

¿Que elementos intervienen en las comunicaciones ?

Capítulo 1

Mensaje

TRANSMISOR

RECEPTOR

Sin tener en cuenta aspectos semánticos ,es decir considerando aspectos estrictamente ingenieril , C. E. Shannon planteó :

***"The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point."***

Shannon, 1948

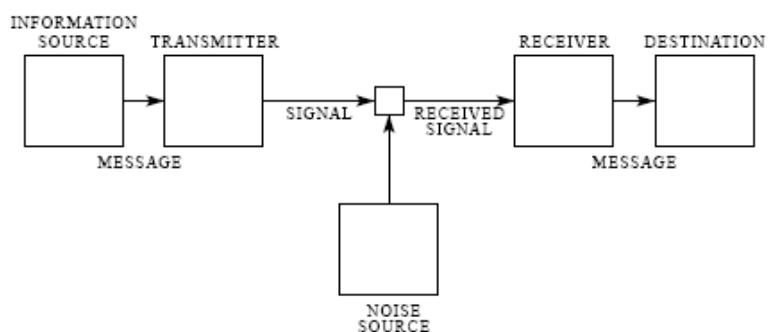
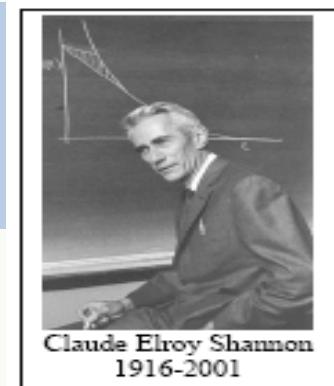
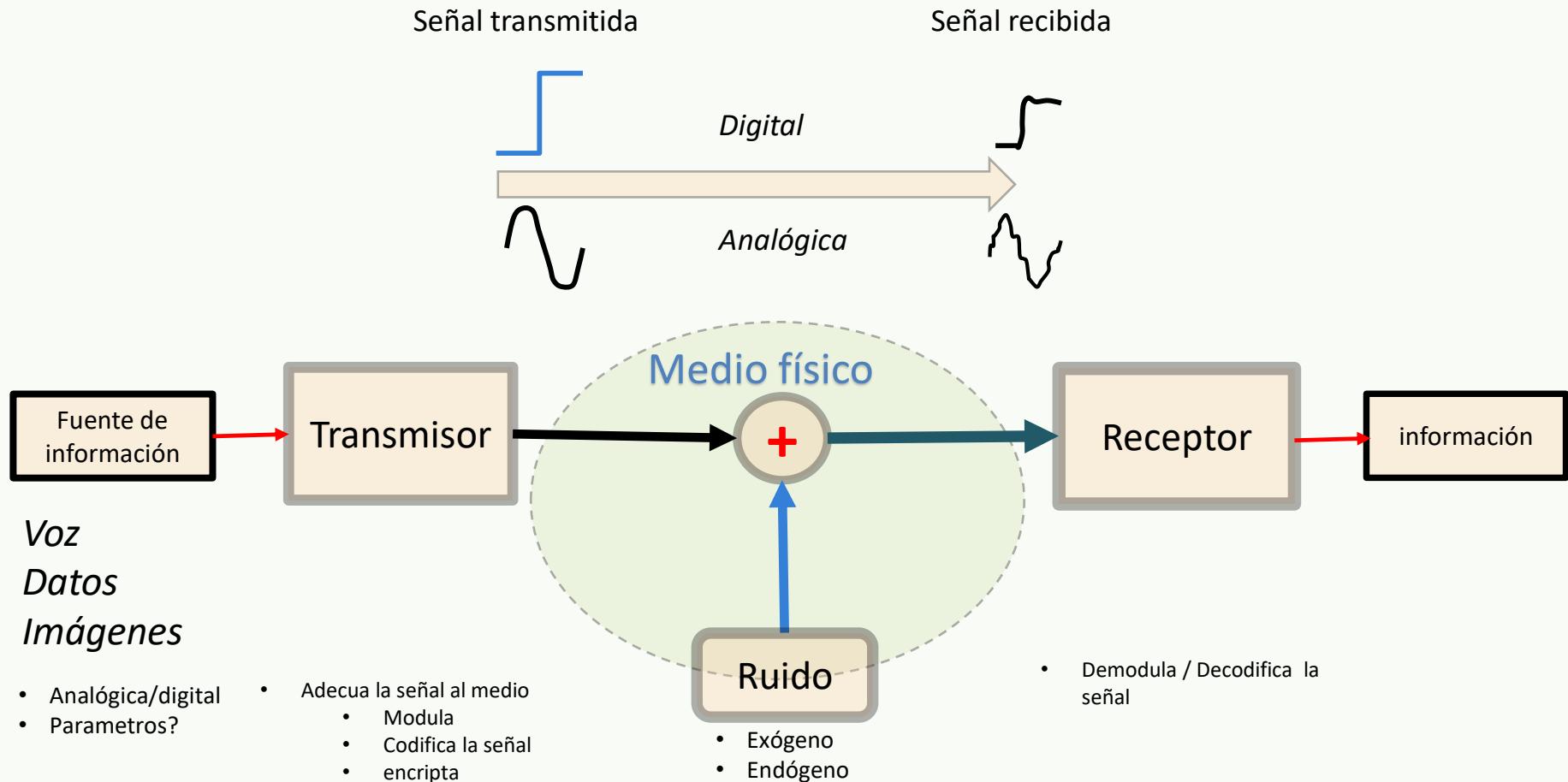


Fig. 1—Schematic diagram of a general communication system.

***"Communications may be broadly defined as the transfer of information from one point to another"***

J. Senior , 2009.



“El ruido eléctrico puede definirse como una señal indesirable que está presente en un sistema de comunicación”

(Connor, 1976).

*“In communication systems, the noise is an error or undesired random disturbance of a useful information signal, introduced before or after the detector and decoder. The noise is a summation of unwanted or disturbing energy from natural and sometimes man-made sources”. (WIKI).*

### Naturaleza del ruido

Algunos autores, discriminan el ruido endogeno al sistema de comunicacion, de la interferencia, ruido producido por causas externas al sistema de comunicacion”

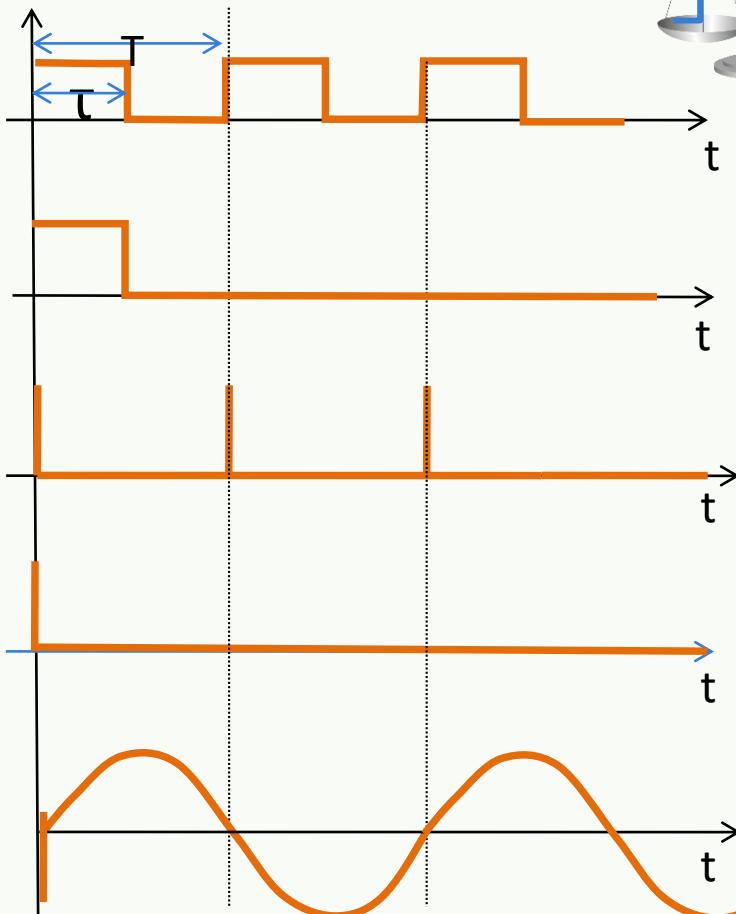
*Noise is, however, typically distinguished from interference, (e.g. cross-talk, deliberate jamming or other unwanted electromagnetic interference from specific transmitters), for example in the signal-to-noise ratio (SNR), signal-to-interference ratio (SIR) and signal-to-noise plus interference ratio (SNIR) measures. Noise is also typically distinguished from distortion, which is an unwanted alteration of the signal waveform, for example in the signal-to-noise and distortion ratio (SINAD). In a carrier-modulated passband analog communication system, a certain carrier-to-noise ratio (CNR) at the radio receiver input would result in a certain signal-to-noise ratio in the detected message signal. In a digital communications system, a certain  $E_b/N_0$  (normalized signal-to-noise ratio) would result in a certain bit error rate (WIKI )*

¿Cómo caracterizamos la señales a trasmisir?: Que parámetros son importantes ?

Dada la ..

**SEÑAL..**

¿Cuál de ellas es la mas difícil de transmitir al otro extremo?



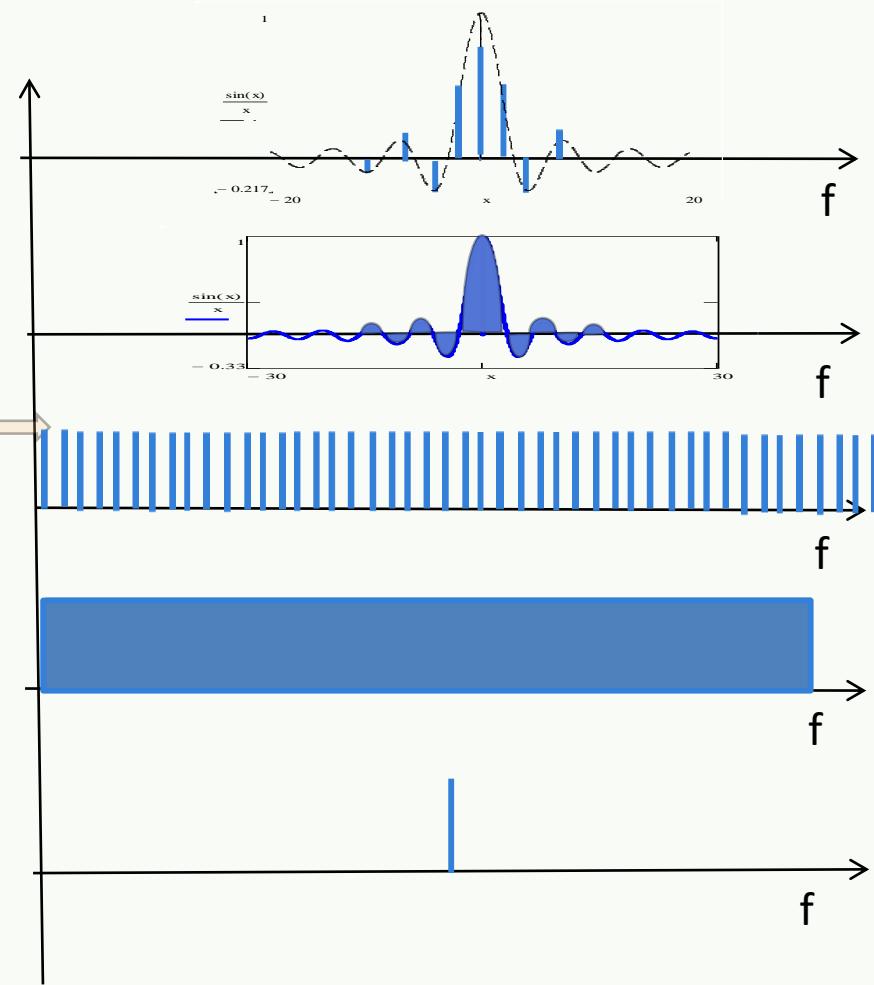
Como se mide esa dificultad ?

**ANCHO DE BANDA?**



**DOMINIO DE FRECUENCIA**

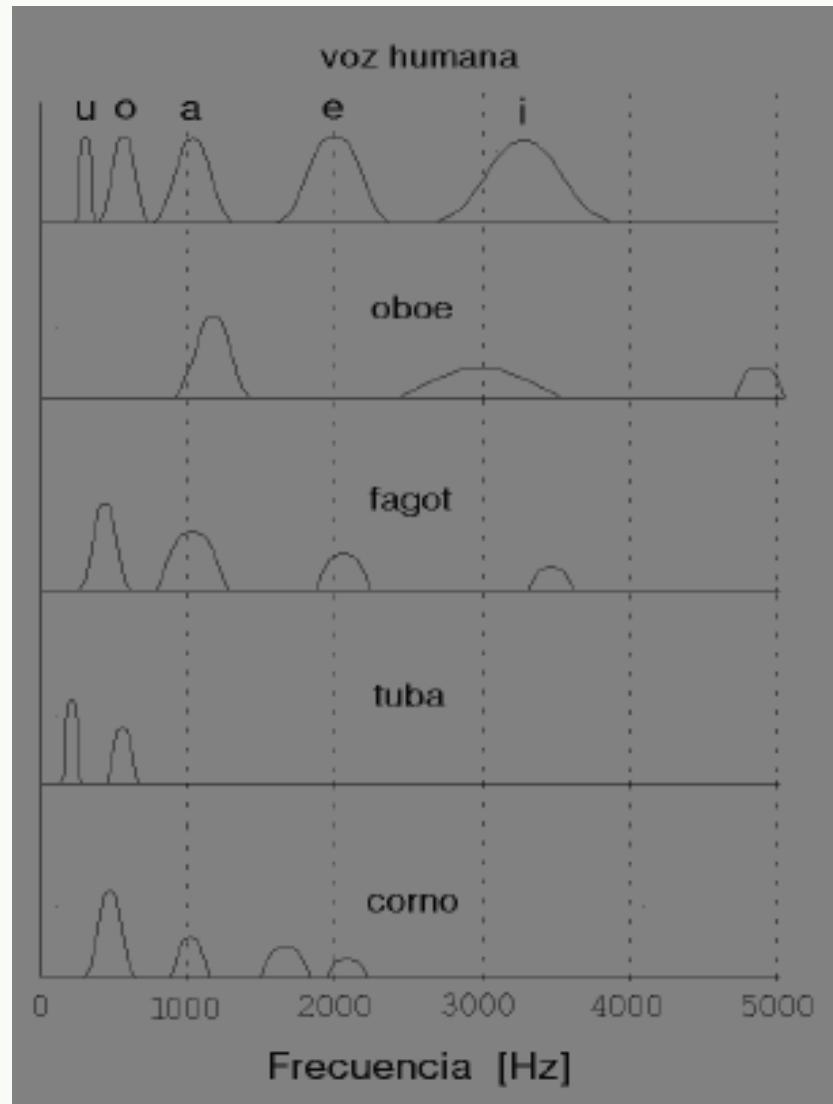
Espectro ?





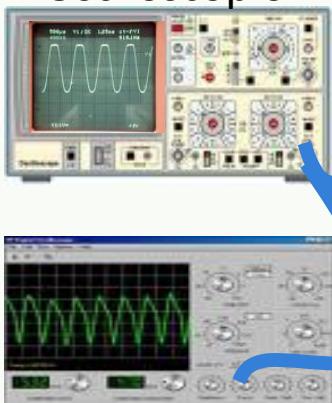
# Conceptos básicos

**Espectro** de vocales y palabras en castellano.

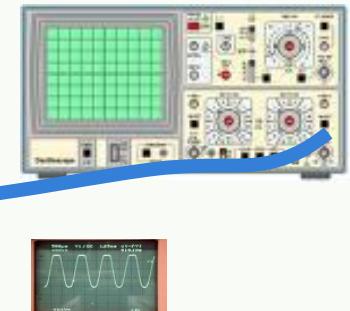




Osciloscopio



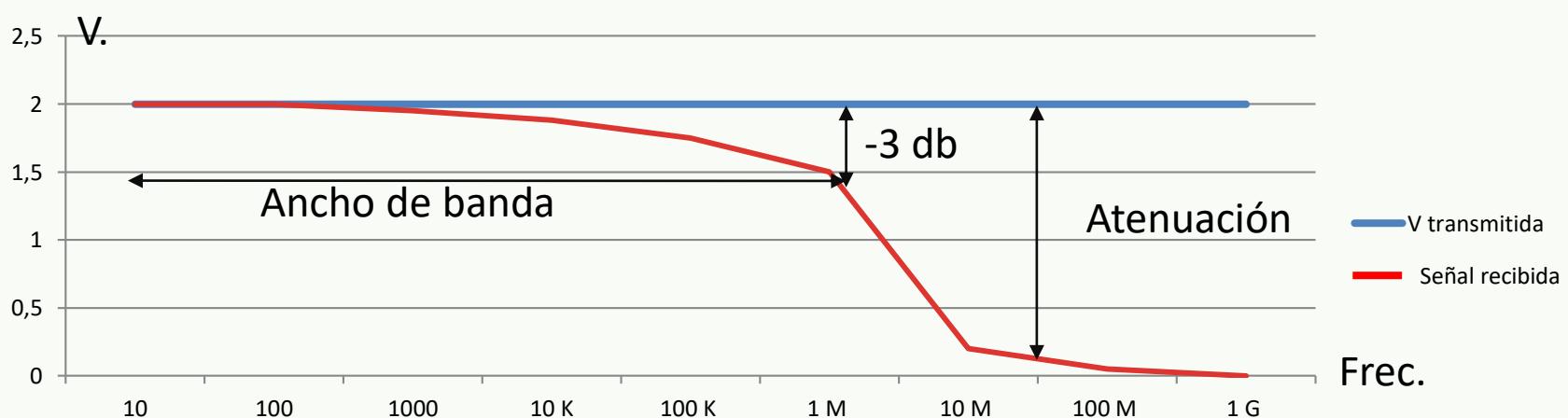
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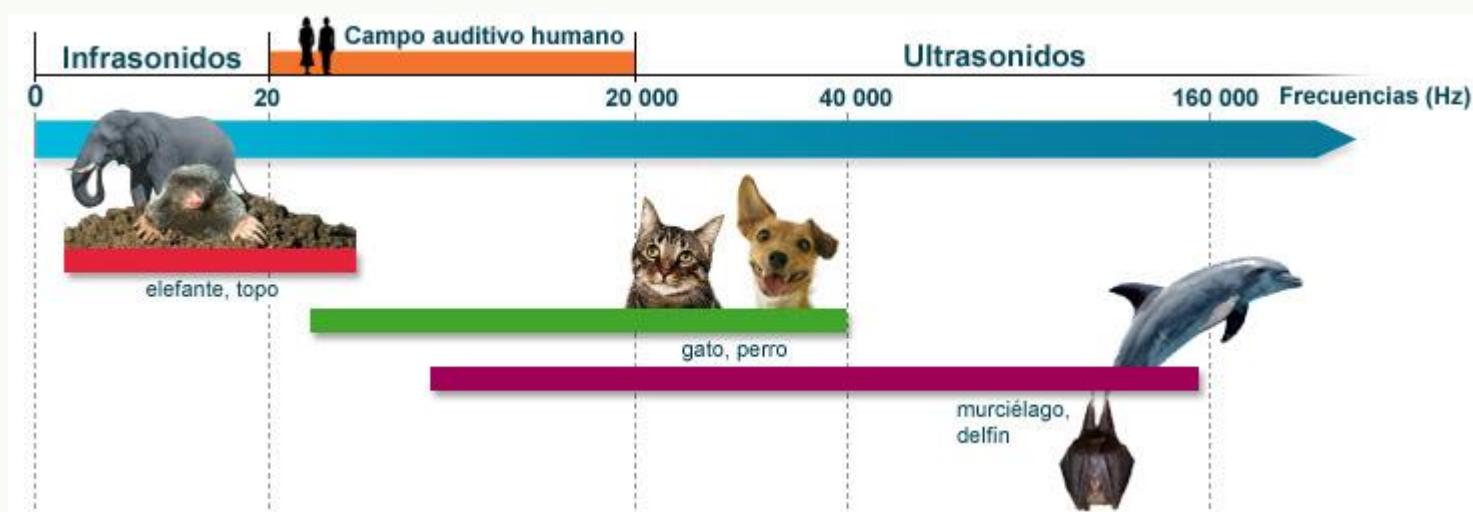
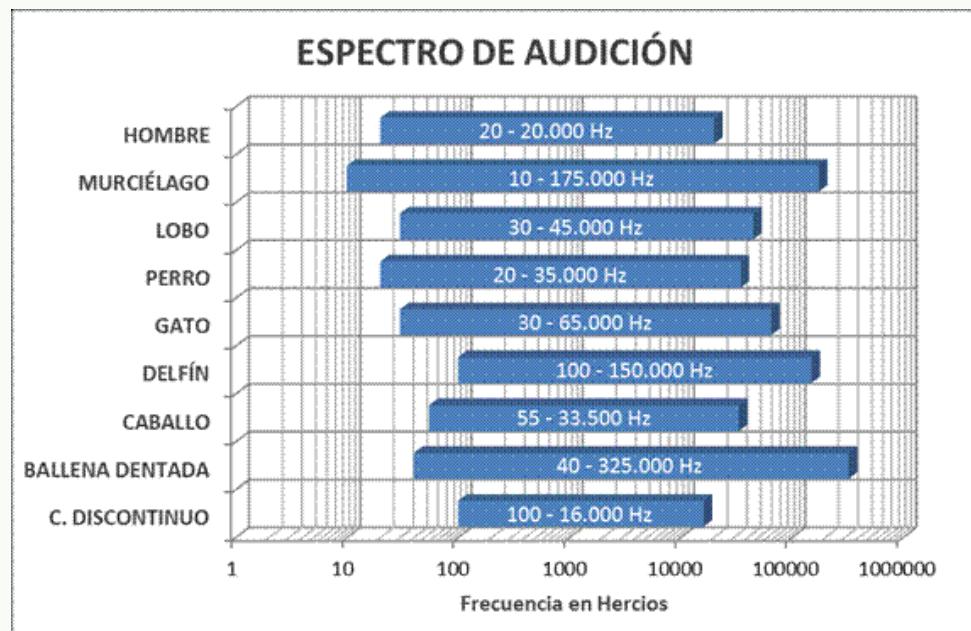
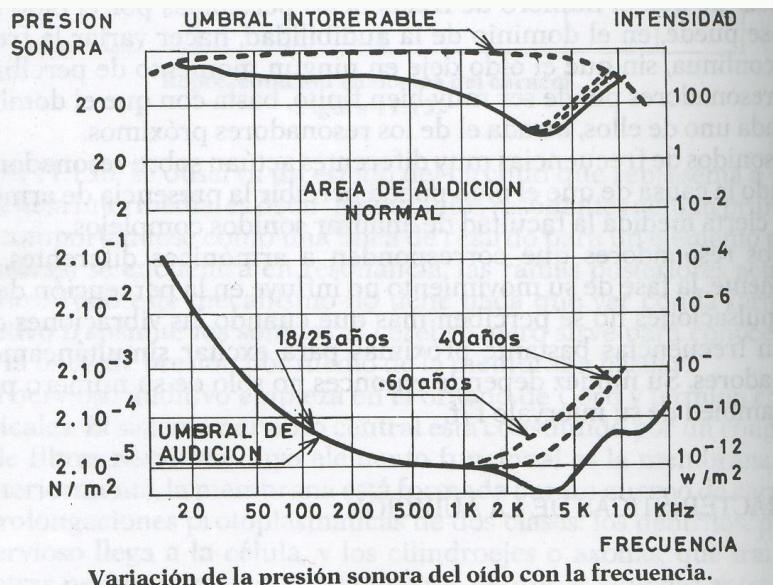
Generador de frec. senoidal



