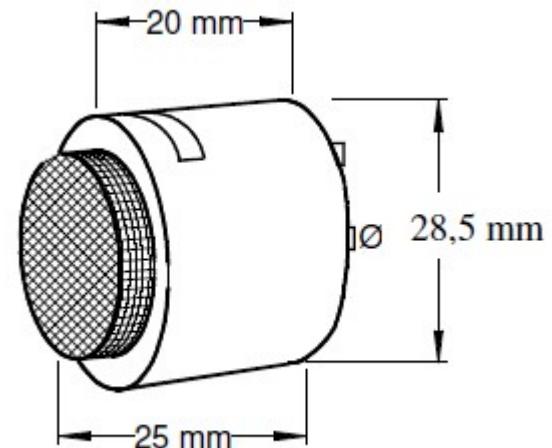
$$C = \frac{\varepsilon \cdot A}{d}$$



Transducteurs Microphone

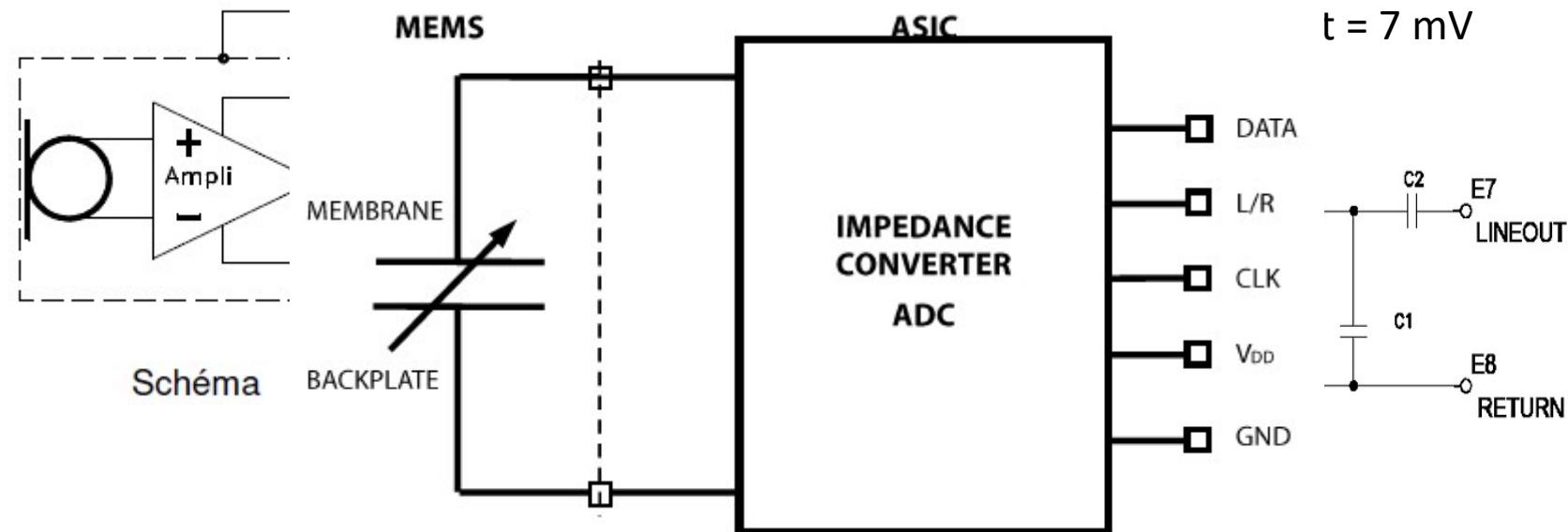


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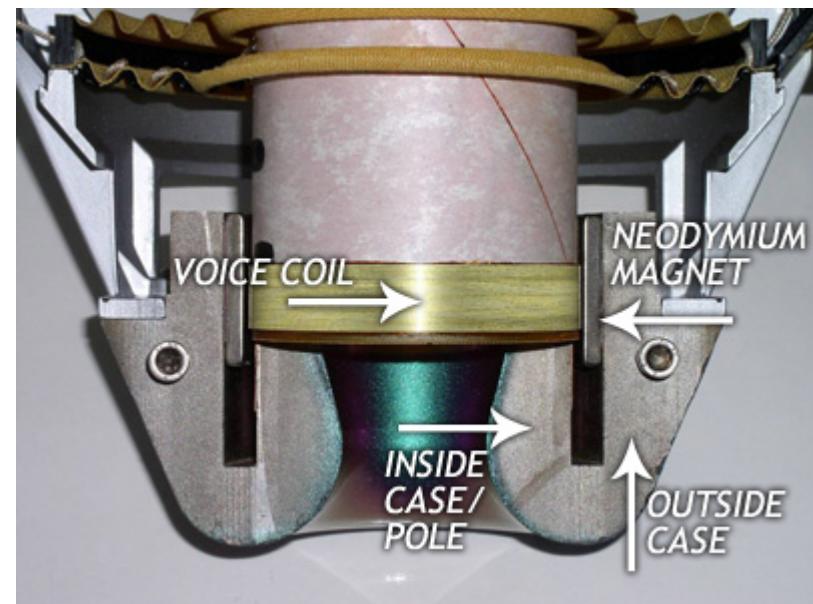
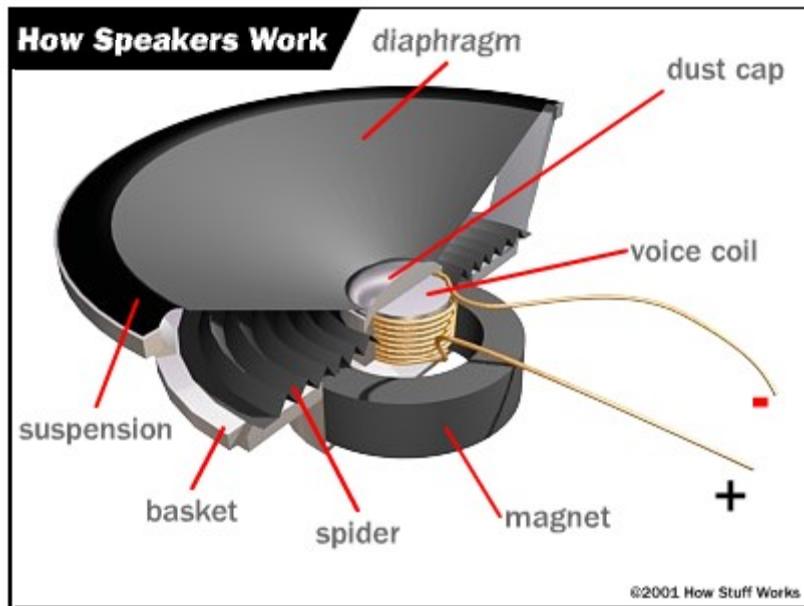
Transducteurs Microphone