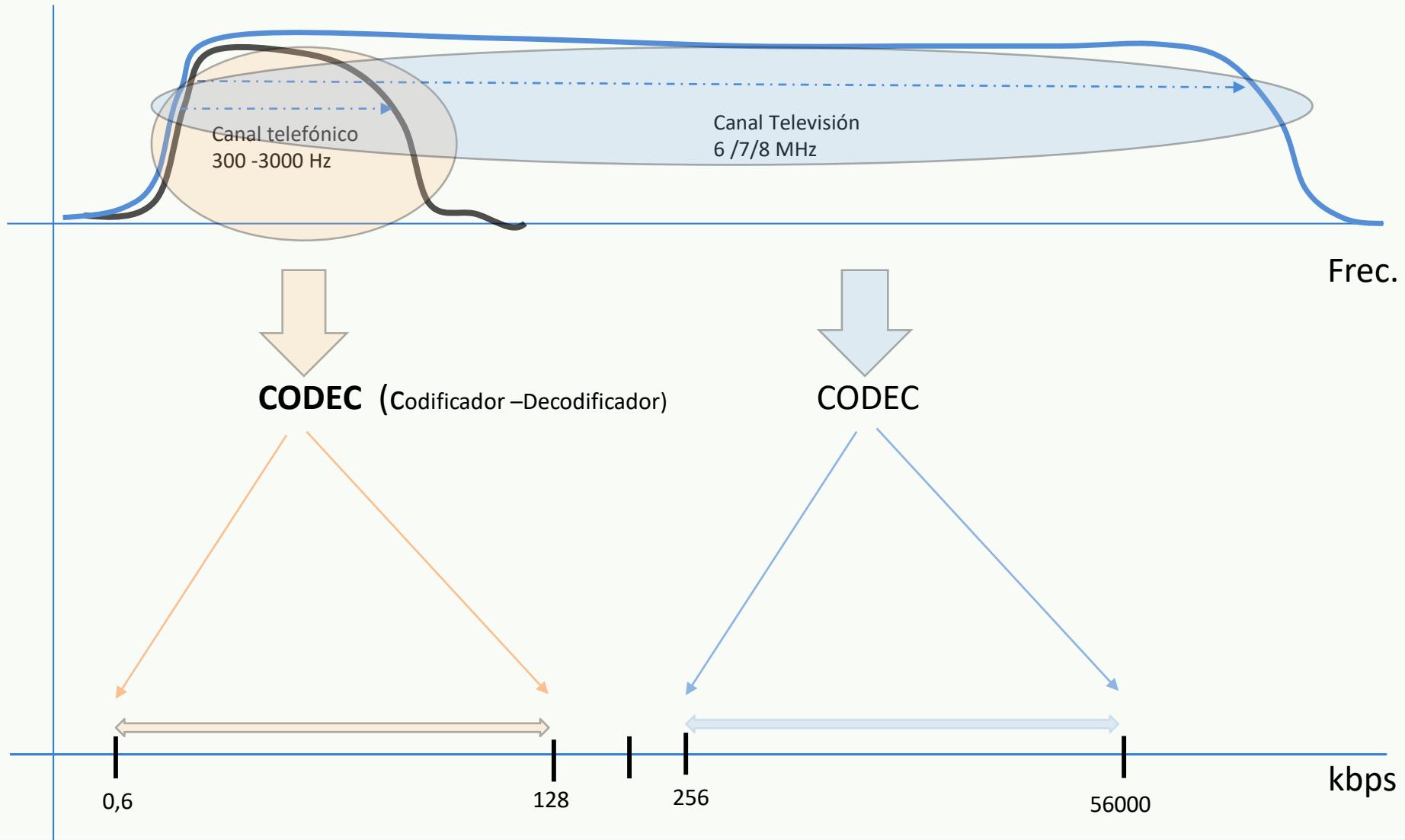
Xx metros de cable



## Distintos anchos de bandas de audición (estimativo)

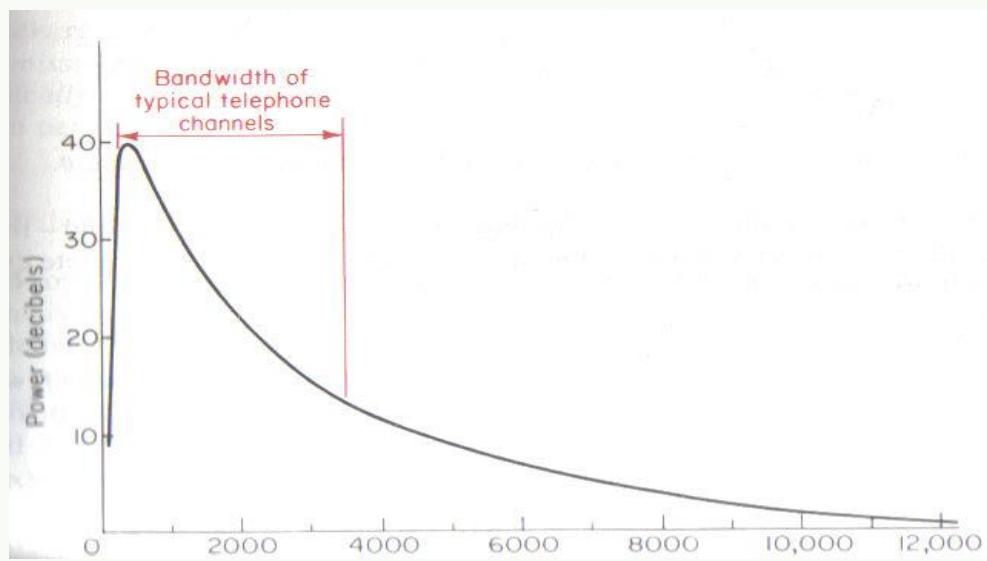


Ancho de banda utilizados en Telecomunicaciones (específicos y normalizados):

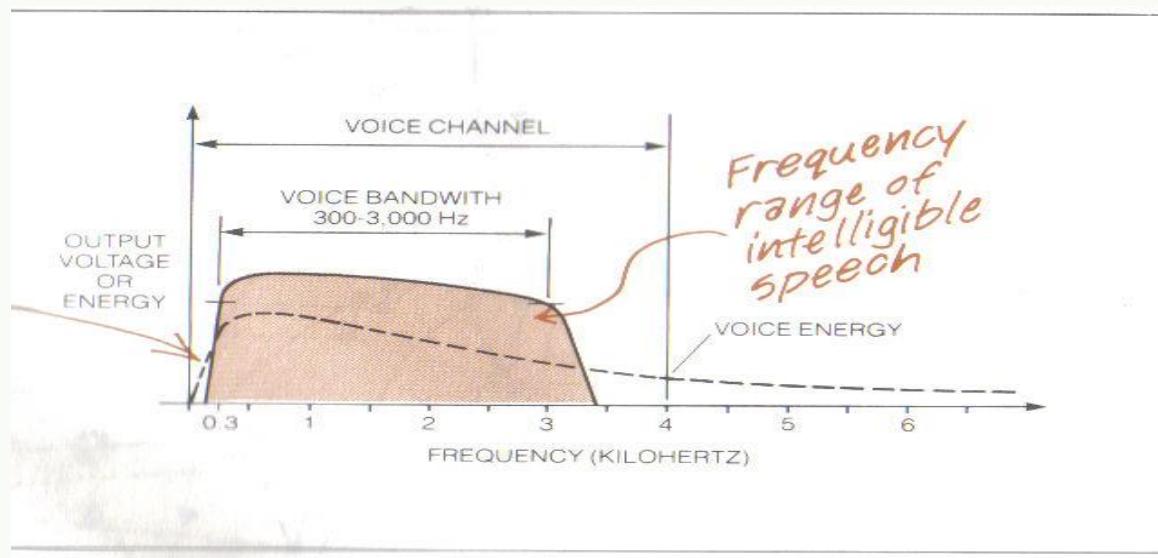


## Canal Telefónico

Voz humana



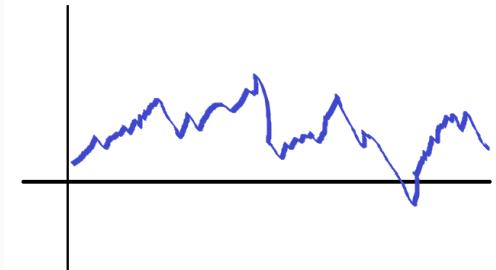
Canal telefónico



# Señal y su caracterización

**AC**

Revisión ...



FOURIER

$$f(x) = \frac{a_0}{T} + \frac{2}{T} \sum_{n=1}^{\infty} (a_n \cos(nw_n t) + b_n \sin(nw_n t))$$

$$b_n = \int_{-\tau/2}^{\tau/2} f(t) \cos(nw_n t) dt$$

$$a_n = \int_{-\tau/2}^{\tau/2} f(t) \sin(nw_n t) dt$$

$$w_n = \frac{2\pi n}{T}$$

Donde

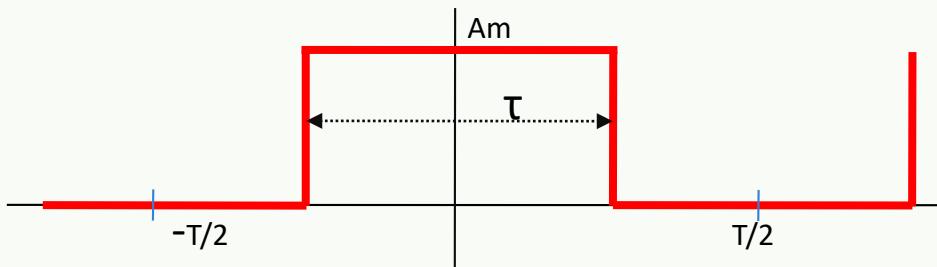
$$C_n = \int_{-T/2}^{T/2} f(t) e^{-jw_n t} dt$$

Expresado por los coeficientes de Fourier

$$f(t) = \frac{1}{T} \sum_{-\infty}^{\infty} C_n e^{-jw_n t}$$

En el caso de una onda cuadrada

Aplicando los coeficientes de Fourier:

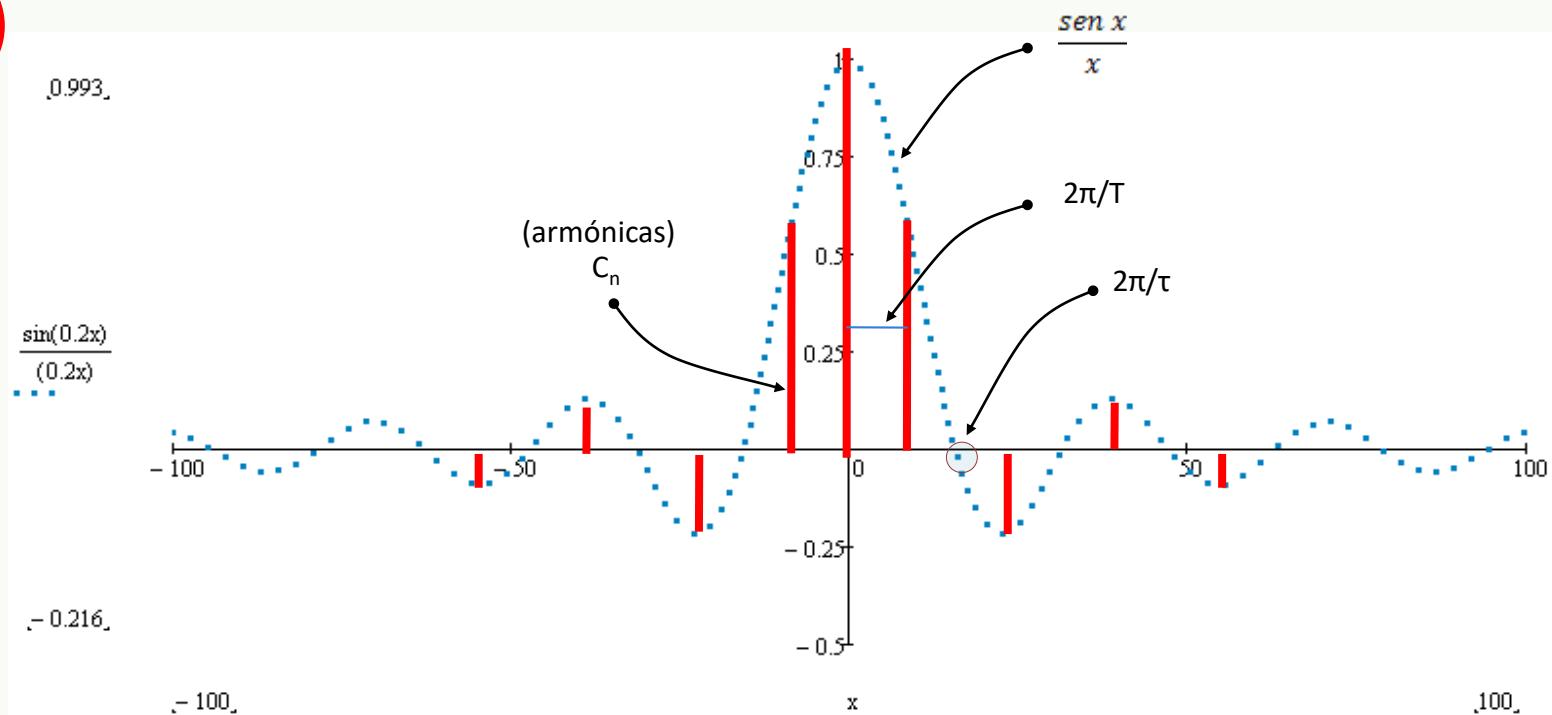


$$C_n = \int_{-T/2}^{T/2} f(t) e^{-jw_n t} dt = \int_{-T/2}^{T/2} Am e^{-jw_n t} dt = \frac{Am}{jw_n} e^{-jw_n t} \Big|_{-T/2}^{T/2} = \tau Am \operatorname{sen}\left(\frac{w_n \tau}{2}\right) / w_n \tau / 2$$

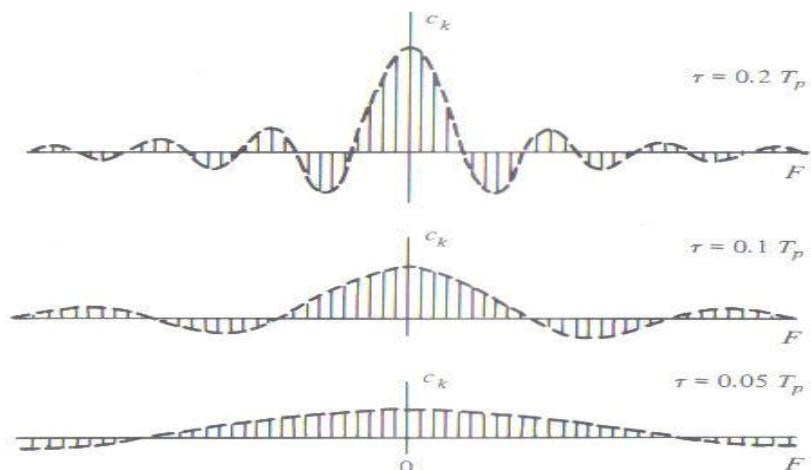
$$C_n = \tau Am \frac{\operatorname{sen} x}{x} \quad x = \frac{w_n \tau}{2}$$

## Espectro de frecuencias de una onda cuadrada

**AC**



Si cambiamos el ancho de pulso ,  
pero no el periodo.....





**AC**

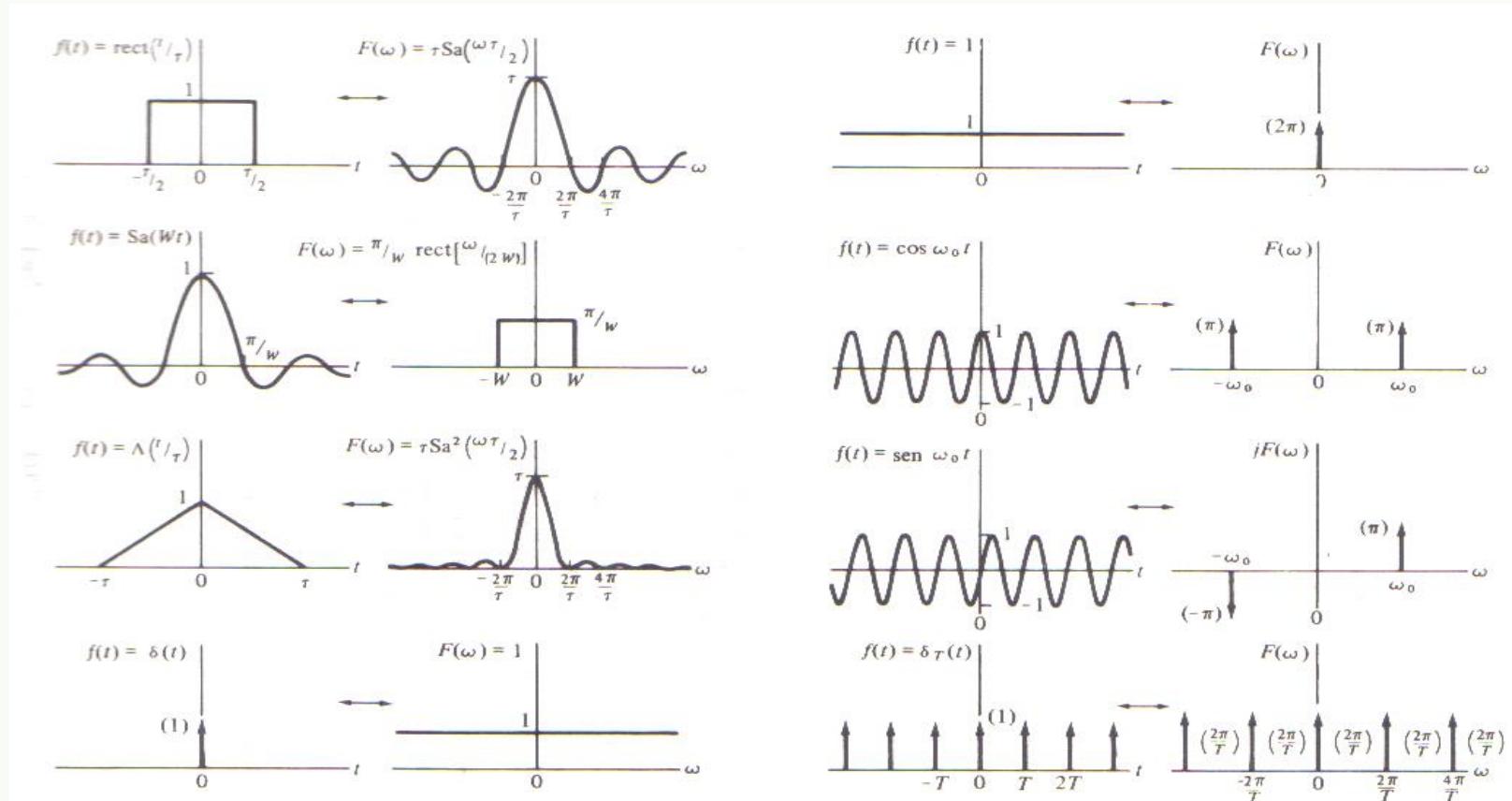


Fig. 3.3 Algunas funciones del tiempo y sus funciones densidad espectral.

**AC**

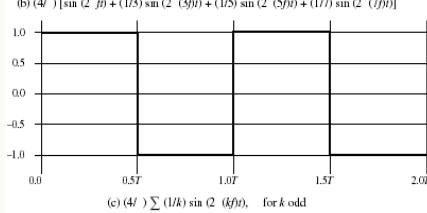
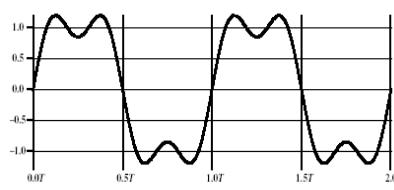
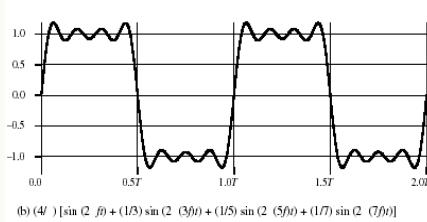
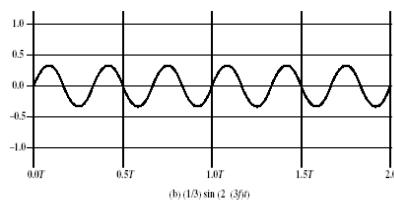
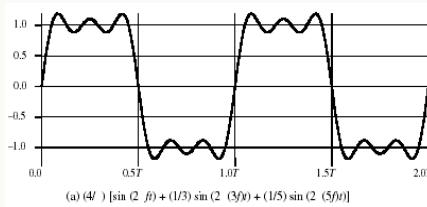
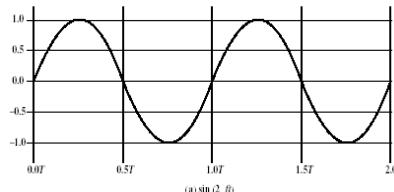
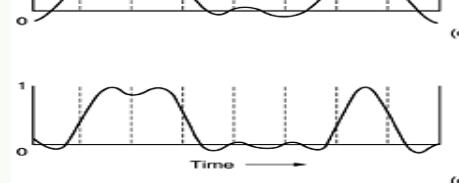
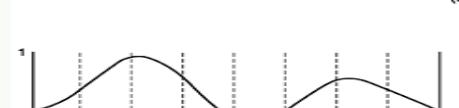
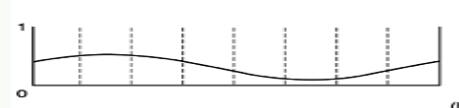
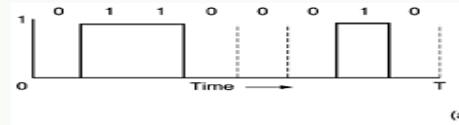


Figure 2.4 Addition of Frequency Components ( $T = 1/f$ )

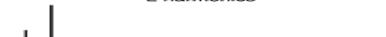
Figure 2.5 Frequency Components of Square Wave ( $T = 1/f$ )



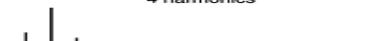
1 harmonic



2 harmonics



4 harmonics



8 harmonics



Desventajas o problemas de la transmisión digital sobre la analógica :



¿Porque se trasmite en forma analógico o digital ?

Portadora/ carrier

## Transmisión

### Analógica

$$f(t) = A_m \operatorname{sen}(2\pi ft + \Phi)$$

#### Modulación Analógica

Método:

AM  
FM

#### Modulación Digital.

Codificación  
ASK  
FSK  
PSK  
QAM

### Digital

#### Modulación Analógica

PCM  
PPM  
PAM

#### "Modulación" Digital

Codificación:  
NRZ  
BIPOLAR  
CMI  
HDB3

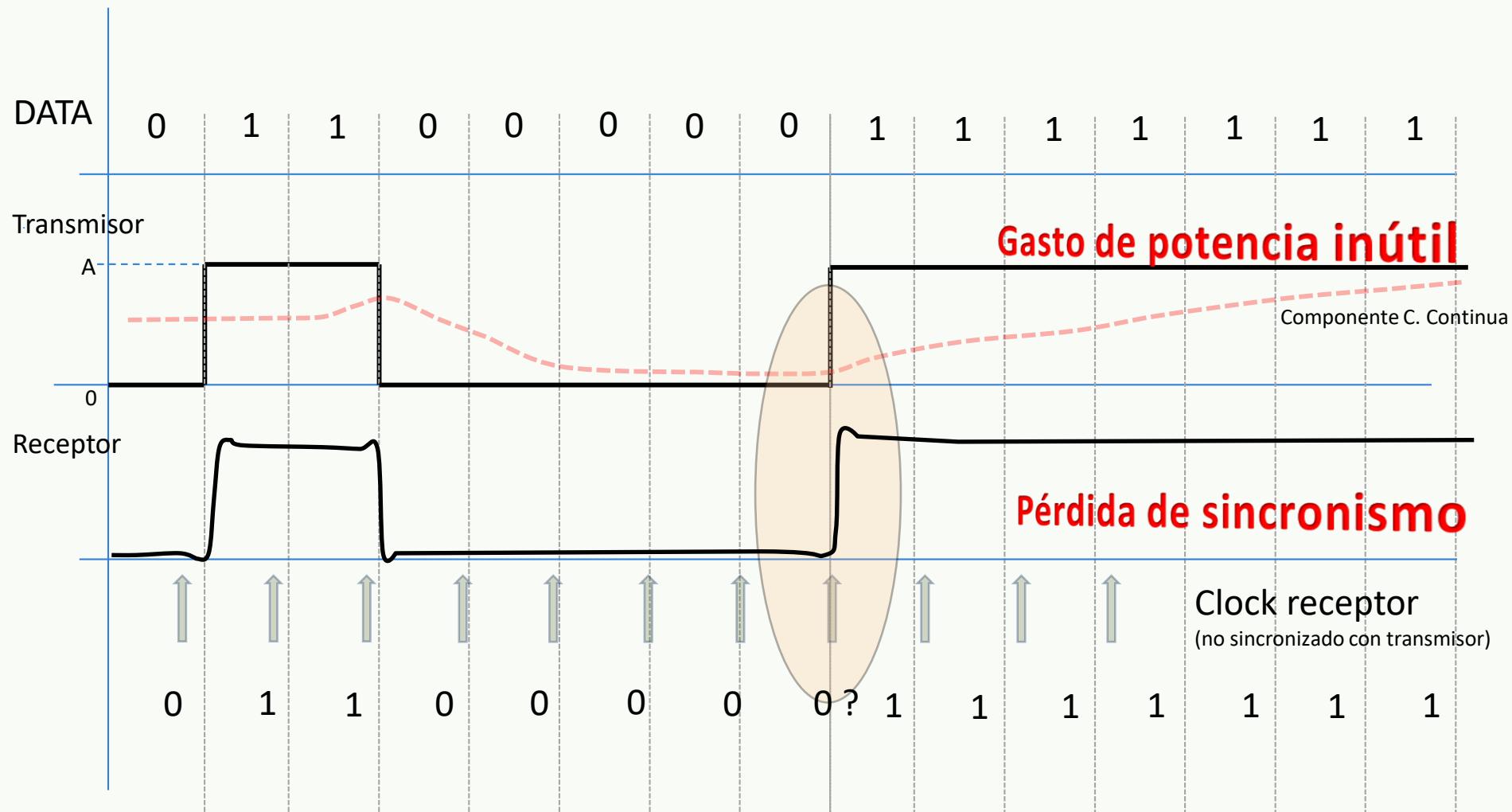
Ej :

Radios  
comerciales

Modem Telefónicos  
Radio enlaces  
PLC  
Wireless

Redes LAN  
Voz digital

## Problemas con la transmisión digital :

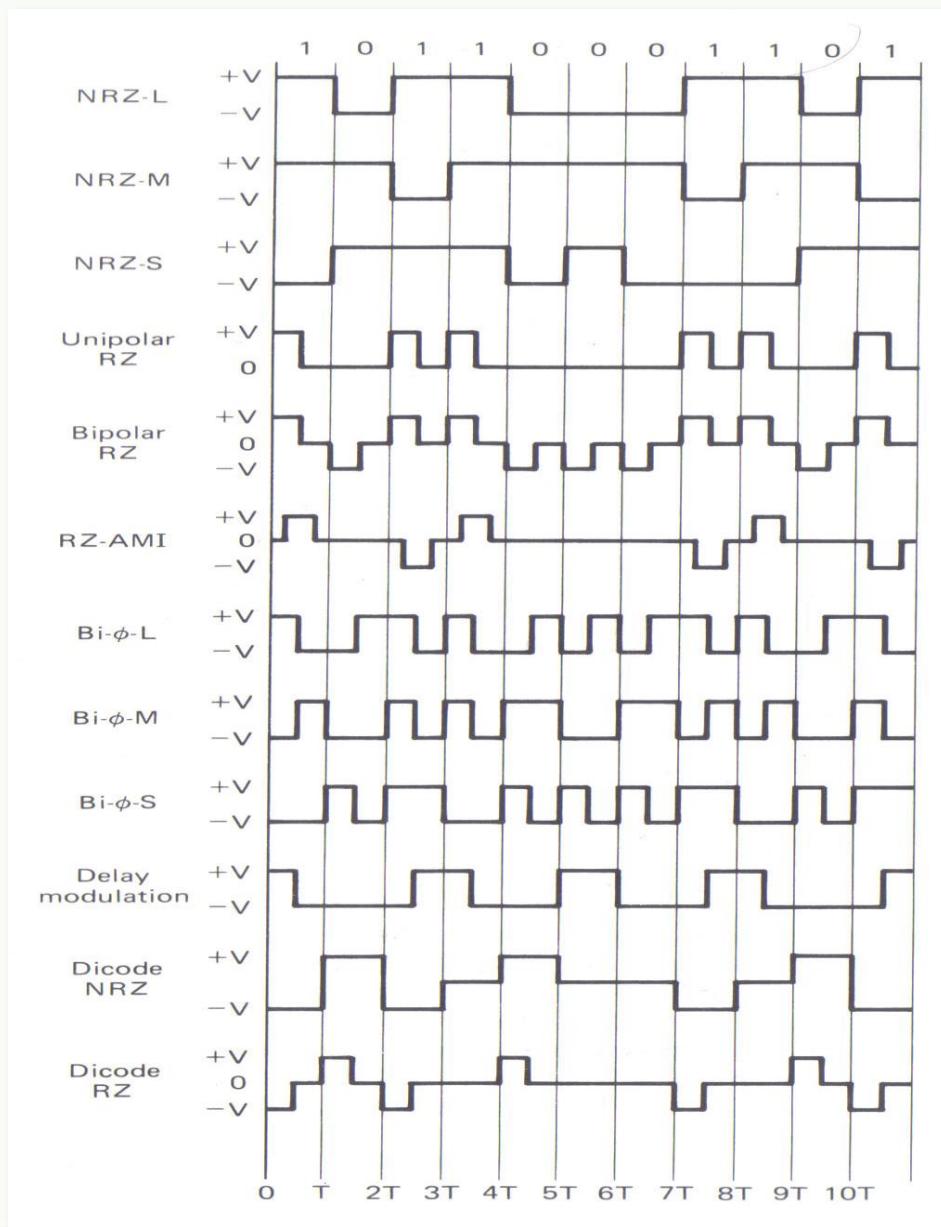
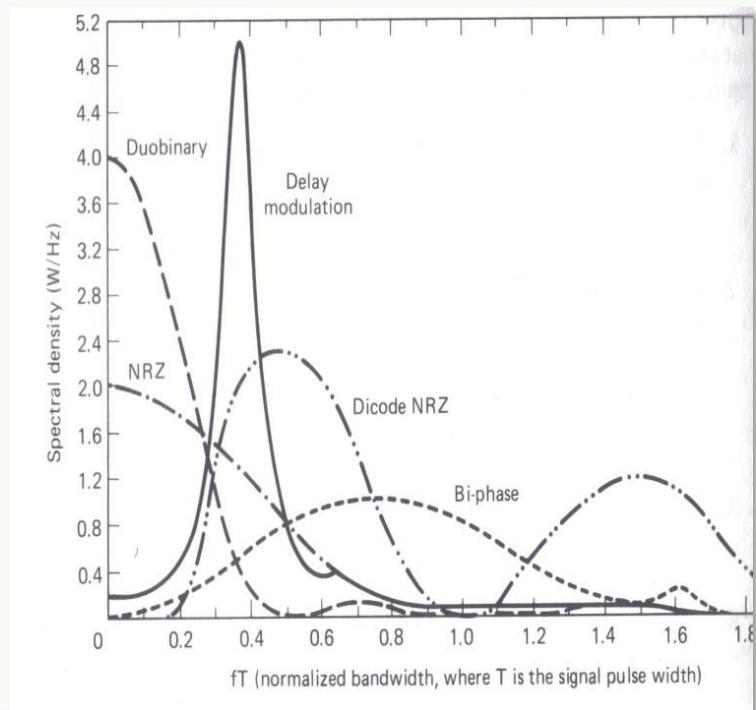


**AI**

## Códigos de banda base y sus espectros codificación de canal de comunicación

Porque se codifica? :

- \* **Asegurar Sincronismo**
- \* **No Transmitir CC.**
- \* **Mejorar la Relación S/R**
- \* **Para evitar Errores (detección)**
- \* **Disminuir el ancho de banda necesario**

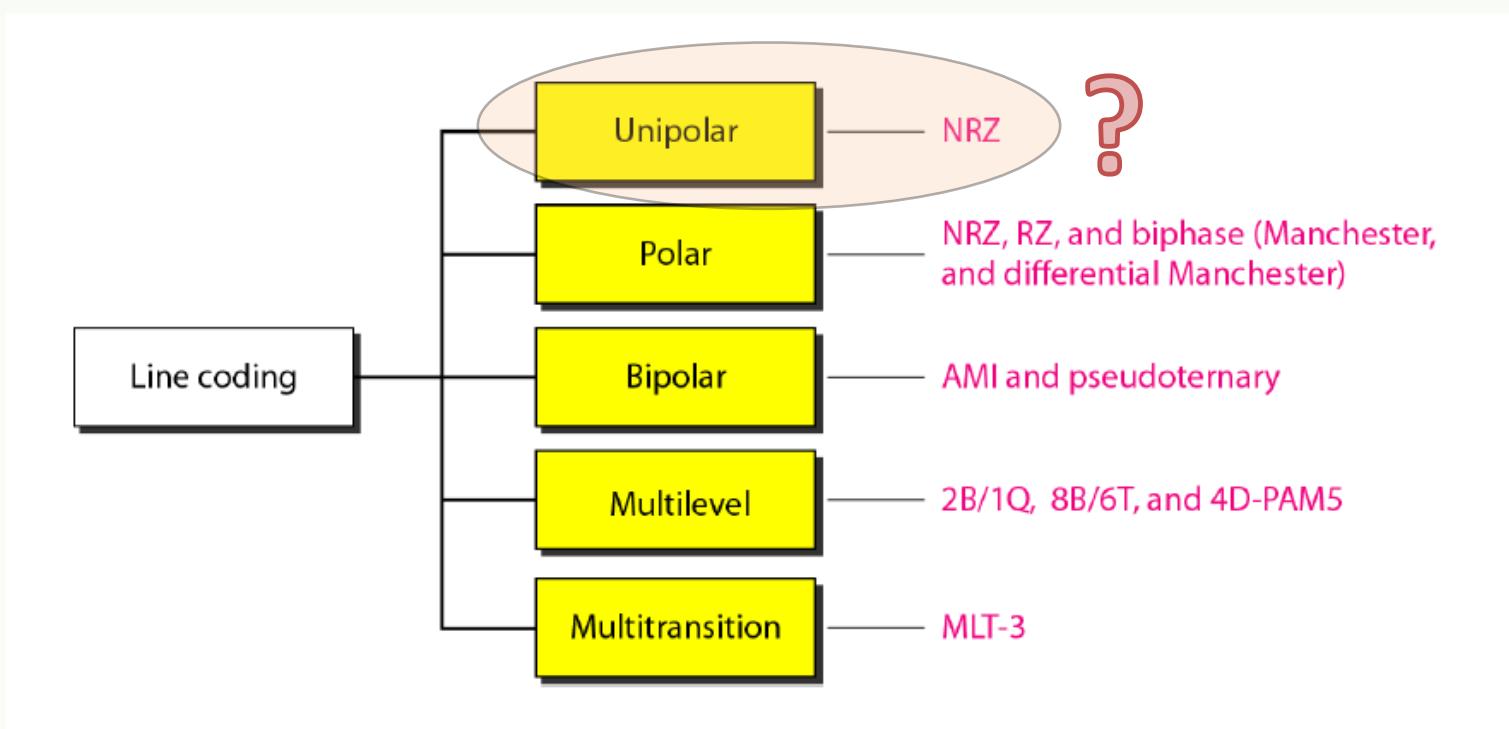


## Codificación del canal :

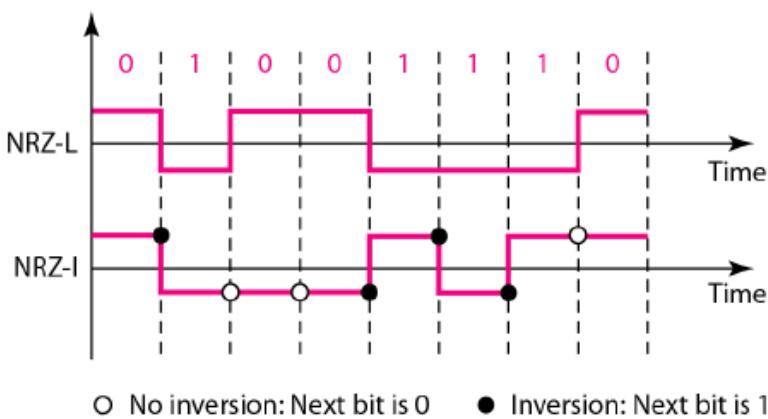
**TIPOS DE CODIFICACION :**  
(clasificación)

Depende de la bibliografía su nombre...

NRZ : Non Return to Zero

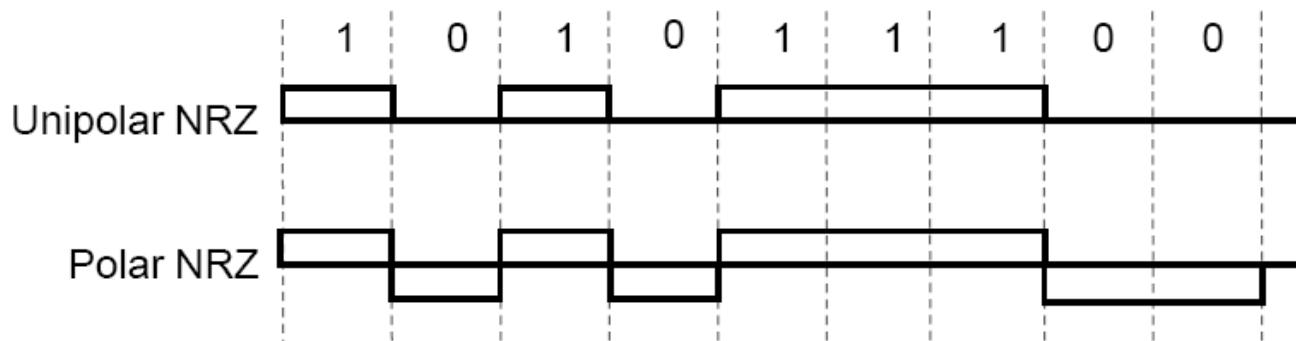


**Codificación:** Depende de la bibliografía su nombre y



- \* NO son normalizados , son aplicaciones para cada sistema en particular ..
- \* Nomenclatura confusa en internet....