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
PERFORMANCE Directionality Sensitivity		1 kHz, 94 dB SPL	-45	Omni -42	-39	dBV

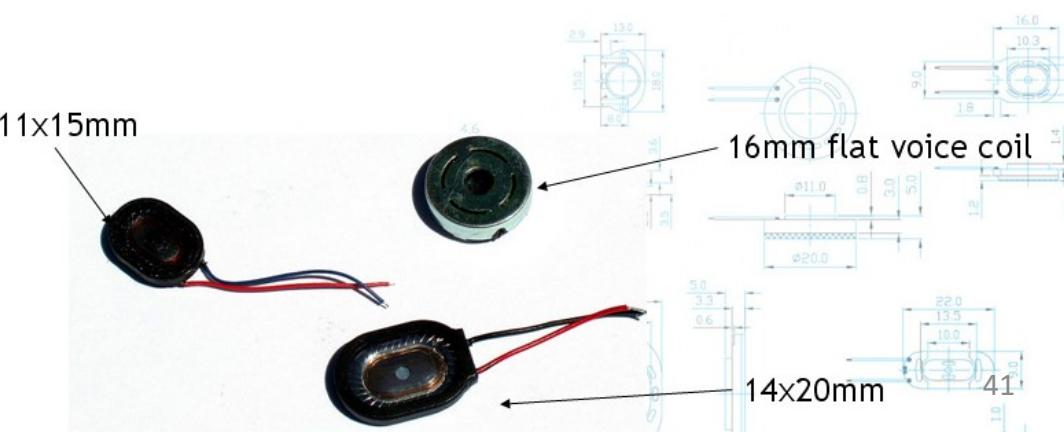


Transducteurs

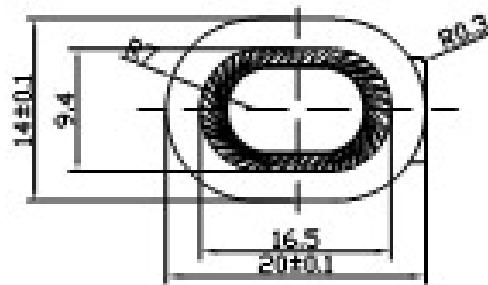
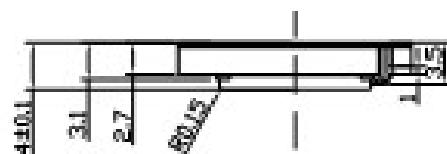
Ecouteur



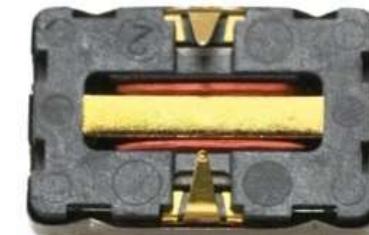
$$F \propto B \cdot L \cdot I$$



Transducteurs Ecouteur



Impedance = $8 \Omega \pm 15\%$
Puissance de sortie – 0.3 W



richgrand.en.alibaba.com



k850 speaker/cell phone speaker/mobile phone speaker(mobile/cell phone accessories) for SE k850

US\$1.03 - 1.03 / Piece

Confirm price with supplier

Min. order: 1 Piece

Quantity Range (Piece)

1 - 100

Price (Per Piece)