## Polar NRZ Scheme



# Codificación del canal :

**AI**

**Los códigos y sus aplicaciones específicas... : 4B5B ; 8B10B; 64B66B.....**

## Codificación 4B5B ↴

Grupo Funcional	Alpha	5bit	
Delimitadores	J	11000	1
	K	10001	1
	L	00101	1
	T	01101	1
DATA	0	11110	0
	1	01001	0
	2	10100	0
	3	10101	0
	4	01010	0
	5	01011	0
	6	01110	0
	7	01111	0
	8	10010	0
	9	10011	0
	A	10110	0
	B	10111	0
	C	11010	0
	D	11011	0
	E	11100	0
	F	11101	0
Line State Symbols	Q	00000	1
	I	11111	1



November 2001; ver. 1.02

## 8b10b Encoder/Decoder MegaCore Function (ED8B10B)

Data Sheet

### Introduction

Encoders and decoders are used for physical layer coding for Gigabit Ethernet, Fibre Channel, and other applications. The 8b/10b encoder takes byte inputs, and generates a direct current (DC) balanced stream (equal number of 1s and 0s) with a maximum run length of 5. Some of the individual 10-bit codes will have an equal number of 1s and 0s, while others will have either four 1s and six 0s, or, six 1s and four 0s. In the latter case, the disparity between 1s and 0s is used as an input to the next 10-bit code generation, so that the disparity can be reversed, and maintain an overall balanced stream. For this reason, some 8-bit inputs have two valid 10-bit codes, depending on the input disparity.

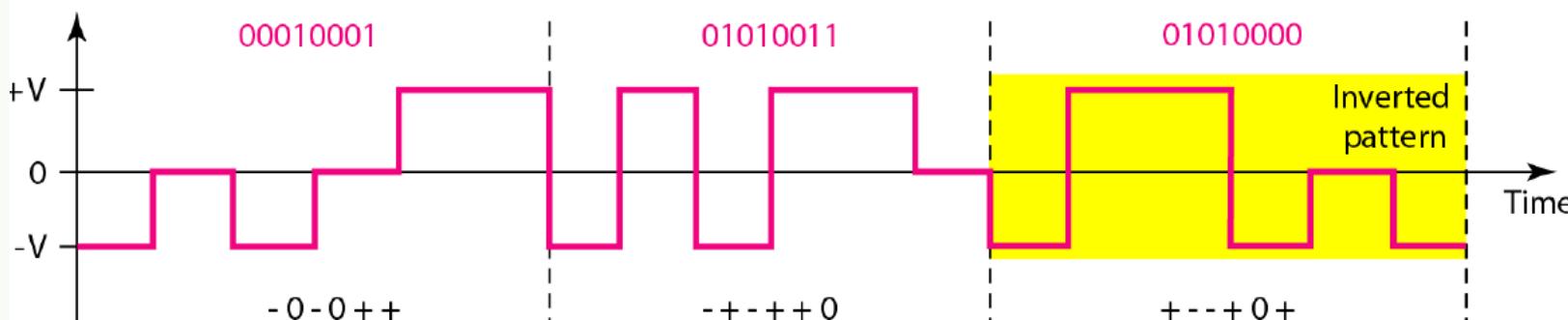
The Altera® 8b10b Encoder/Decoder MegaCore® Function (ED8B10B) is a compact, high performance core capable of encoding and decoding at Gigabit Ethernet rates (125 MHz; 1 Gbps). The ED8B10B is optimized for the APEX™ 20K, FLEX 10K®, and Mercury™ devices.

Versión PCIe	Codificación	Velocidad de Línea	Rendimiento (x16)
1.0	8b/10b	2.5 Gbps	4 GB/s
2.0	8b/10b	5 Gbps	8 GB/s
3.0	128b/130b	8 Gbps	15,8 GB/s
4.0	128b/130b	16 Gbps	31,5 GB/s

*Los códigos y sus aplicaciones específicas...*

## Multilevel: 8B6T Scheme

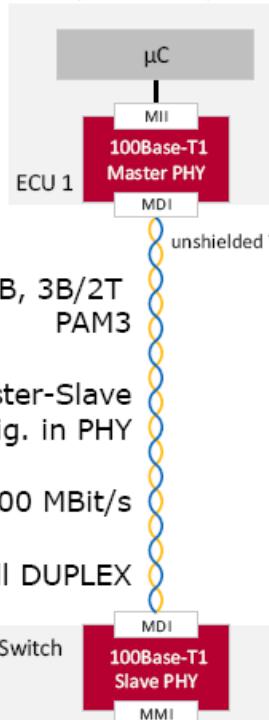
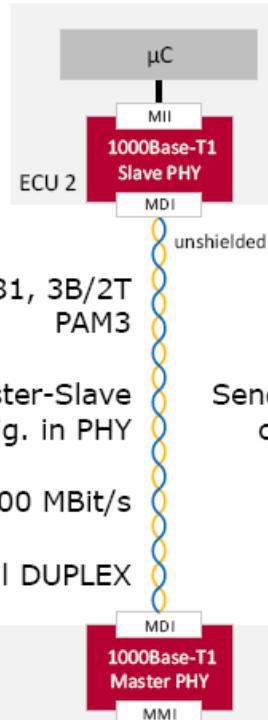
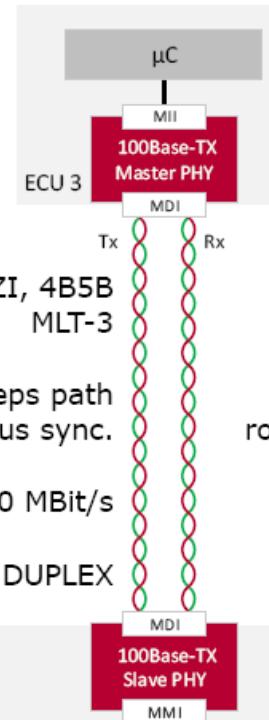
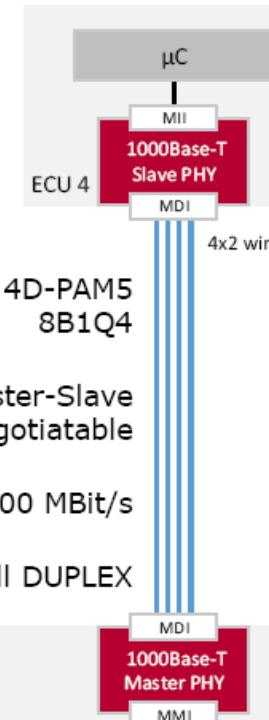
- Used in 100BASE-4T cable (四對雙絞線).
- 8-bit pattern to a pattern of **6 signal elements**.
- **Three levels**: -, 0, + (ternary).
- $2^8 = 256$  different data patterns and  $3^6 = 729$  different signal patterns.
  - $729 - 256 = 473$  redundant signal elements
  - **Synchronization**.
  - **Error detection**.
  - **DC balance**.



# Codificación del canal :

*Los códigos y sus aplicaciones específicas...*

## Automotive Ethernet Variants

	100Base-T1 (aka OABR)	1000Base-T1	100Base-TX	1000Base-T
				
Coding / Decoding	4B/3B, 3B/2T PAM3	80B/381, 3B/2T PAM3	NRZI, 4B5B MLT-3	4D-PAM5 8B1Q4
Clock / Synchronisation	Master-Slave Config. in PHY	Master-Slave Config. in PHY	Sender keeps path continuous sync.	Master-Slave roles negotiable
Data Rate	100 MBit/s	1000 MBit/s	100 MBit/s	1000 MBit/s
Characteristics	Full DUPLEX	Full DUPLEX	Full DUPLEX	Full DUPLEX

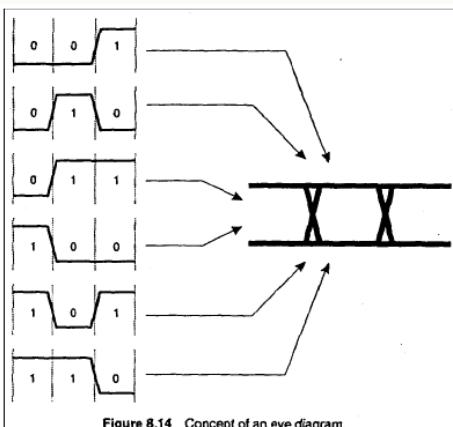
\* ¿Qué ocurre si perdemos sincronismo?....

**Bit error rate : BER**   $BER = 10^{-6}$   1 bit erróneo en  $10^6$  bit transmitidos.

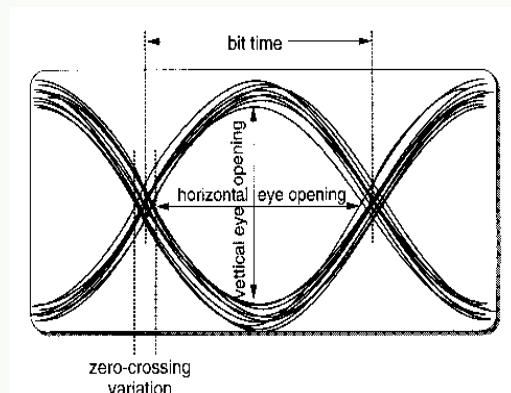
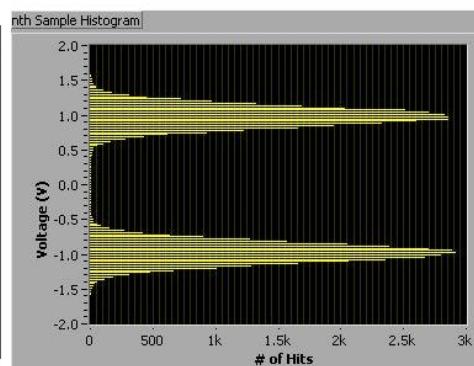
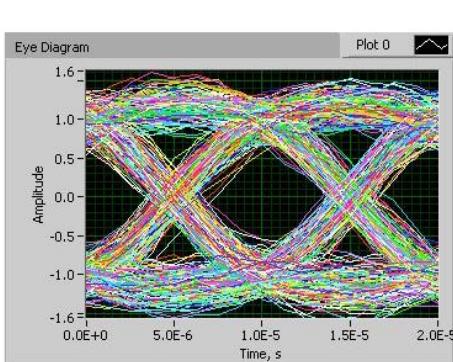
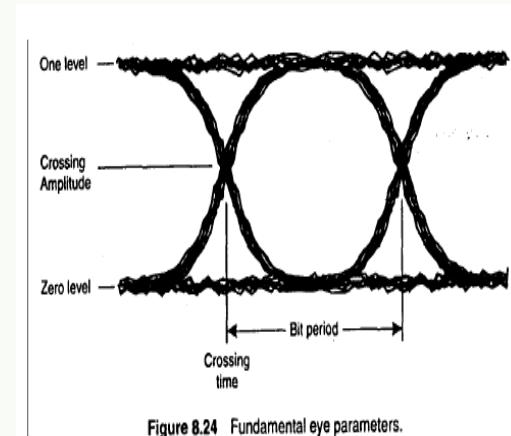
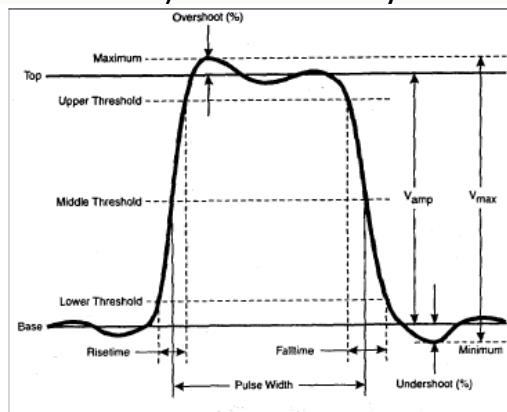
\* Una medición cualitativa de la relación S/R:

## Eye Diagram

Jitter increases the bit error rate.



irregular random movement (as of a pointer or an image on a television screen) also : vibratory motion





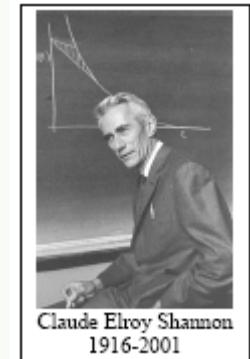
## "A Mathematical Theory of Communication"

Shannon 1948

*La información es inversamente proporcional a la probabilidad del evento*

Cuando se suministra información de dos fuentes independientes

$$I = I_A + I_B = F(1/P_A) + F(1/P_B)$$



(1)

Por teoría de las probabilidades se sabe si los eventos son independientes :

$$P_{A \text{ y } B} = P_A \cdot P_B$$

o sea que

$$I = F(1/P_A \cdot P_B) \quad (2)$$

*La función que cumple las ec. 1 y 2 es ..una función logarítmica !*

$$I = \log(1/P)$$

Según la base del logaritmo se han definidos unidades de información ,  
si el log es :

en base 2 = bits

en base e = nats.

en base 10 = hartleys

\* Hartley, R.V.L., "Transmission of Information", *Bell System Technical Journal*, July 1928, p.535.

\* Shannon S C: *A mathematical theory of communication*. Bell System Technical Journal, vol. 27, pp. 379- 423 and 623- 656, July and October, 1948.



Suponiendo una cantidad de 10 dígitos de los cuales 7 son ceros y 3 son unos la probabilidades son

$$P_0 = 7/10$$

$$P_1 = 3/10$$

por lo tanto

$$I_0 = \log 10/7 = 0,515$$

$$I_1 = \log 10/3 = 1,737 \dots \text{mas información!!!.....}$$

Si se considera  $P_0 = P$

$$\text{y } P_1 = 1 - P$$

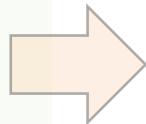
Podemos definir ....

## Entropía:

*Una medida sobre la cantidad de información,  
sobre la incertidumbre del sistema.*

*“La cantidad promedio de información”*

$$H = - \sum p(x) \log p(x)$$



The entropy in the case of two possibilities with probabilities  $p$  and  $q = 1 - p$ , namely

$$H = -(p \log p + q \log q)$$

is plotted in Fig. 7 as a function of  $p$ .

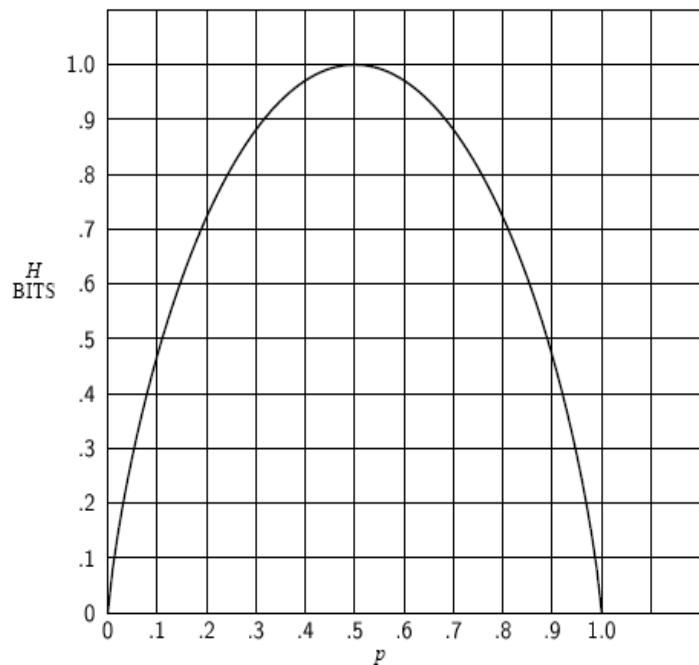


Fig. 7—Entropy in the case of two possibilities with probabilities  $p$  and  $(1 - p)$ .





- Si se observa el ejemplo anterior , se concluye que la máxima entropía es cuando el cero y el uno tiene la misma probabilidad:

$$H_{\max} = 1 \text{ bit/pulso}$$

- Si existiera una **señal cuaternaria** ( cuatro niveles de señal), las probabilidades son :

$$P_0 = P_1 = P_2 = P_3 = 1/4 \text{ entonces } \dots I = \log_2 1/P = \log 4 = 2$$

$$H_{\max} = 2 \text{ bits/ pulso} ; \text{ por lo tanto,}$$

- Se define una velocidad de información (cantidad de información que se transmite en un seg )

$$R = \{\text{bits/seg.}\}$$

$$R = r.H \leq r.H_{\max} = r.\log_2 \mu \quad \text{Donde } \mu \text{ representa la distintas posibilidades de señal}$$

$$R_{\max} = r_{\max}.H_{\max} = 2 s.\log_2 \mu \quad S \text{ representa al ancho de banda}$$

*Velocidad de Nyquist*

$$C = 2 Bw \log n$$

[ bps] canal sin ruido



Canal de comunicación:

$$C = 2 Bw \log_2 n$$

[ bps] canal sin ruido

Hertz  
Propiedad  
Del canal físico

Combinaciones  
"capacidad del T/R"

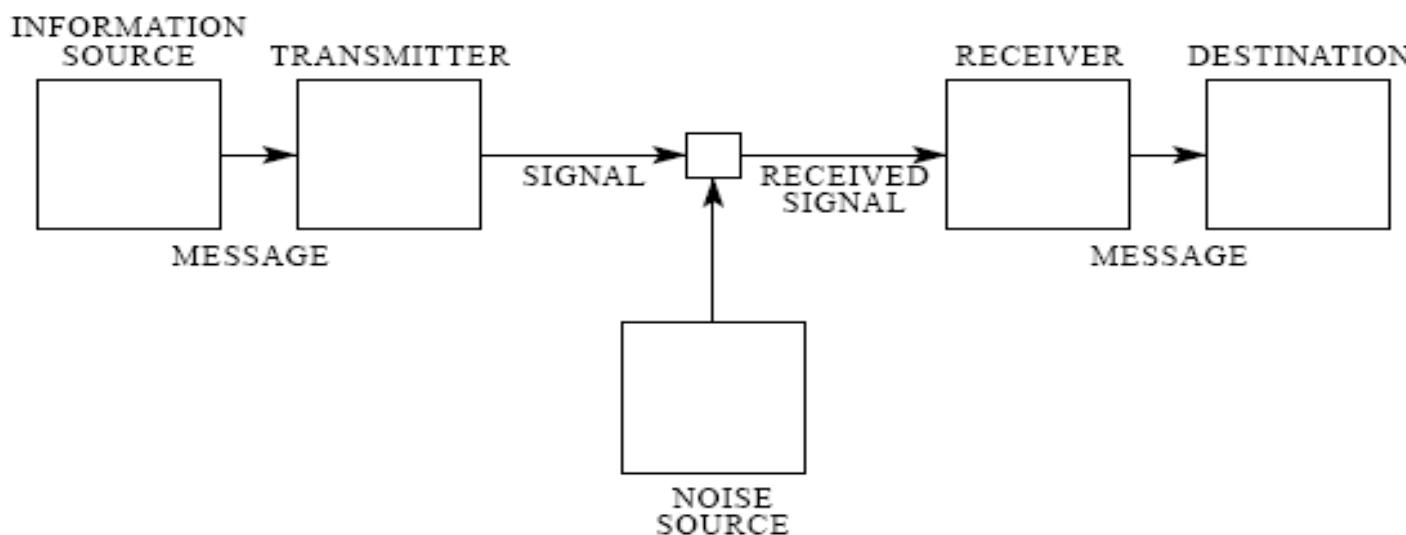
**n = ∞ ?**

**Shannon estableció matemáticamente!! un límite:**

$$C = Bw \log_2 (1 + S/R)$$

[ bps] canal con ruido

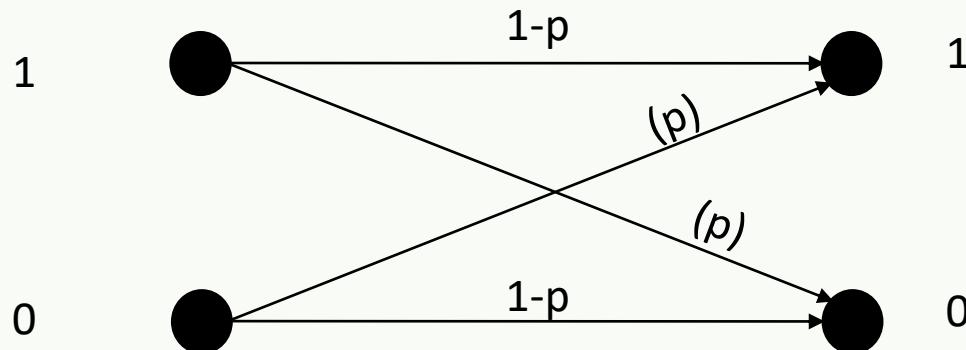
Dependiente del medio físico





## Capacidad de un canal en presencia de ruido

En un canal binario simétrico



**Entropía de dos variables (Joint entropy)**

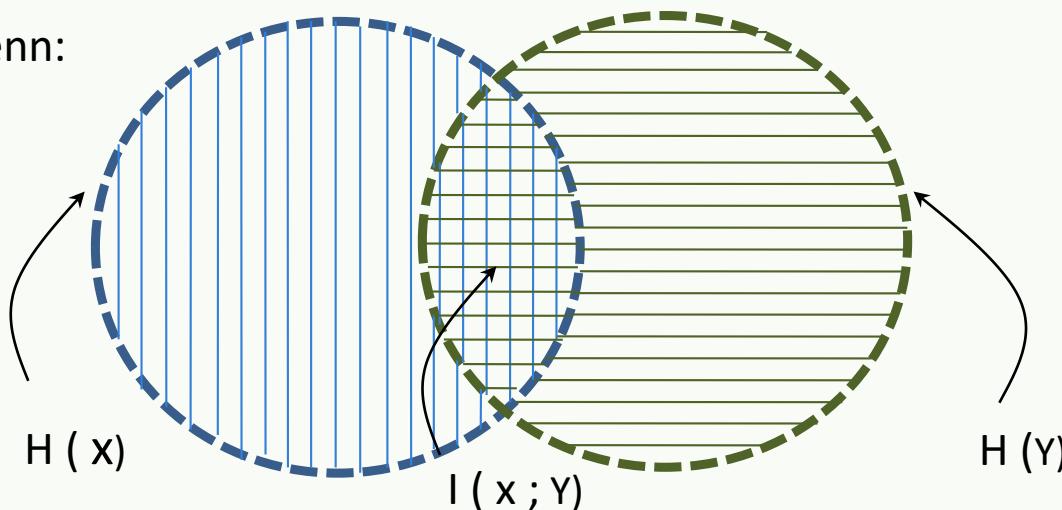
$$H(X,Y) = -\sum p(x,y) \log (x,y)$$

**Información mutua (Mutual information)**

$$I(X:Y) = -\sum p(x,y) \log \frac{p(x,y)}{p(x)p(y)}$$



El diagrama de Venn:



E. Shannon en 1948 formuló la máxima capacidad del canal , tomando el ruido en el canal como ruido de naturaleza térmica, el cual responde a una distribución Normal.

$$C = \text{Max } I(X:Y)$$

Es decir :

$$C = \max H(Y) - H(Y|X)$$

Si representamos el ruido como : ( Distribución Normal)

$$p(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left(\frac{(x-\mu)^2}{2\sigma^2}\right)}$$



$$H = - \sum p(x) \log p(x)$$

Reemplazando .....

$$H(x) = \log \sqrt{2\pi e} \sigma$$

$$H(y) = W \log 2\pi e (P + N)$$

Donde  $P$  es la potencia de la señal  
 $N$  es la pot. del ruido  
 $W$ : el ancho de banda

$$H(n) = W \log 2\pi e N$$

$$C = H(y) - H(n) = W \log \frac{(P + N)}{N}$$



## RESUMEN:

Canal de comunicación:

$$C = 2 Bw \log_2 n$$



Hertz

Propiedad  
Del canal físico



Combinaciones

"capacidad del T/R"

[ bps]

canal sin ruido

(Shannon)

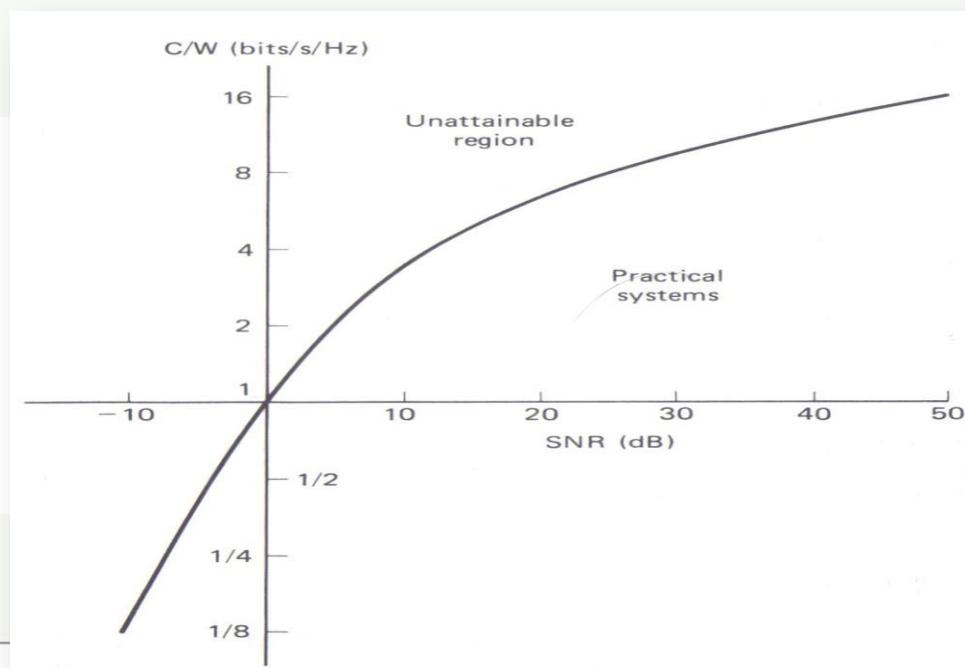
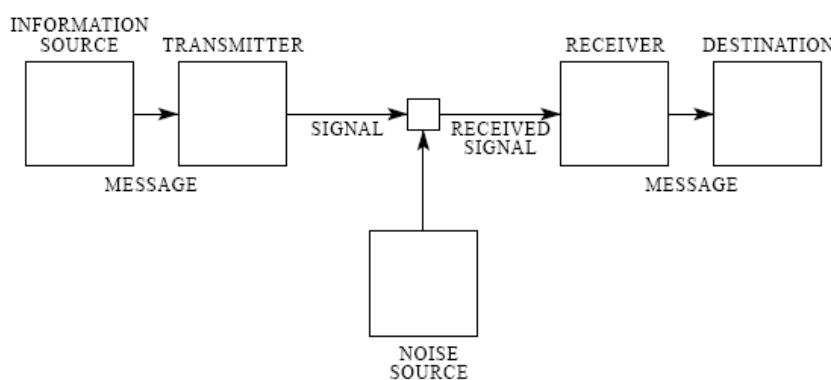
$$C = Bw \log_2 (1 + S/R)$$



Medio físico

[ bps]

canal con ruido





## Aplicaciones de la Teoría de la información .....

### 2.2. CÁLCULO Y APLICACIÓN DE LA ENTROPIA CONDICIONAL

En la Teoría de la Información, la entropía hace referencia a la información media que contiene una variable aleatoria X. Ésta se determina como la información media del conjunto de valores discretos que puede adoptar. Una baja entropía se produce cuando existen repeticiones periódicas de un determinado patrón de señal y una alta entropía se produce cuando existen repeticiones dinámicas aperiódicas.

En este proyecto se utiliza la entropía condicional para evaluar los acoplamientos no lineales entre series temporales de EEG durante la terapia con fármacos ansiolíticos, en concreto con el fármaco alprazolam.

La Entropía Condicional mide cuánta entropía residual tiene una variable aleatoria Y cuando conocemos completamente una variable aleatoria X. Se define la Entropía Condicional de Y dada X como:

$$H(Y/X) = H(Y, X) - H(X)$$

Ec. 2.1

AC

AT

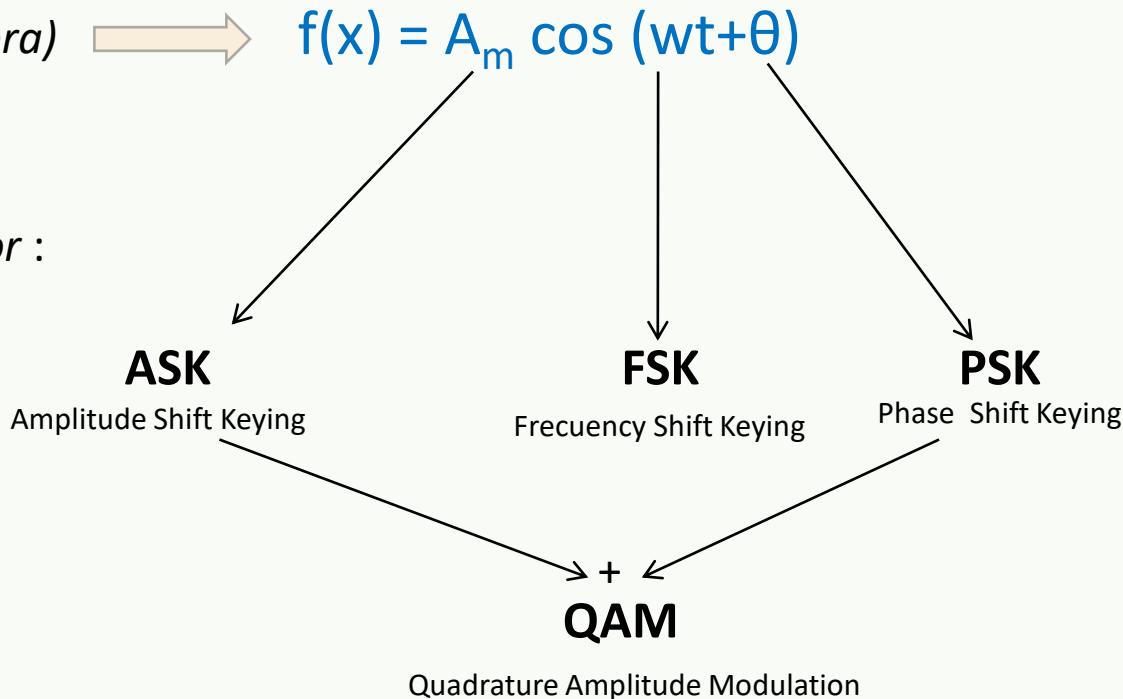
## Modulación Digital :

Carrier (portadora)

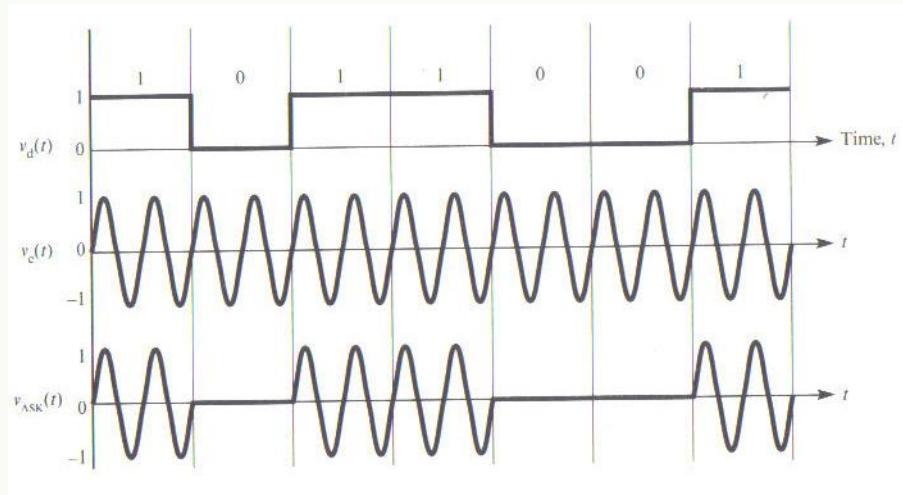
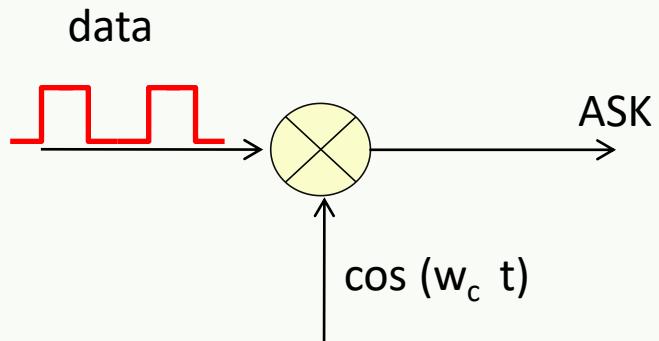


$$f(x) = A_m \cos (wt+\theta)$$

Modulación por :

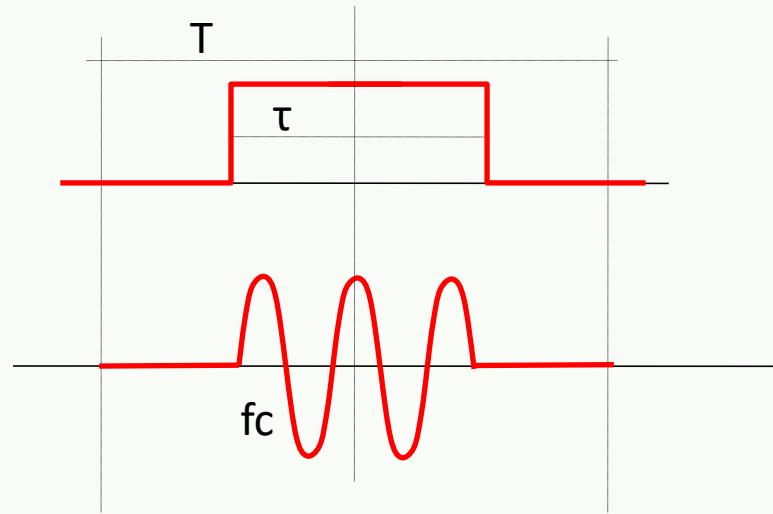


## Amplitude Shift Keying (ASK)

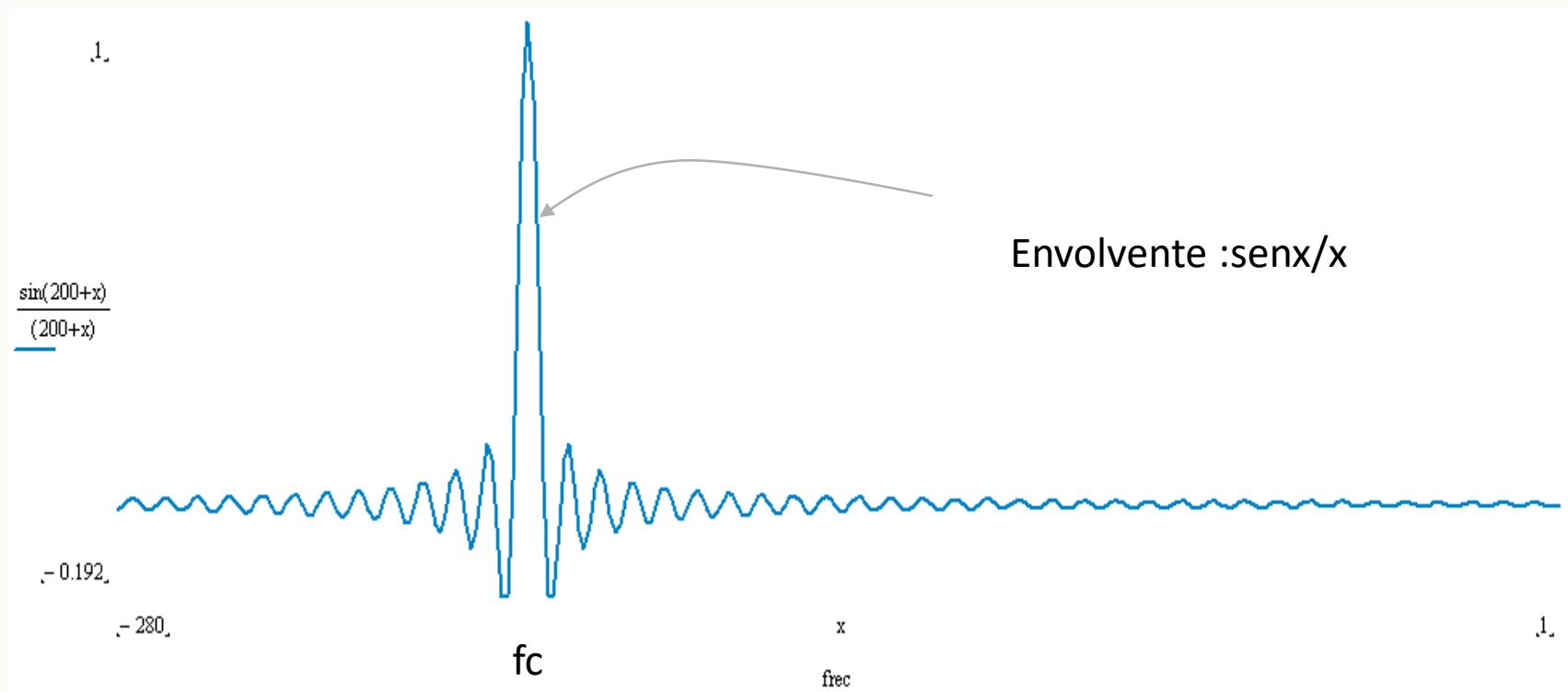


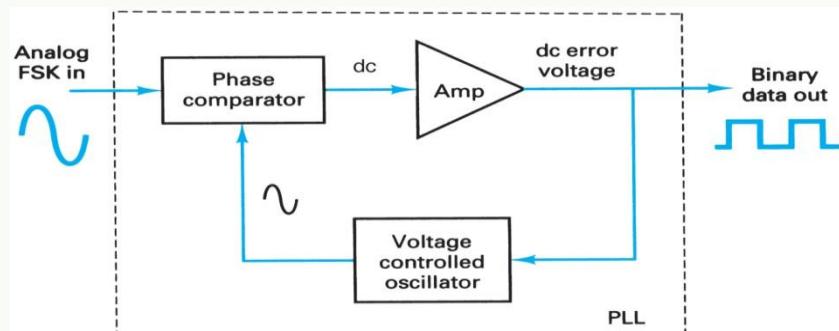
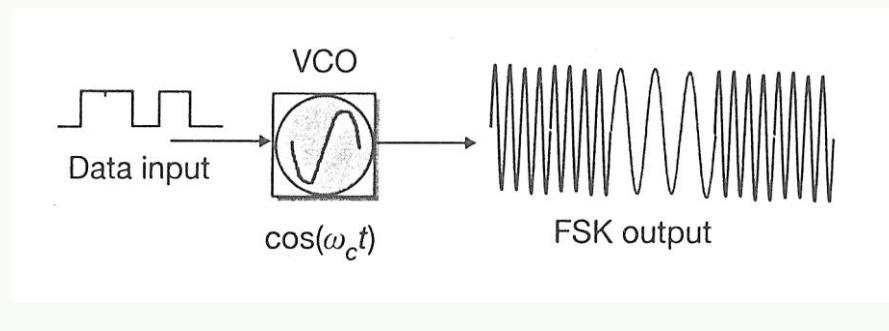
¿Cuál es el espectro de un ASK ?

$$\begin{aligned}
 C_n &= \int_{-T/2}^{T/2} f(t) e^{-jw_n t} dt \\
 &= \int_{-T/2}^{T/2} Am \cos(w_c t) e^{-jw_n t} dt \\
 &= \int_{-T/2}^{T/2} Am \frac{(e^{jw_c t} - e^{-jw_c t})}{2} e^{jw_n t} dt
 \end{aligned}$$



$$= Am \frac{e^{j(w_c-w_n)t} - e^{j(w_c+w_n)t}}{2} \Big|_{-\tau/2}^{\tau/2} = Am \left[ \frac{\sin(w-w_c)\tau/2}{(w-w_c)\tau/2} - \frac{\sin(w+w_c)\tau/2}{(w+w_c)\tau/2} \right]$$





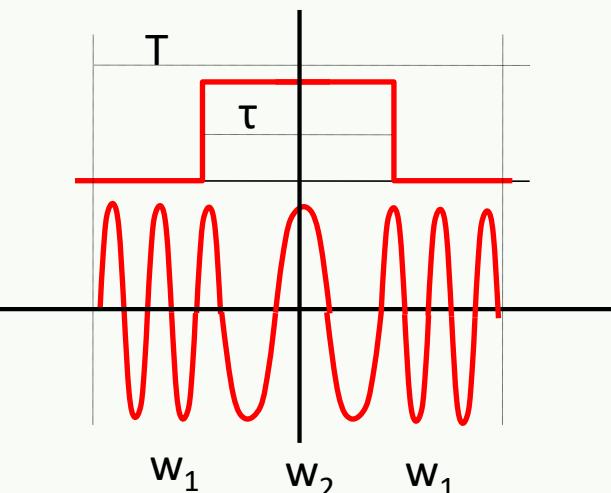
*Espectro de una modulación FSK...*

*A los efectos de nuestro análisis consideramos una superposición de 2 ASK...*

$$C_n = \int_{-T/2}^{T/2} f(t) e^{-jw_n t} dt = \int_{-T/2}^{T/2} Am \cos(w_c t + \Delta w) e^{-jw_n t} dt =$$

$$C_n = \int_{-T/2}^{T/2} f(t) e^{-jw_n t} dt = \int_{-T/2}^{T/2} Am \cos(w_c t - \Delta w) e^{-jw_n t} dt =$$

$$C_n = \int_{-T/2}^{T/2} Am \cos(w_1 t) e^{-jw_n t} dt + \int_{-T/2}^{T/2} Am \cos(w_2 t) e^{-jw_n t} dt =$$