US\$1.03

Processing Time

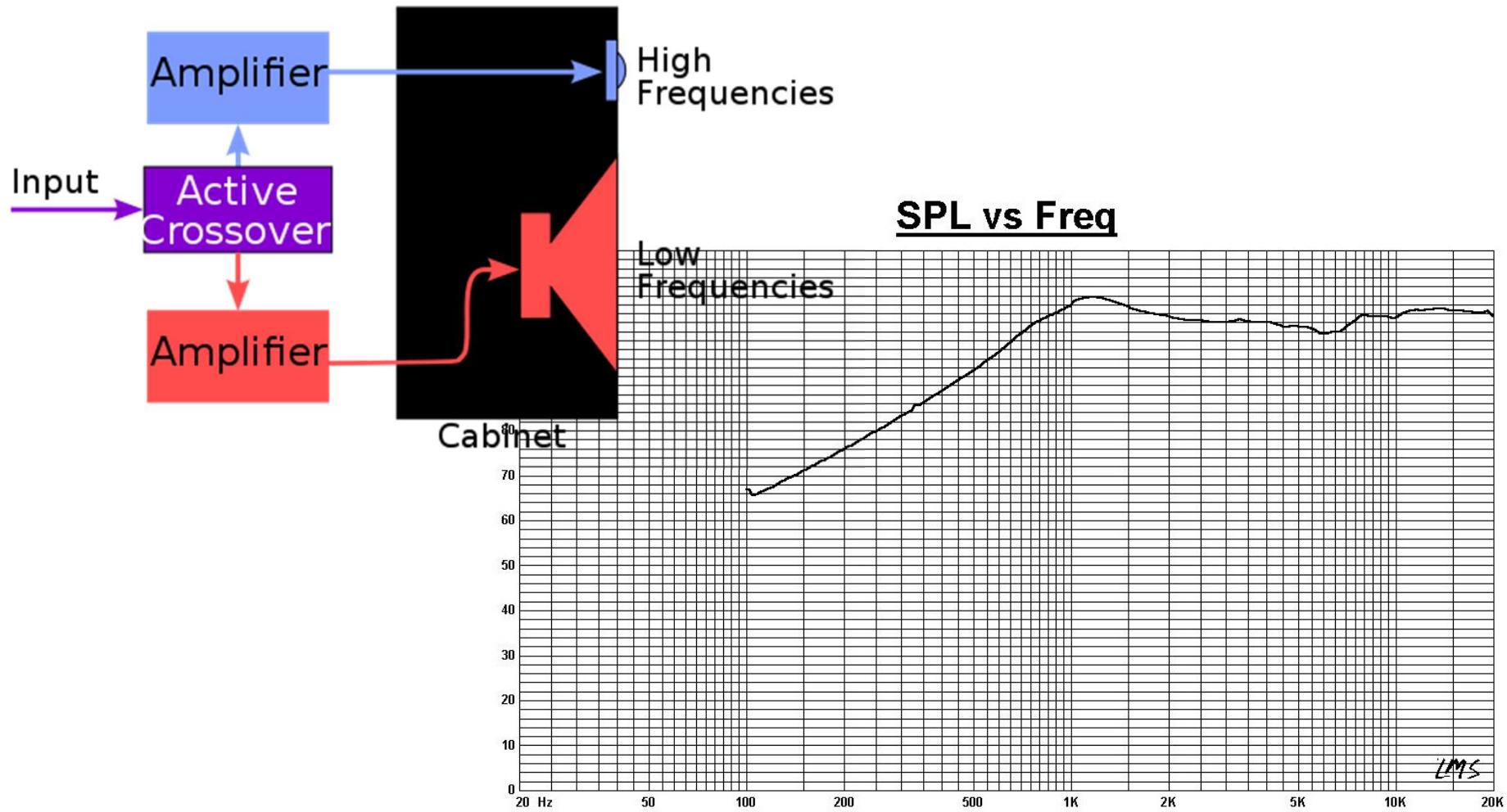
3 Days

Quantity: Piece

Shipping Cost: US\$30.93 To

Transducteurs

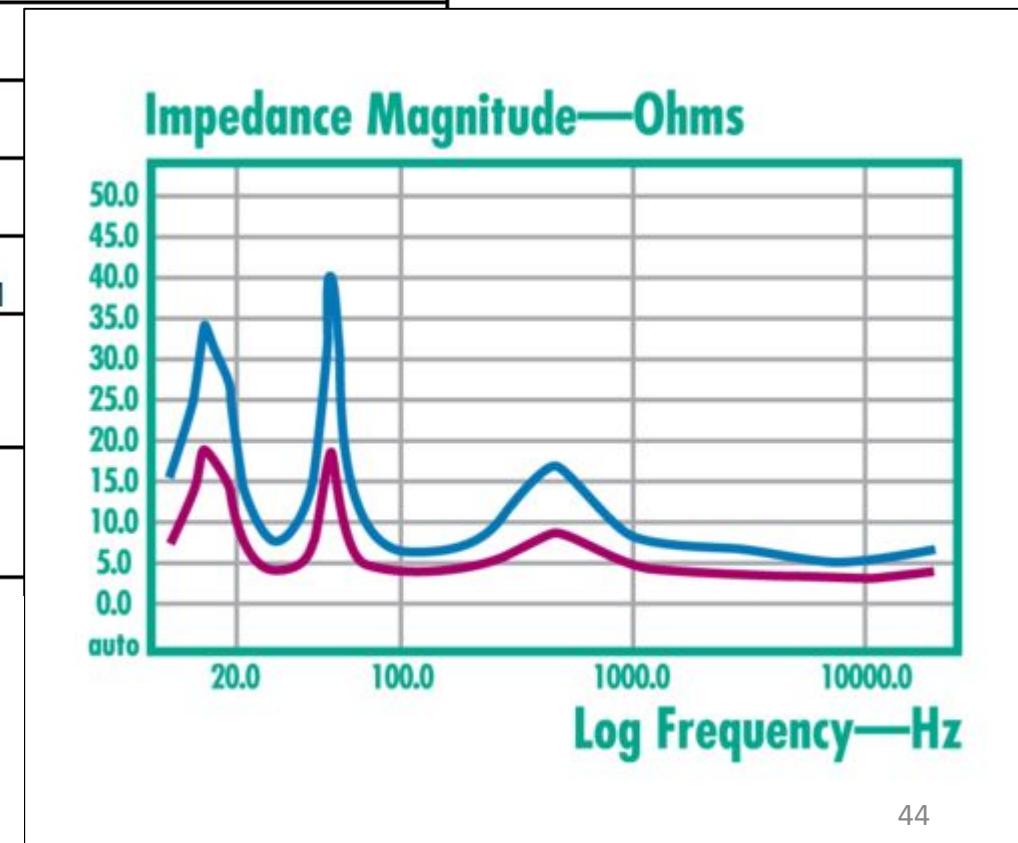
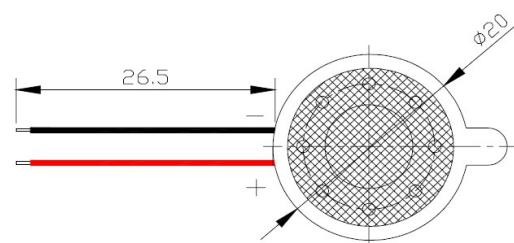
Ecouteur



Transducteurs

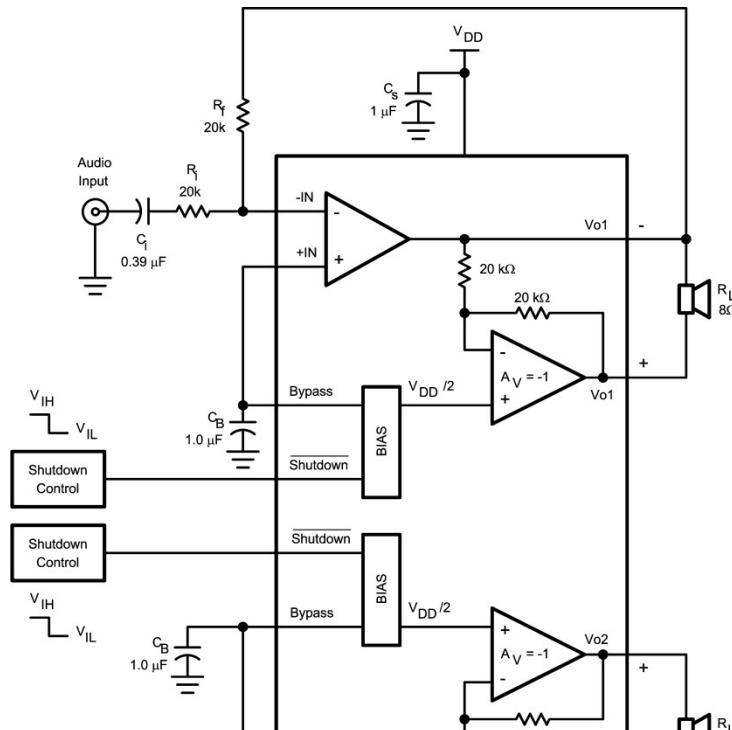
Ecouteur

Items	Technical Specifications
1. Frequency Range	300-3400HZ
2. DC Resistance	$7.4 \pm 10\%$ ohm
3. Impedance	$8.0 \pm 10\%$ ohm @2kHZ,1V
4. Measuring Diagram	Shown in Fig.1
5. Frequency Response	Shown in Fig.2
6. Sensitivity	$85 \pm 3\text{dB}$ @2kHZ,0.1W/0.1M
7. Rated Input	$I=300\text{ mA}$ 0.8W RMS
8. Max Input	1.2W MAX



Audio Amplificateur

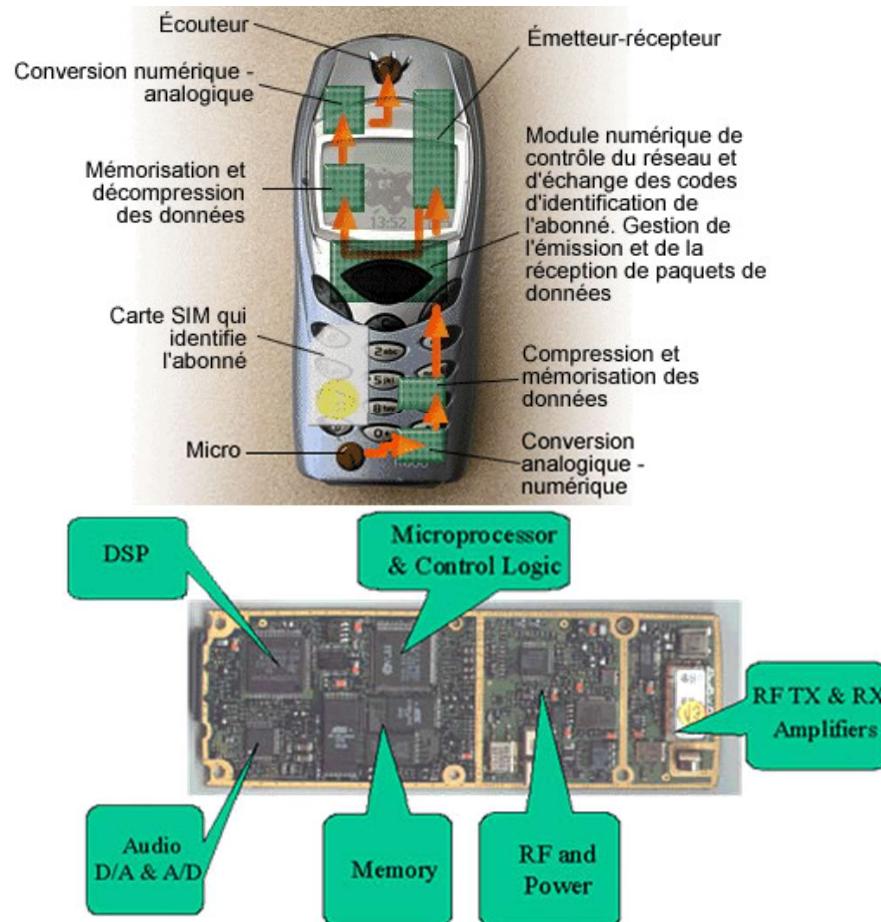
LM4992 Boomer® Audio Power Amplifier Series 420mW Stereo Cell Phone Audio Amplifier



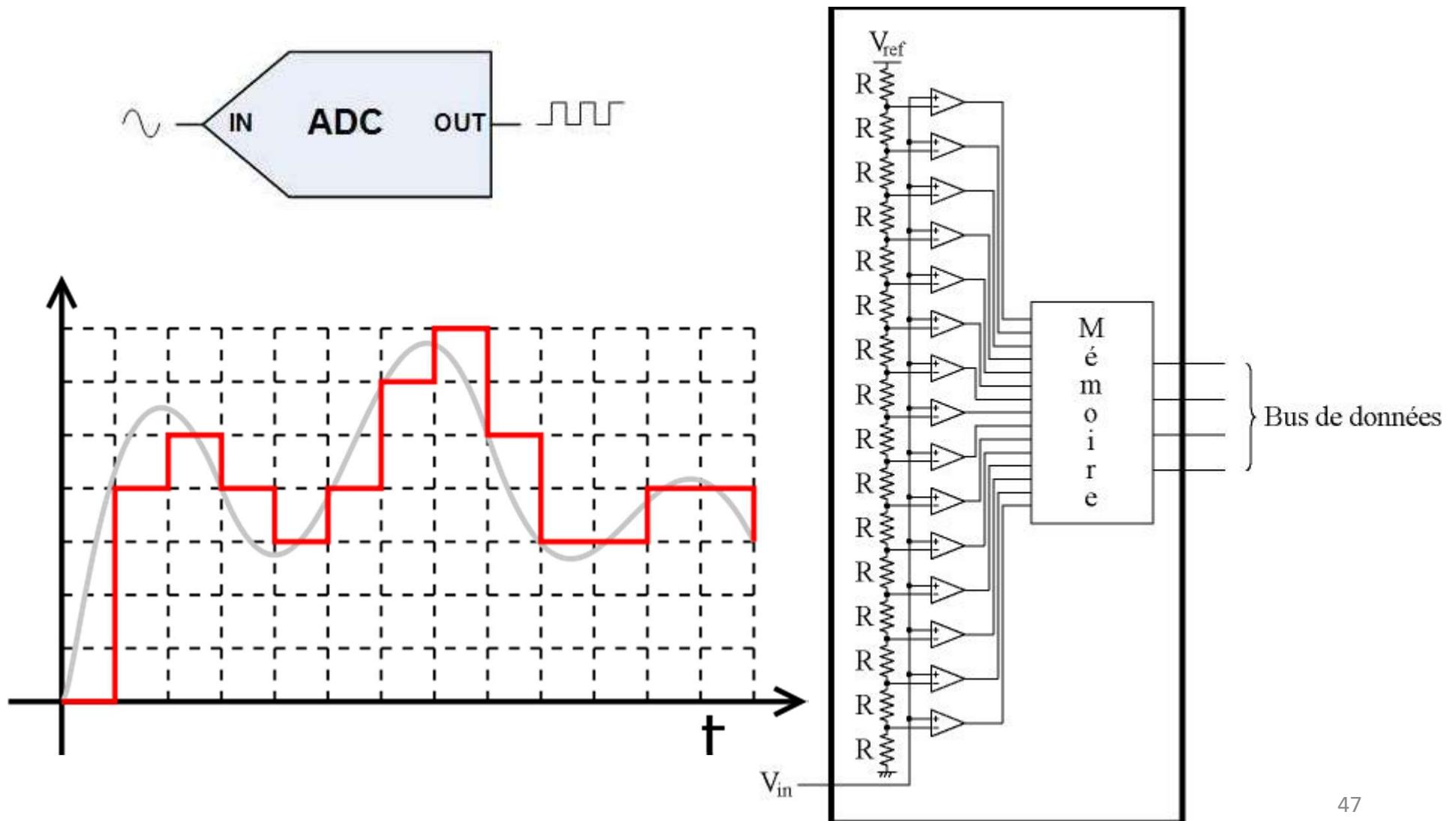
- Improved PSRR at 217Hz & 1KHz 64dB (1KHz)
- Stereo Output Power at 5.0V, 1% THD, 8Ω 1.07W (typ)
- Stereo Output Power at 3.3V, 1% THD, 8Ω 420mW (typ)
- Shutdown Current, $V_{dd} = 3.3V$ 0.2µA (typ)