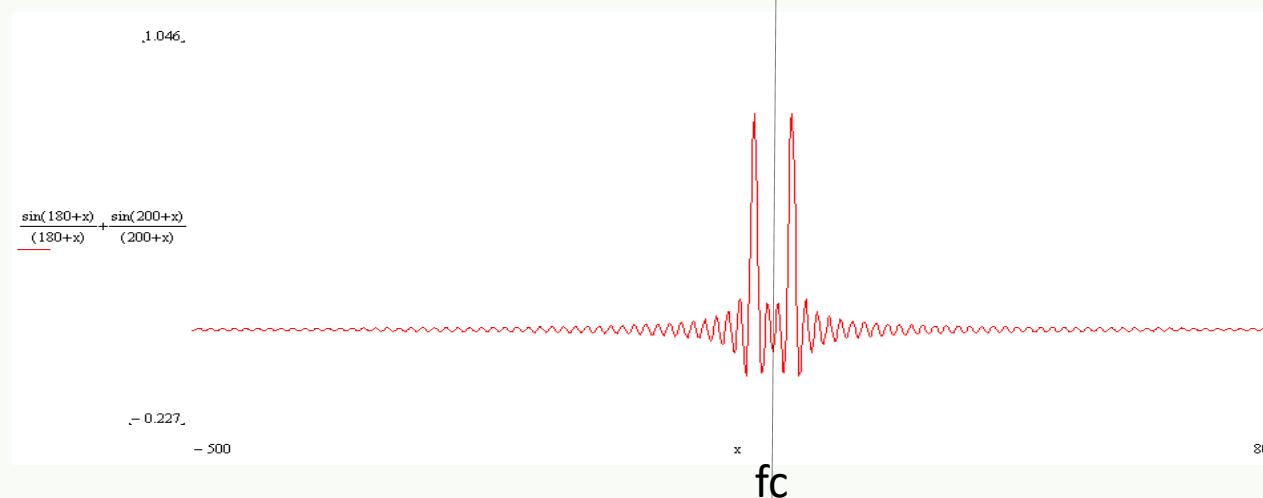
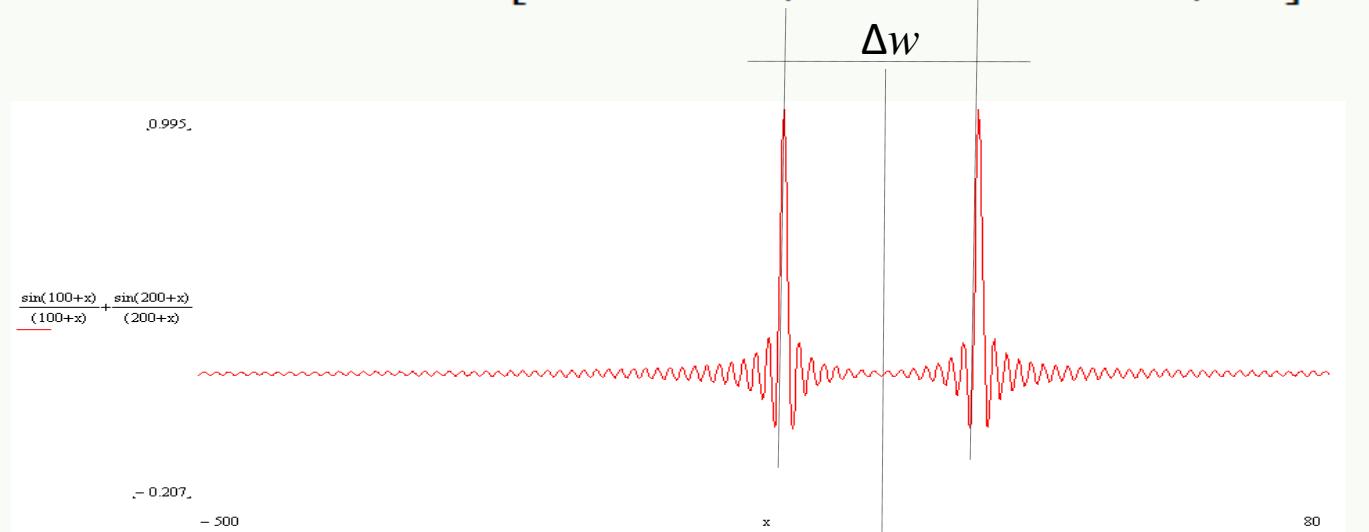


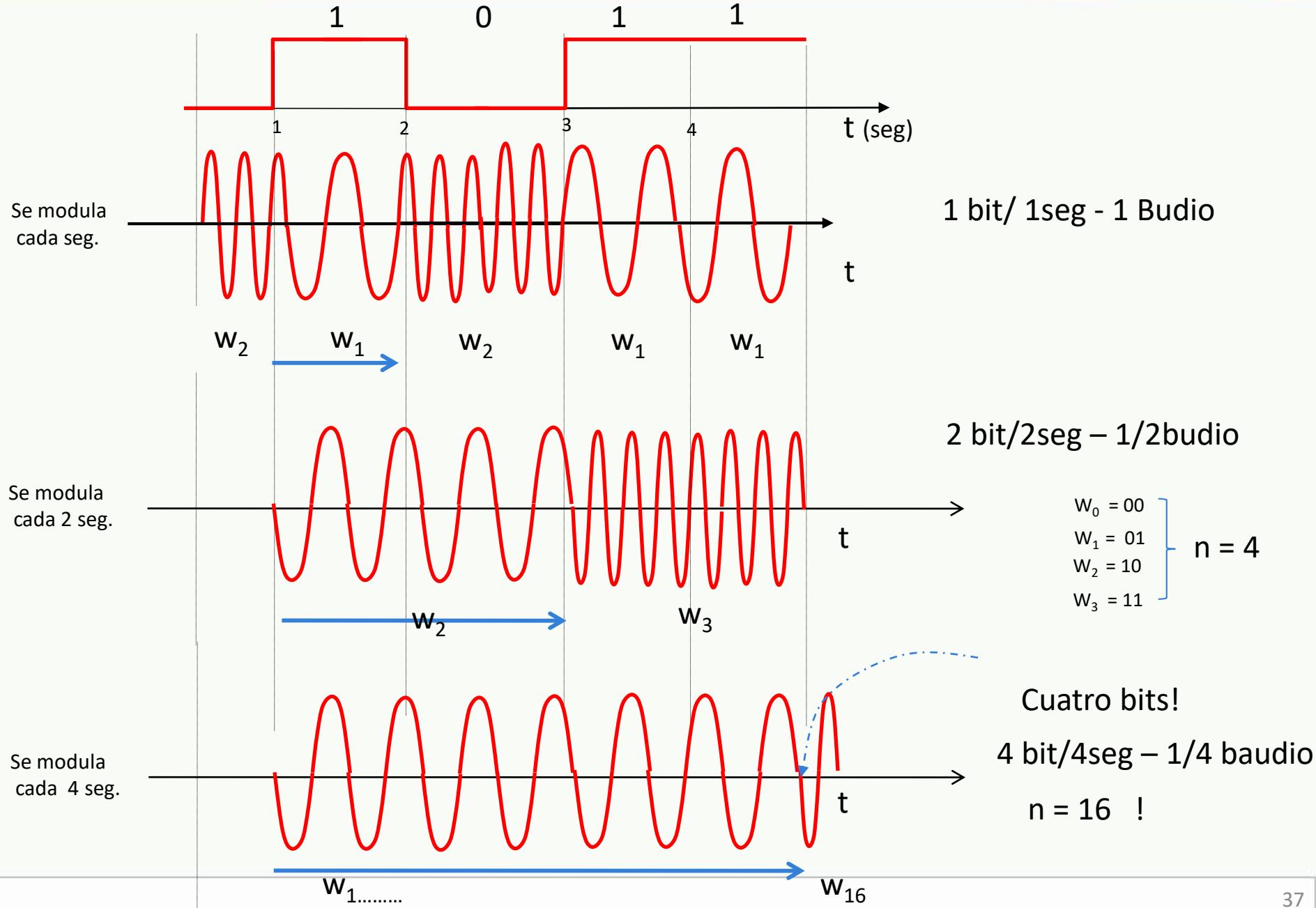


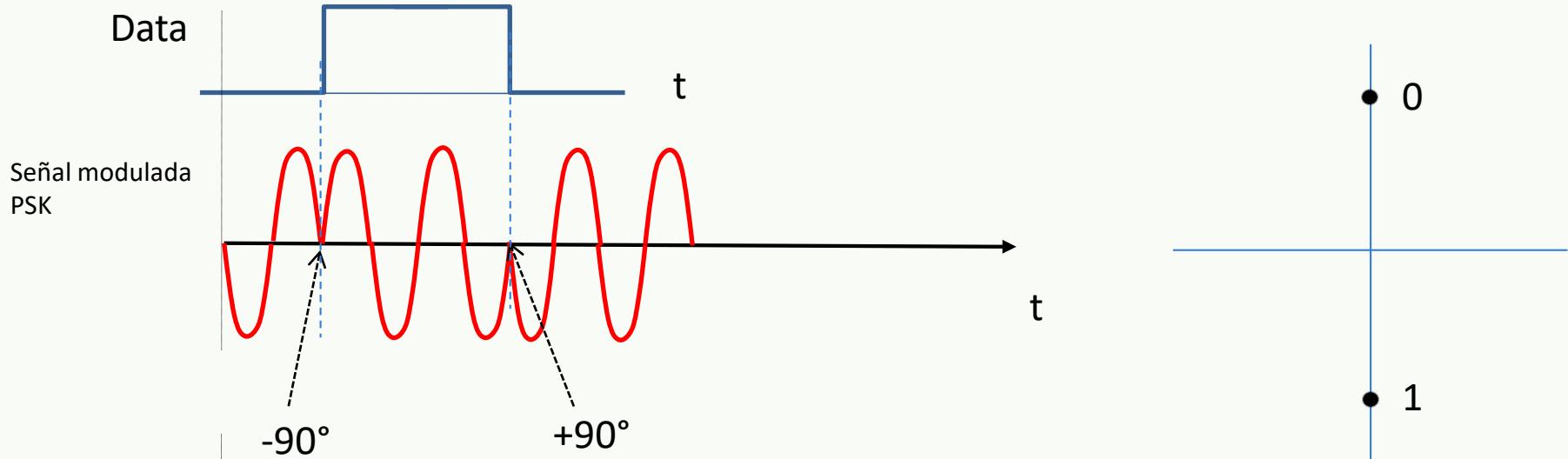
# Frecuency Shift Keying (FSK)

Simplificando...

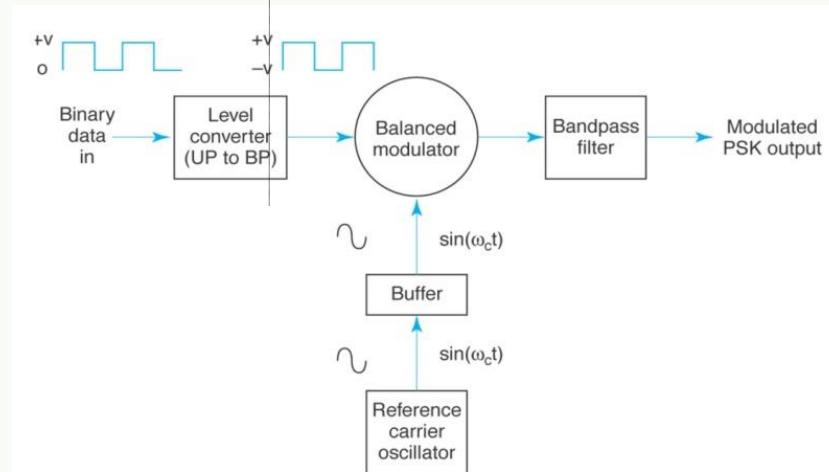
$$= Am \left[ \frac{\sin(w + w_1) \tau/2}{(w + w_1)\tau/2} - \frac{\sin(w + w_2) \tau/2}{(w + w_2)\tau/2} \right]$$



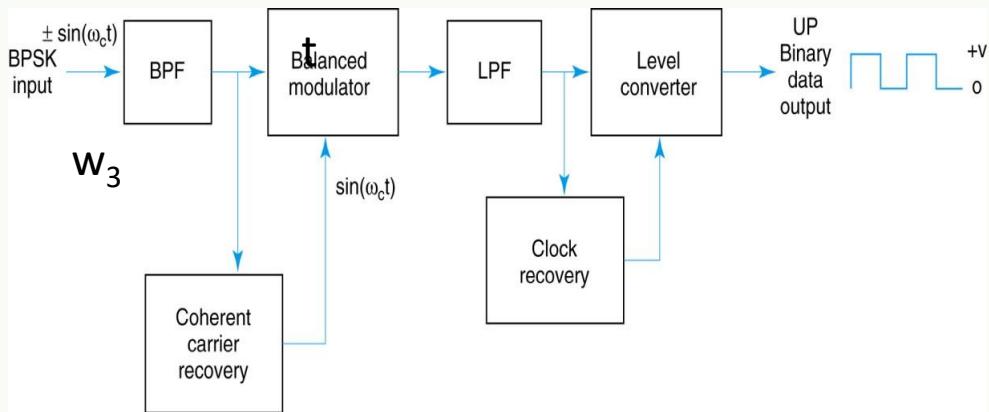




## Modulador

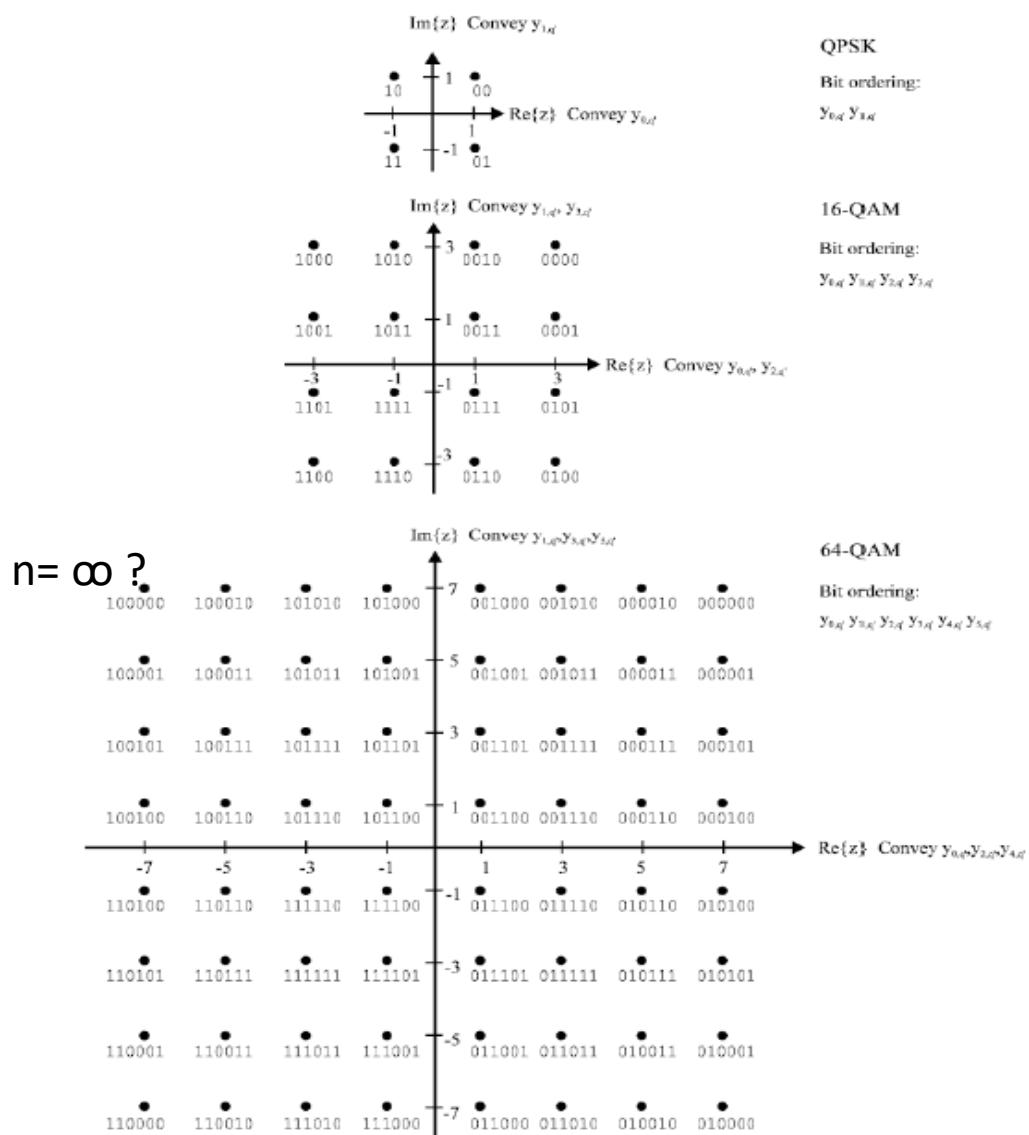


## Demodulador



# Quadrature Amplitude Modulation

## Quadrature Amplitude Modulation (QAM)



$$C = 2 Bw \log_2 n$$

$$C = Bw \log_2 (1 + S/R)$$

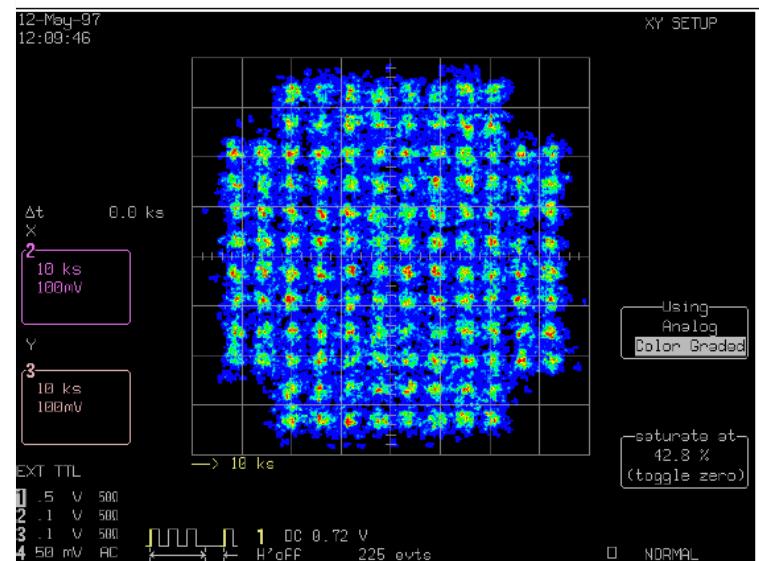
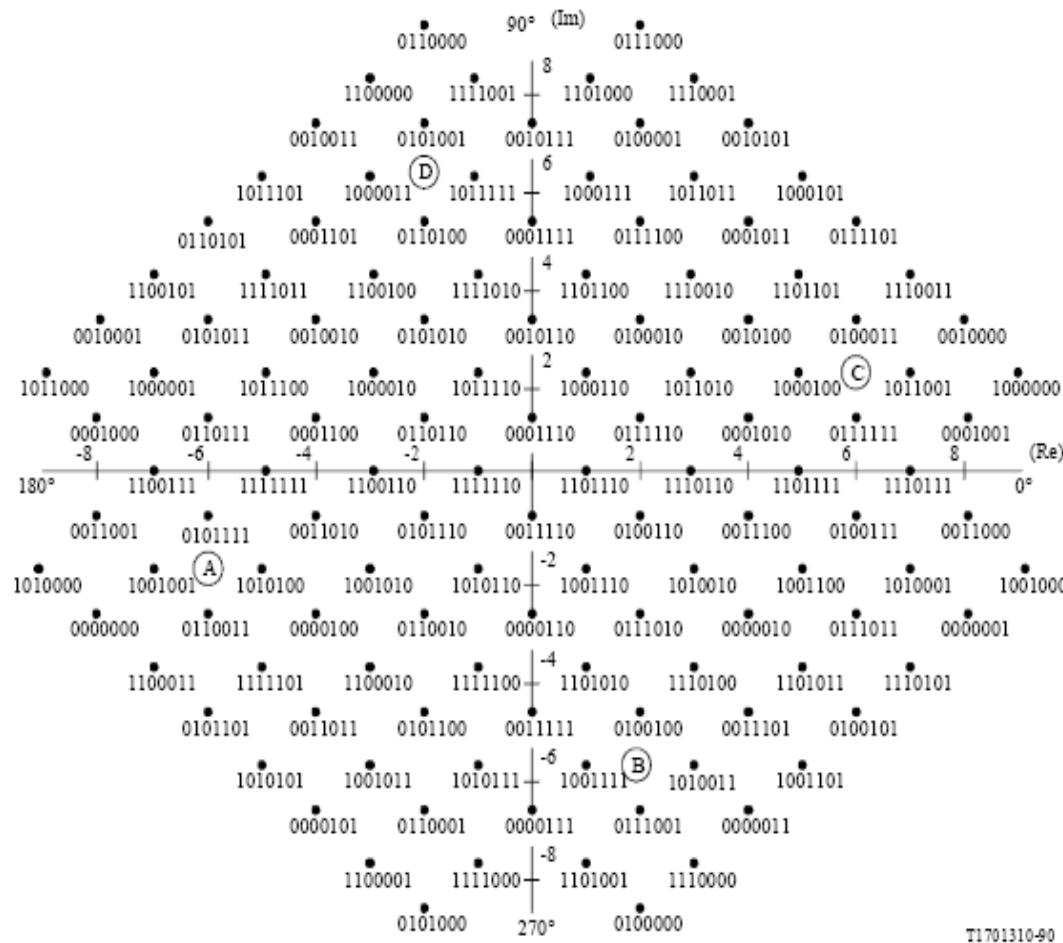


Figure 5 - Color graded persistence display of a 128 QAM constellation diagram

## Ejemplo de QAM (Quadrature Amplitude Modulation)

# **MODEM V.32bis**



*Nota* – Los números binarios se refieren a Y<sub>0</sub> , Y<sub>1</sub> , Y<sub>2</sub> , Q<sub>3</sub> , Q<sub>4</sub> , Q<sub>5</sub> , Q<sub>6</sub> . A, B, C, D se refieren a elementos de la señal de sincronización.