Part Number(s) (NSID)	Top View	Availability	Current Reported Stock				Budgetary Pricing	Standard Pack Size
			Distributor	Region	Qty			
LM4992SD/NOPB LM4992SD RoHS Status	LLP	Full production Lead Time: 6 weeks Samples	DIGIKEY Buy Now	Worldwide	2573	KEIKONG Buy Now	Asia Pacific 111000	\$0.70 each at 1K+ pcs reel of 1000

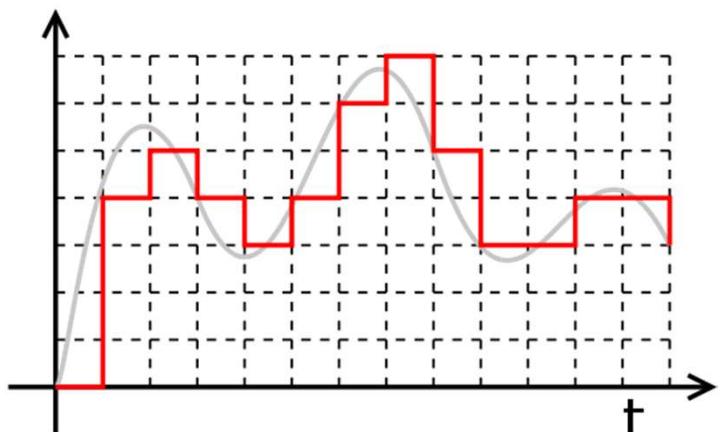
L'Architecture du Mobile



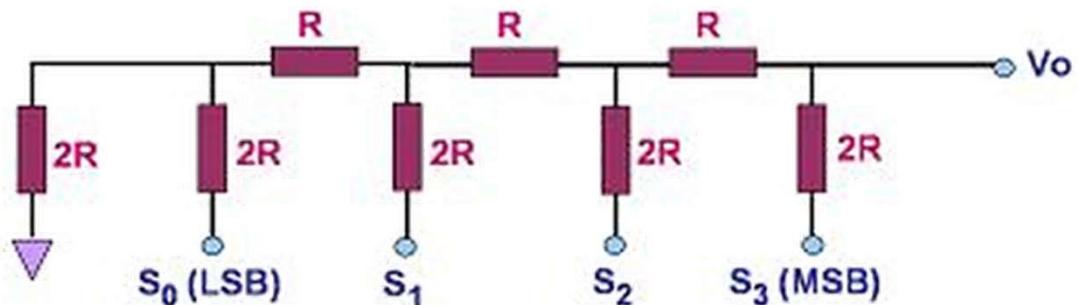
Convertisseur analogique-numérique (ADC)



Convertisseur numérique-analogique (DAC)

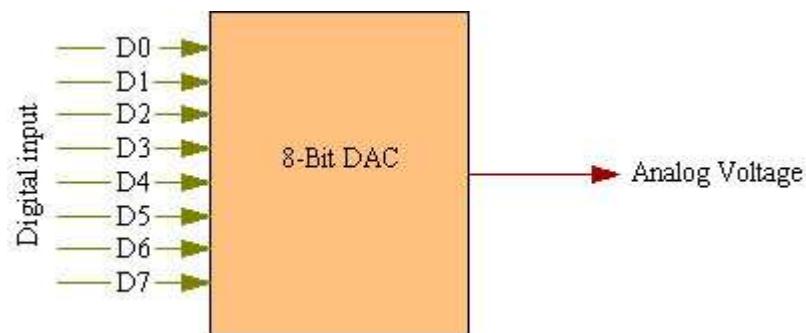
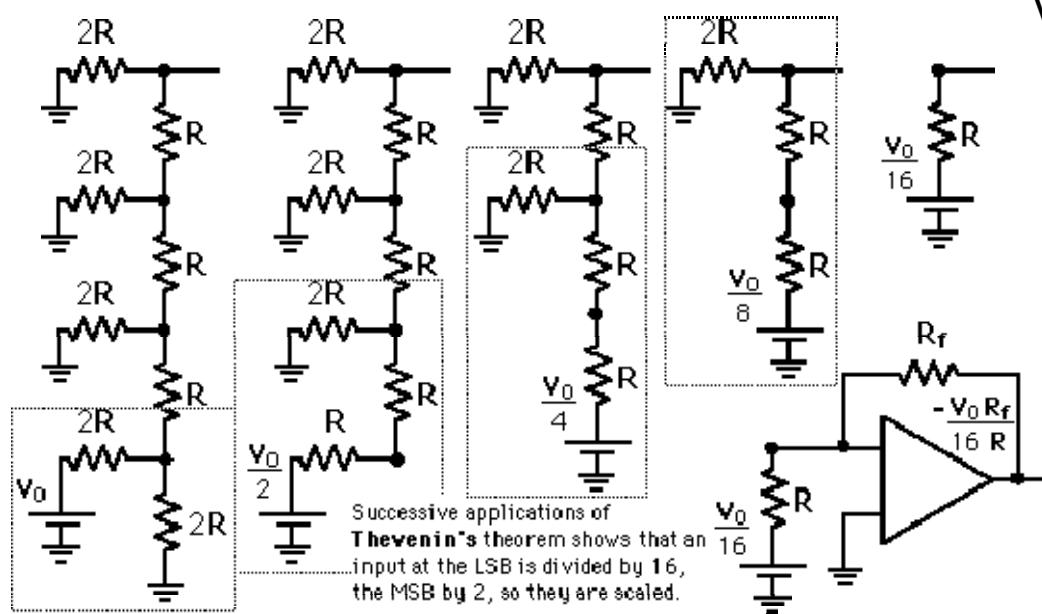


R-2R DAC



$$V_o = V_R / 2^N (S_{N-1} 2^{N-1} + S_{N-2} 2^{N-2} + \dots + S_0 2^0).$$

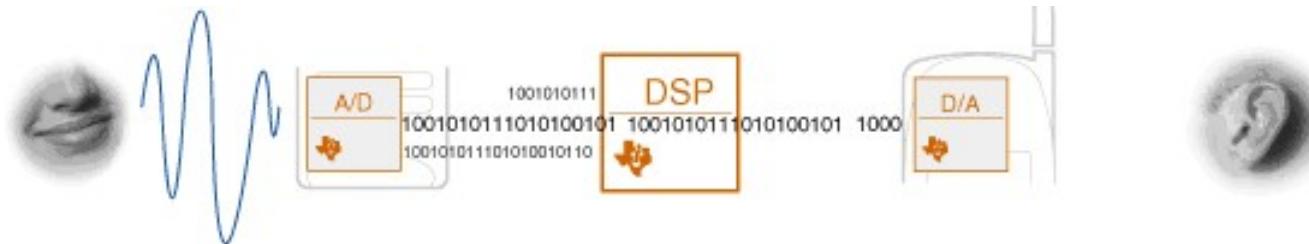
$$V_o = V_R (S_3 / 2 + S_2 / 4 + S_1 / 8 + S_0 / 16)$$





Digital Signal Processor – DSP

Processeur de Signal Numérique



- microprocesseur optimisé pour le traitement du signal numérique (filtrage, extraction de signaux, etc.)
- traitement numérique du signal en temps réel
- DSP compresses le donnée (la voix) et supprime le bruit de fond, ainsi la voix est transfere à un vitesse plus élevée

1982 TI introduces its first programmable general-purpose digital signal processor (DSP) to market - the [TMS32010](#) DSP - operating at five million instructions per second (MIPS). It was ideal for modems and defense applications.

Clavier

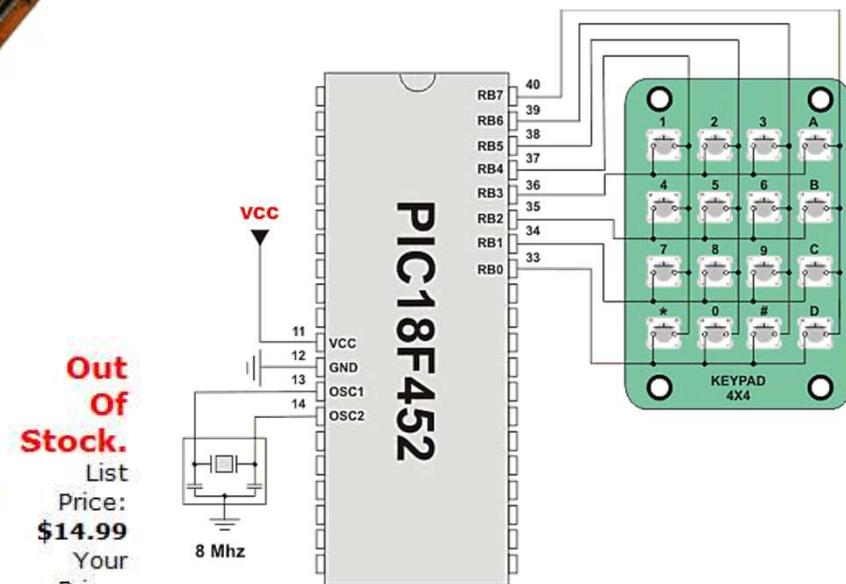
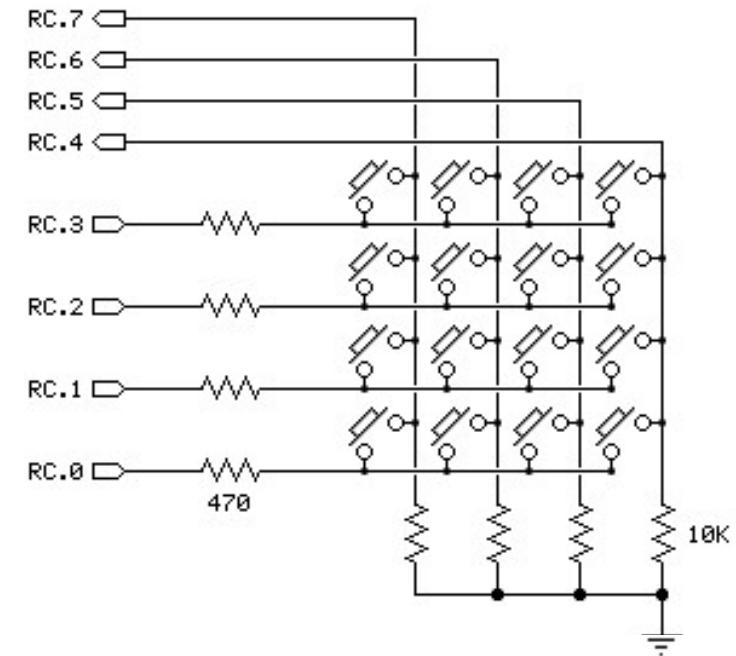