FIGURA 2-1/V.32bis



## Modem Telefónicos : evolución de la modulación en ellos

### MODEM Banda vocal – Recomendaciones ITU

CARACTERISTICA	V.19	V.20	V.21	V.22	V.23	V.26	V.26 bis	V.27	V.27 bis	V.27 ter	V.29	V.36
Velocidad de trans: bits/s	≤10	<240	≤300	≤600/1.200	≤600/1.200	2.400	1.200/2.400	4.800	2.400/4.800	2.400/4.800	9.600	48.000
Tipo de transmisión	Paralelo.	Asín./paral.	Asíncr.	Sínc./asínc.	Sínc/asínc.					Síncrona		
Modo de explotación	S.D.	S.D.	SD o DI	DI	S/línea	SD o DI	SD	SD o DI	s/línea	SD	SD o DI	DI
Tipos de línea utilizables	R.T.C.	R.T.C.	R.T.C. P.P.2H	R.T.C. P.P.2H	R.T.C. P.P.2/4H	P.P.4H	R.T.C. P.P.2H	P.P.4H	P.P.2H P.P.4H	R.T.C.	P.P.4H	Grupo 1. 60-108 kHz
Calidad mínima de línea	N	—	N	N	N	E	N	E	N/E	—	E	
Canal auxiliar a 75 b/s	—	—	—	—	—	opcional	—	—	—	—	—	—
Interfaces con ETD	V.24/V.28	V.24/V.31	—	—	—	V.24 y V.28	—	—	—	—	V.24 V.10 y V.11	
Origen señal síncr. en Trans.	—	—	—	ETD/ETCD	ETCD	—	—	ETD o ETCD	—	—	—	—
Tipo de modulación	Multifrec.	Multifrec.	FSK	DPSK 2/4	FSK	DPSK-4	DPSK 2/4	DPSK-8	DPSK 4.8	DPSK 4/8	DPSK-ASK	ASK-BLU
Frecuencias portadoras: Hz	2 de 8	920+80n	1.080/1.750	1.200/2.400	1.500/1.700	—	—	1.800	—	1.700	—	100 kHz
Frecuencia canal auxiliar: Hz	—	—	—	—	—	420	—	—	—	—	—	—
Igualador de aten. y fase	—	—	—	fijo Trans/-Rec.	—	—	—	fijo	manual	autom.	autom.	—
Seudoselectorizador	—	—	—	$1+x^{-14}+x^{-17}$	—	—	—	—	$1+x^{-6}+x^{-7}$	$1+x^{-18}+x^{-23}$	Complejo.	
N.º de bits por baudio	—	≤6	1	1/2	1	2	1/2	3	2/3	2/3	4	—
Velocidad de modulación: bd	≤10	≤40	≤300	600	≤600/1.200	1.200	1.200	1.600	1.200/1.600	1.200/1.600	2.400	—
Variaciones de frecuencia o de fase por estado	—	2 de 8 o 3 de 12	$f_0 \pm 100$	$+90^\circ + 270^\circ$ $90^\circ \times n$	$f_0 \pm 200$ $f_0 \pm 400$	A:n.90° o B:45°+n.90°	$+90^\circ$ $+270^\circ$ B (n = 0...7)	n.45° V.26/V.27 (n = 0...7)	V.26/V.27	V.26/V.27	n.45° (n = 0...7)	
Amplitudes relativas	—	—	—	—	—	—	—	—	—	—	3.5, 2.3, 2	
Sensibilidad en recep.	—45 dBm	—49 dBm	—43	—43	—43	—26	—43	—26	—26/-43	—43	—26	—

Tabla 4.6 Modems normalizados. Resumen de características.

## Comunicación simple



## Comunicación half dúplex



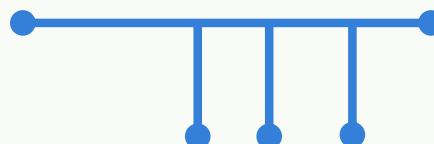
## Comunicación full dúplex



## Comunicación punto a punto.

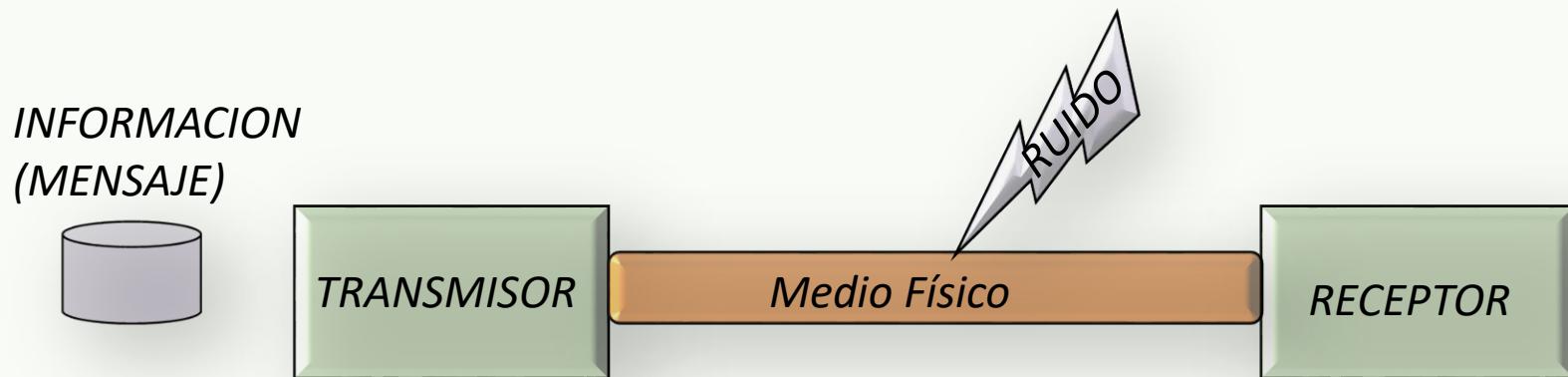


## Comunicación multipunto .





## Que característica del medio físico interesa en las telecomunicaciones ?



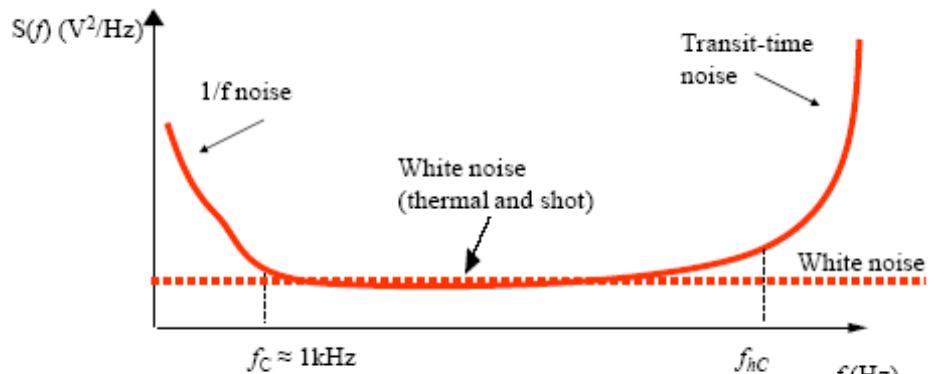
Depende de ...

1. Que cantidad de información queremos trasmisitir en un determinado tiempo.
2. Como queremos que llegue la información.
3. Retardo en llegar al receptor.

*¿Que relación hay entre la cantidad de información y las características del medio físico ?*

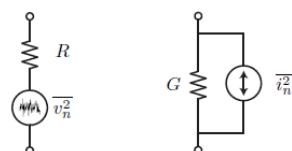
- Térmico (Johnson or white noise.)
- Galáctico /Atmosférico
- De Granalla :
- Shot : (quantum noise, Schottky noise)
- Impulsivo (popcorn, Burst noise) :
- Fliker (pink noise; 1/fnoise. )
- Diafonía:
- Eco :
- Cuantización :
- Distorsión armónica

Internal noise – spectral density



Legend:  $f_C$  – critical frequency ( $\approx 1\text{kHz}$ ),  $f_{hC}$  - high-frequency cutoff (device specific)

## Thermal Noise of a Resistor



- All resistors generate noise. The noise power generated by a resistor  $R$  can be represented by a series voltage source with mean square value  $\overline{v_n^2}$

$$\overline{v_n^2} = 4kTRB$$

- Equivalently, we can represent this with a current source in shunt

$$\overline{i_n^2} = 4kTGB$$

- Here  $B$  is the bandwidth of observation and  $kT$  is Boltzmann's constant times the temperature of observation

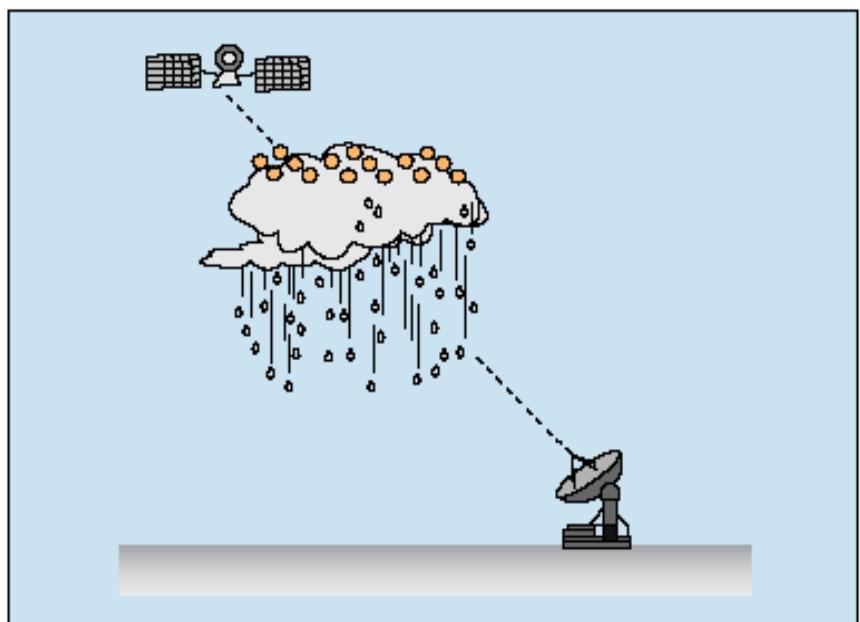
## Diode Shot Noise

- A forward biased diode exhibits noise called *shot noise*. This noise arises due to the quantized nature of charge.
- The noise mean square current is given by

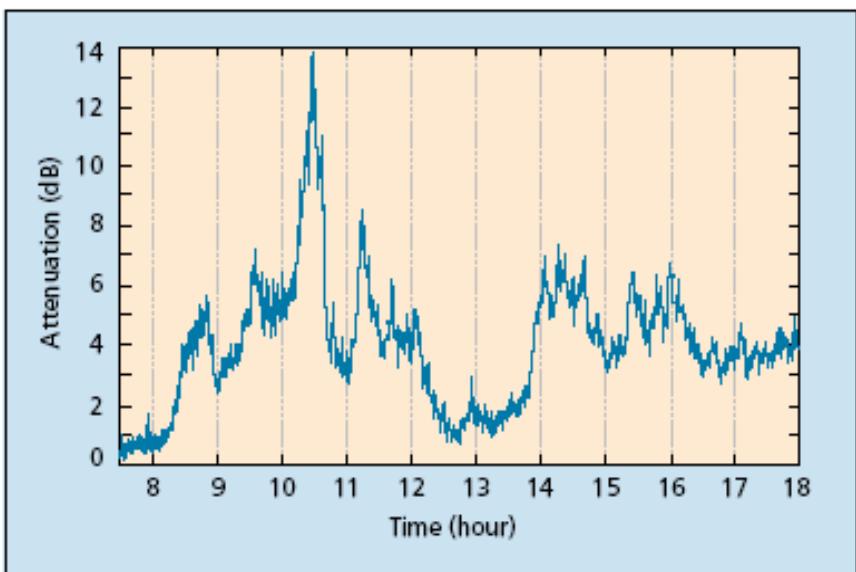
$$\overline{i_{d,n}^2} = 2qI_{DC}B$$

IEEE Communications

Third Quarter 2004



■ FIGURE 1. A satellite slant path affected by propagation impairments.



■ FIGURE 2. Typical picture of attenuation fluctuations due to rain and scintillations.

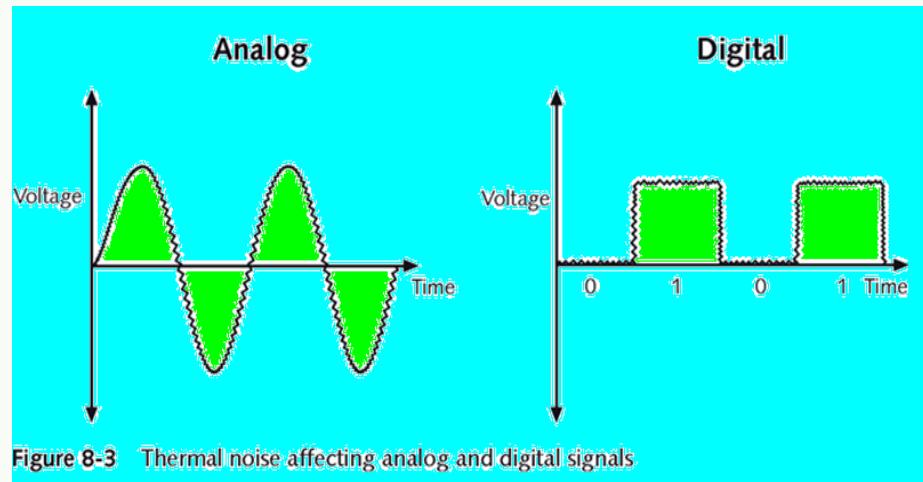


Figure 8-3 Thermal noise affecting analog and digital signals

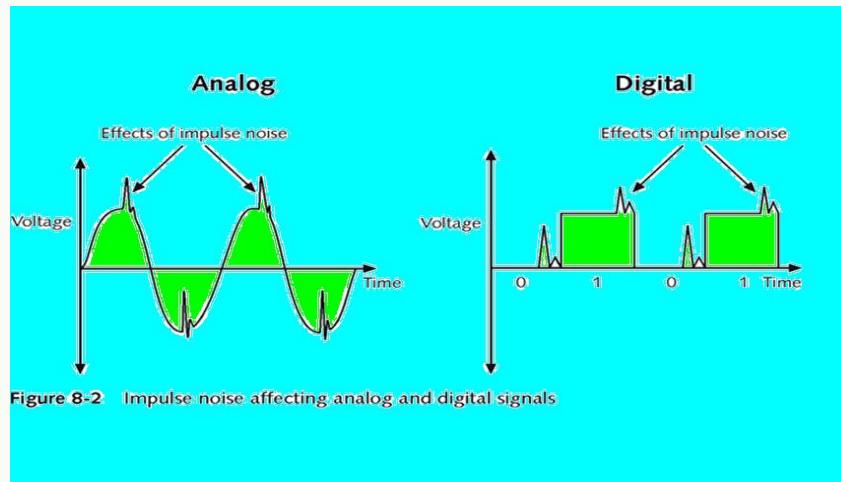
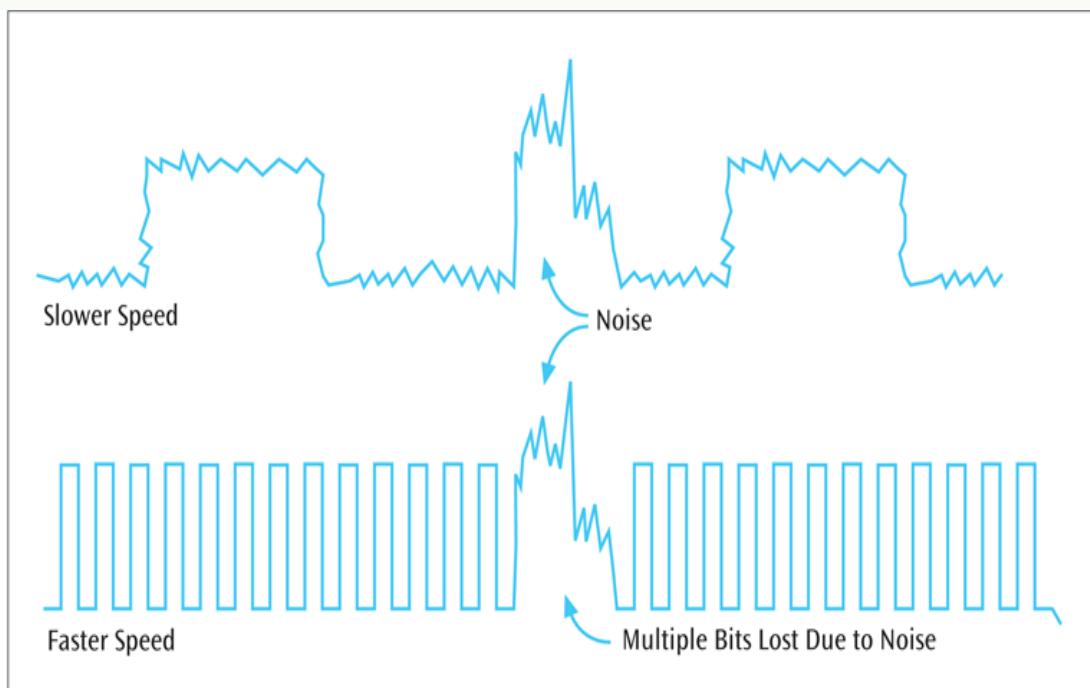


Figure 8-2 Impulse noise affecting analog and digital signals

1μs de ruido impulsivo, afecta :

\* 2 bits cuando la velocidad de los datos es 1Mbps.

\* 101 bits cuando la velocidad de los datos 100Mbps





# Estructura de las comunicaciones

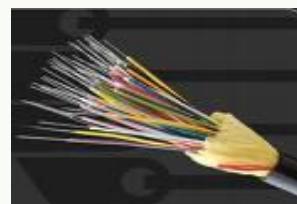
Cable de Cobre  
“Cable Telefónico”



Cable coaxial



Cable de fibra óptica



Radios enlaces



¿Que particularidades interesa en las telecomunicaciones de estos medios físicos ?



## Introducción medios físicos de comunicación

### FAQ

¿Que capacidad de transmitir información tiene un medio físico ?

¿De que depende ?.

¿Que parámetros intervienen en el ancho de banda ?

¿Dado un medio físico , se puede transmitir mas información , como ?.

¿Cuáles son las limitaciones que se tiene para aumentar la velocidad?

¿Cuál es el mejor medio físico para las comunicaciones ?

$$C = Bw \log_2 (1 + S/R)$$



## Teoría

Cable de cobre • **Modelo de constante distribuidas**

## Tecnología

UTP  
STP  
FTP

Fibra óptica

- **Estudio desde la óptica (haz de luz)** Monomodo
- **Estudio como transmisión electromagnética (guía de onda)** Multimodo
- OS ; Plástico

Radio enlaces

<u>Clasificación</u>	<u>Transmisión</u>	<u>Material</u>	<u>Construcción</u>	<u>Tipo</u>	<u>Estandar / propietario</u>
<b>Medios guiados</b>	<b>Eléctrica</b>	Cobre	Par trenzado	UTP FTP STP	Cat 3; 4; 5; 6; 7; 8
	<b>Electromagnética <i>(Guía de onda)</i></b>	OS / OS Plástico /OS Plástico /Plástico	Coaxial Multimodo Monomodo Gradual	Monoaxial Biaxial 62.5/125-micron 50/125-micron Estándar Bajo pico de agua Con desplazamiento	OM1 OM2 OM3 OM4 OM5
<b>Medios no guiados</b>	<b>Electromagnética</b>	Aire	Frecuencia Licencia	Onda larga Onda corta Con licencia Sin Licencia	
					50

## Parámetros:

## unidad

Atenuación db/m ; db/km

Potencia de transmisión dbm (en referencia a 1 mW) : 0 dbm =1 mW.