MOTOROLA RAZR V3 KEYPAD



MOTOROLA RAZR V3 OEM Gold Cell Phone Keypad

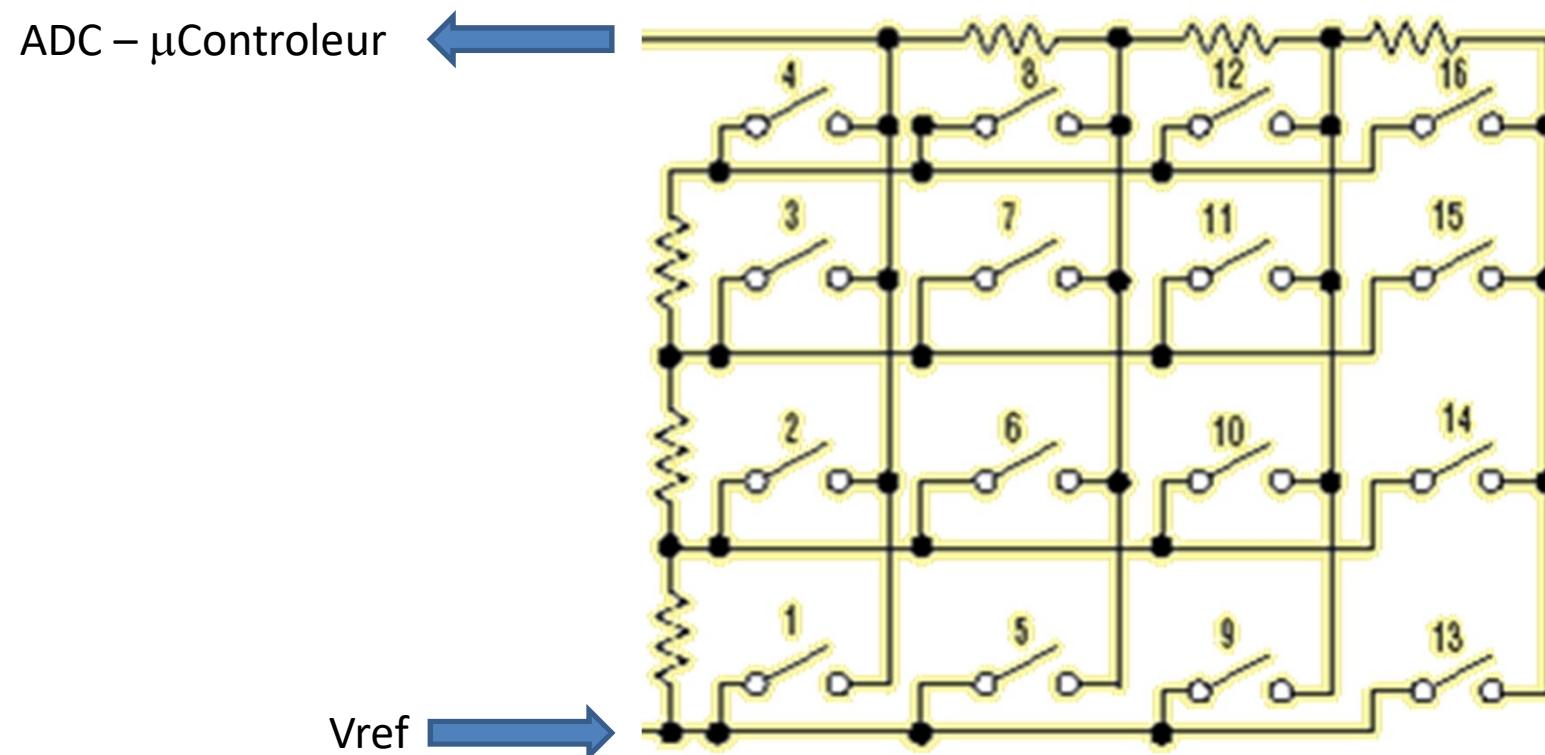
For MOTOROLA RAZR V3: OEM Gold Cell Phone Keypad for your cellular phone to change or renew your old cell phone key pads. Or you can use this cell phone keypad to personalize... [Details](#)
Ref#: 25206



Out Of Stock.
List Price: **\$14.99**
Your Price: **\$3.89**

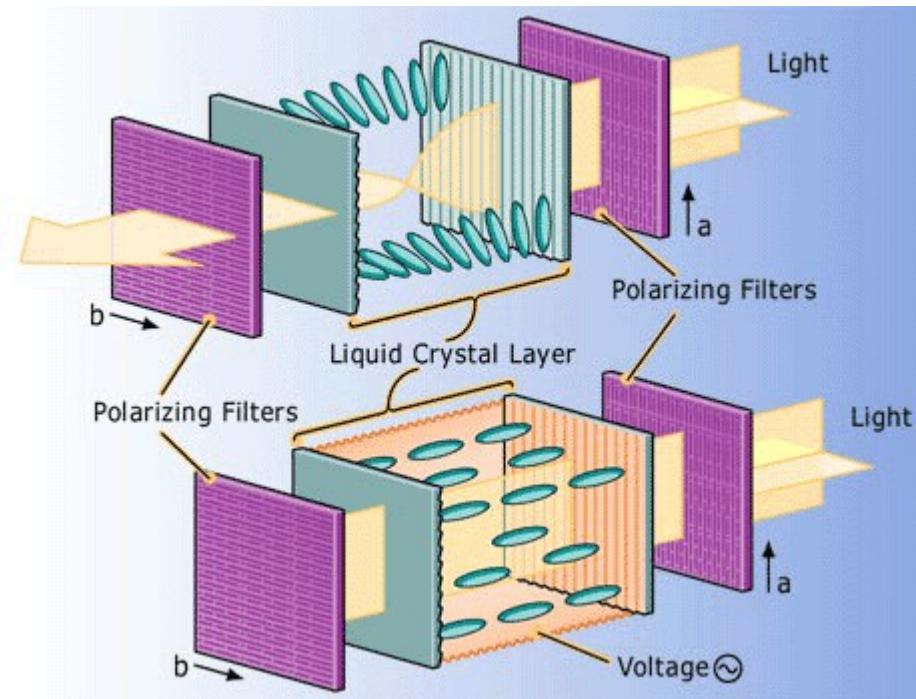
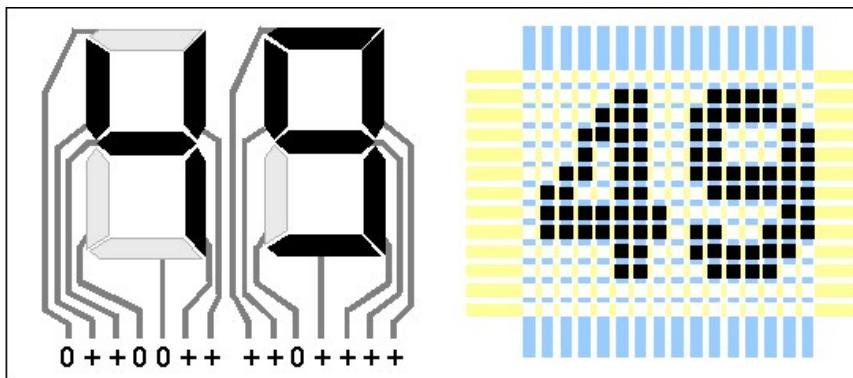
4x4 Keypad connection scheme

Clavier

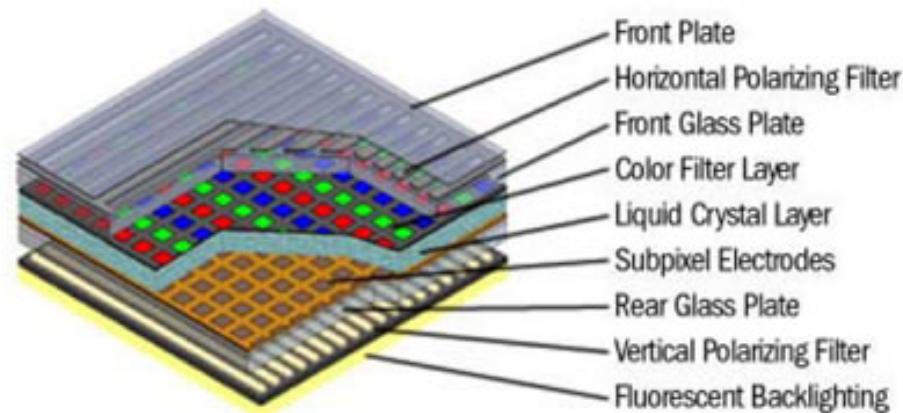
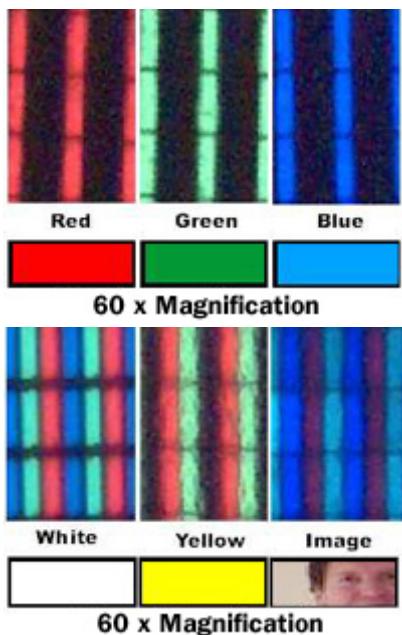


LCD (Liquid Cristal Display)

Écran à Cristaux Liquides



LCD Couleur



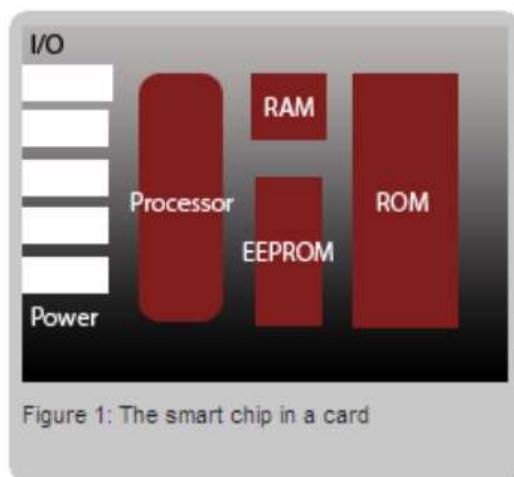
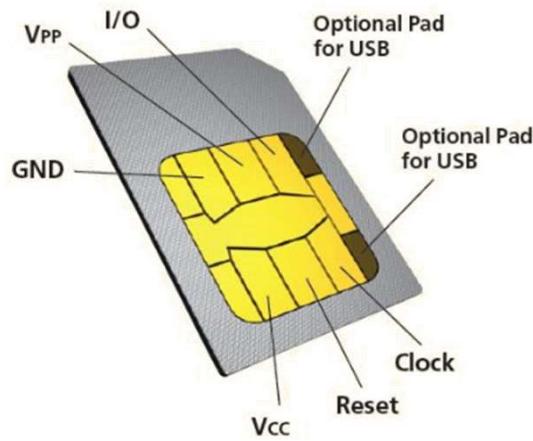
The multi-layered structure of an active-matrix LCD panel.

Because they use red, green and blue color filters in place of phosphor dots, LCD panels are completely immune to image burn-in.



Carte SIM

Subscriber Identity Module



- Microprocesseur et mémoire
- Stocker information importantes:
 - **International Mobile Subscriber Identity (IMSI)**
 - **Integrated Circuit Card ID (ICC-ID)**
 - **Authentication key (K_i)**
 - **Location area identity**
 - **SMS messages and contacts**
 - **Universal Subscriber Identity Module**
- Baseé sur Java Card