Distorsión Armónica , de fase. retardo

Imperfecciones Típicas del medio:

Tipos de ruido/  
Susceptibilidad al ruido S/R(db) ruido blanco, fliker,  
Impulsiyo.

Velocidad de propagación m/s ; km/s; % C

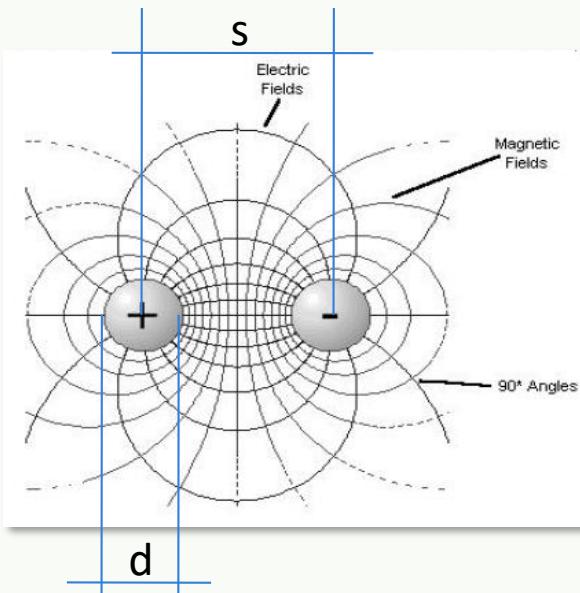
## Ancho de banda

## **Hertz, KHz, MHz , GHz**

## Par trenzado

**AC**

¿De que depende el ancho de banda utilizable en un cable de cobre ?



**Resistencia de un conductor :**

$$R = \frac{\rho \cdot L}{A}$$

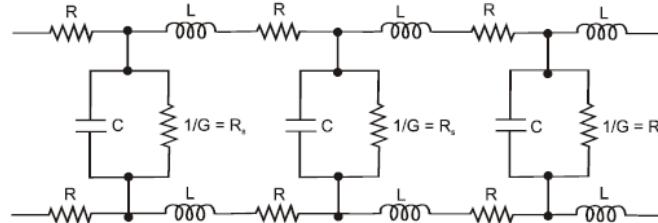
$$R = R_{20} (1 + \alpha (\theta - 20^\circ C)) \quad [\text{con respecto a la temp}]$$

**Characteristic impedance of twisted pair ( $\Omega$ ):**

$$Z_{TWIST}(d, s, \epsilon_r) := \frac{120}{\sqrt{\epsilon_r}} \cdot \ln\left(\frac{2 \cdot s}{d}\right)$$

**Modelo de constantes distribuidas.**

Líneas de transmisión de dos cables paralelos, circuito equivalente eléctrico



C) =) capacitancia - dos conductores separados por un aislante)

R) =) resistencia - oposición al flujo de corriente)

L) =) autoinductancia (inductancia propia)

1/G =) resistencia de dispersión del dieléctrico)

R\_s) =) resistencia de dispersión en derivación)

$\rho$  = Resistividad eléctrica

$\Theta$  = temperatura de conductor.

**A = Área del conductor.**

**L = Longitud conductor**

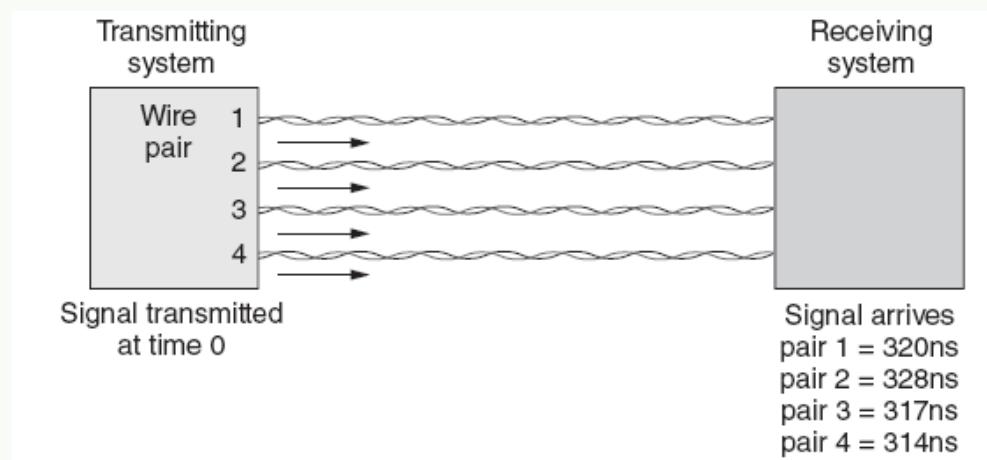
$\alpha$  = Coeficiente de temp. de resistencia

$\epsilon_r$  = Constante dieléctrica del aislante

**Propagation delay per in. twisted pair (s/in.):**



- Interferencia electromagnética :
  - ruido externo ,
  - propia de los cables multipares: (*Cross-talk*) diafonía).
- Propagation Delay :
- Delay Skew





## Efectos no deseados en cables de cobre ..

Diafonía .. (*cross talk*)

- Es la interferencia de un par sobre otro-
- Depende de la frecuencia
- Se produce en el extremo cercano y en el extremo lejano
- (*near end cross talk, NEXT* y *Far end cross talk ,FEXT*)

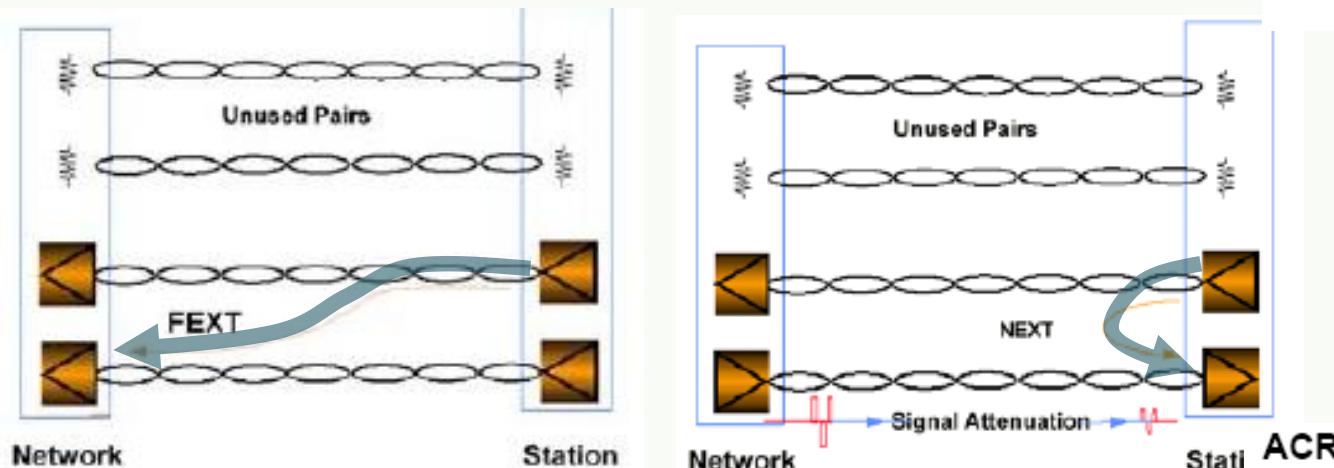
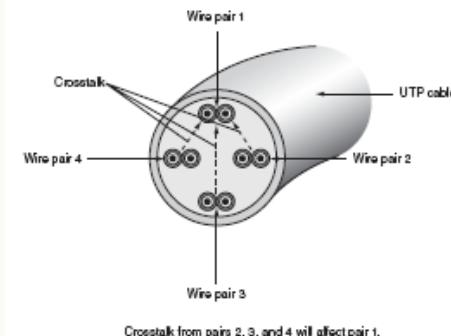
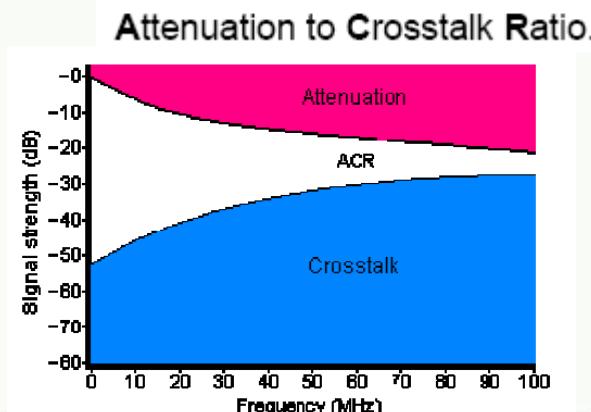
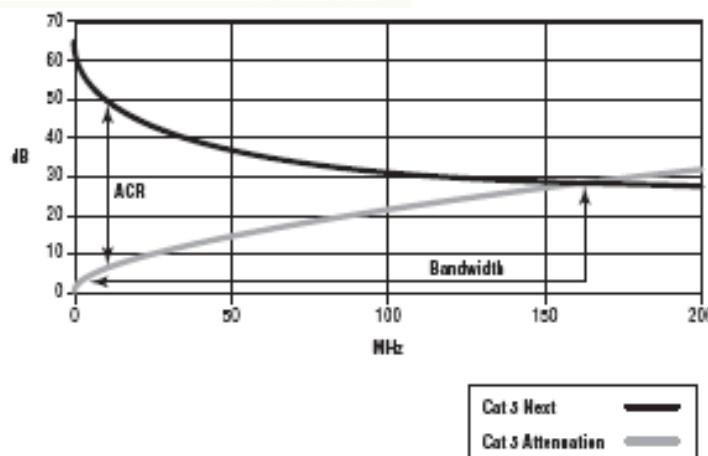


FIGURE 1.17  
Attenuation-to-  
crosstalk ratio for a  
Category 5e chan-  
nel link



## Tipos de cables de cobre



UTP

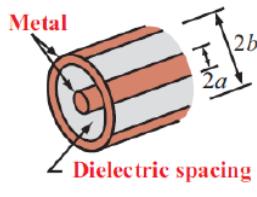
STP

FTP

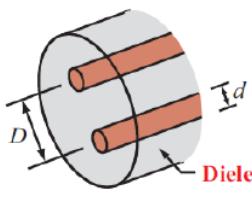
cinta

Shielded twisted-pair (STP ) will be called U/FTP .

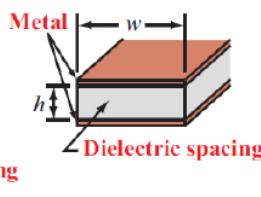
Screened twisted-pair (ScTP or FTP ) will be called F/UTP .  
foil twisted-pair (FTP)



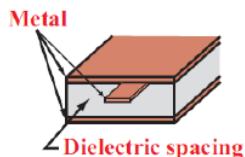
(a) Coaxial line



(b) Two-wire line



(c) Parallel-plate line



(d) Strip line

## Velocity of Propagation

MATERIAL	RELATIVE PERMITTIVITY, $\epsilon_r$	VELOCITY FACTOR, $v_r$ (%)
Vacuum	1.00000	100
Air	1.0006	99.97
Teflon	2.10	69.0
Polyethylene	2.27	66.4
Polystyrene	2.50	63.2
Polyvinyl chloride (PVC)	3.30	55.0
Nylon	4.90	45.2

Table 1-2. Relative dielectric constant of various materials.

## Consideraciones sobre medidas y entidades

### American Wire Gauge

AWG #	Diameter (mm)	Diameter (inch)
23	0.5733	0.0226
24	0.5106	0.0201
25	0.4547	0.0179
26	0.4049	0.0159

### Entidades de certificaciones

NFPA	The National Fire Protection Association
NEC	The National Electrical Code that is published by the NFPA once every 3 years
UL	The Underwriters Laboratories
CSA	The Canadian Standards Association
PCC	The Premise Communication Cord standards for physical wire tests defined by the CSA

# Cables de cobre

## Categorías

Cat.	Ancho de banda (MHz)	Aplicaciones	Notas
<b>Cat.1</b>	< 0.5 MHz	Líneas telefónicas y módem de banda ancha.	No descrito en las recomendaciones del EIA/TIA. No es adecuado para sistemas modernos.
<b>Cat.2</b>	4CG CANDE	Cable de conexión de antiguos terminales como el IBM 3270	No descrito en las recomendaciones del EIA/TIA. No es adecuado para sistemas modernos.
<b>Cat.3</b>	16 MHz Clase C	10BASE-T y 100BASE-T4 Ethernet	Descrito en la Norma EIA/TIA-568. No es adecuado para transmisión de datos mayor a 16 Mbit/s. Usado en telefonía.
<b>Cat.4</b>	20 MHz	16 Mbit/s Token Ring	No es usado habitualmente.
<b>Cat.5</b>	100 MHz Clase D	10BASE-T y 100BASE-TX Ethernet	Usado en conexiones Ethernet entre dispositivos de red.
<b>Cat.5e</b>	100 MHz Clase D	100BASE-TX y 1000BASE-T Ethernet	Mejora del cable de Categoría 5.
<b>Cat.6</b>	250 MHz Clase E	1000BASE-T Ethernet	Transmite a 1000Mbps.
<b>Cat.6a</b>	250 (500 MHz según otras fuentes) MHz Clase E	10GBASE-T Ethernet	Estándar mejorado probado a 500MHz. Puede extenderse hasta 100 metros. Estandarizado según las normas ISO/IEC 11801, 2 <sup>a</sup> edición (2008) y ANSI/TIA-568-C.1 (2009)
<b>Cat.7</b>	600 MHz Clase F	Para servicios de telefonía, TV por cable y Ethernet 1000BASE-T en el mismo cable.	Cable blindado bajo estándar ISO/IEC 11801, pero no reconocido por EIA/TIA.
<b>Cat.7a</b>	1000 MHz Clase F	Para servicios de telefonía, TV por cable y Ethernet 1000BASE-T en el mismo cable.	Cable S/FTP (pares blindados, cable blindado trenzado) de 4 pares bajo el estándar ISO/IEC 11801, pero no reconocido por EIA/TIA.
<b>Cat.8</b>	1200 MHz	40 GBASE-T Ethernet o 1000BASE-T para servicios de telefonía, TV por cable y Ethernet en el mismo cable.	Cable S/FTP (pares blindados, cable blindado trenzado) de 4 pares. Descrito por las normas ANSI/TIA-568-C.2-1 e ISO/IEC 11801-1:2017.
<b>Cat.9</b>	25000 MHz	Norma en creación por la UE.	Cable S/FTP (pares blindados, cable blindado trenzado) de 8 pares con Mylar y poliamida.
<b>Cat.10</b>	75000 MHz	Norma en creación por la GERA (Relationship Between Companies Anonyma G) e IEEE.	Cable S/FTP (pares blindados, cable blindado trenzado) de 8 pares con Mylar y poliamida).

# Par trenzado

## xDSL Cables



### Distribution



Conductor	Tinned copper 0.4 to 0.9 mm
Insulation	PVC
Cabling	Pair or quad; unit and sub-unit
Size	1 to 400 pairs
Screen	Polyester plated AL tape (if specified)
Sheath	PVC

### Jumper wire



Conductor	Tinned copper 0.4 to 0.9 mm
Insulation	PVC
Size	1 pair or 1 quad
Sheath	PVC (loose tube)

### Subscriber wire



Conductor	Copper 0.4 to 0.9 mm
Insulation	Solid PE
Size	1 pair or 1 quad
Sheath	PVC (loose tube)
Outher Sheath	Low Smoke Zero Halogen

### xDSL screened cables



Nombre del Producto

Fast-Lan Cat. 6 U/UTP 23AWGx4P

Freq. (MHz) Máximo	Atenuação (dB)		NEXT (dB)		PSNEXT (dB)		ACR (dB)	
	TIA/EIA TÍPICO	TIA/EIA MÍNIMO	TIA/EIA TÍPICO	TIA/EIA MÍNIMO	TIA/EIA TÍPICO	TIA/EIA MÍNIMO	TIA/EIA TÍPICO	
1	2,0	1,5	74,3	94,0	72,3	88,3	72,3	88,5
4	3,8	3,2	65,3	86,2	63,3	80,0	61,5	77,1
8	5,3	4,6	60,8	81,9	58,8	75,2	55,4	70,0
10	6,0	5,2	59,3	80,9	57,3	74,1	53,3	68,8
16	7,6	6,7	56,2	76,7	54,2	70,9	48,7	64,0
20	8,5	7,5	54,8	74,5	52,8	69,1	46,3	60,9
25	9,5	8,5	53,3	73,6	51,3	67,7	43,8	59,5
31,25	10,7	9,5	51,9	71,5	49,9	65,4	41,2	57,6
62,5	15,4	13,8	47,4	70,2	45,4	62,7	32,0	48,9
100	19,8	17,8	44,3	66,9	42,3	61,4	24,5	43,9
200	29,0	26,1	39,8	62,4	37,8	56,5	10,8	29,2
250	32,8	29,3	38,3	60,1	36,3	53,2	5,5	23,4
300	32,5	-	57,5		51,6		18,9	
350	35,3	-	55,8		49,5		12,5	
400	38,0	-	53,0		47,6		7,0	
500	42,8	-	52,0		48,5		5,0	
550	45,0	-	50,0		47,5		2,0	
600	47,0	-	48,0		46,1		-2,0	

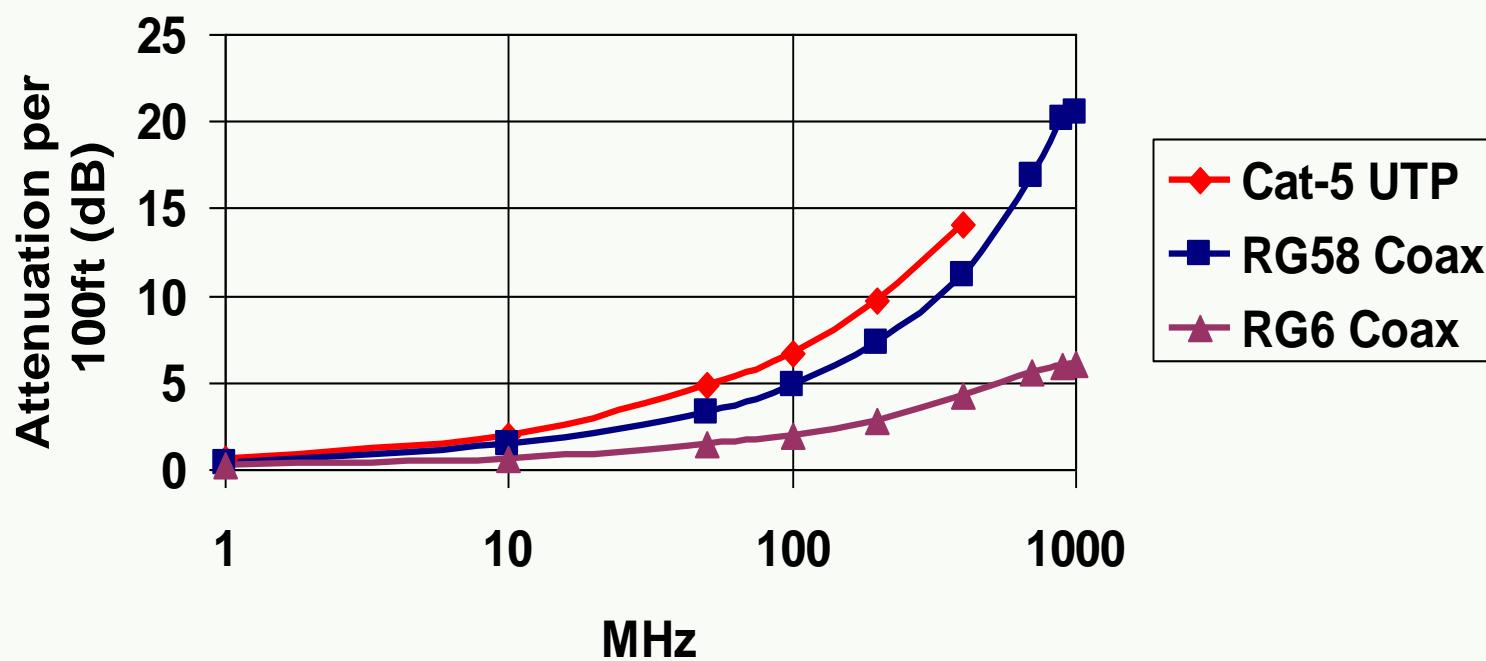
### Desempeño

Desequilibrio Resistivo	5%
Resistencia Eléctrica CC Máxima del Conductor en 20°C	93,8 Ω/km
Capacitancia Mutua Máxima en 1kHz	56 pF/m
Desequilibrio Capacitivo Par x Tierra 1kHz - Máximo	3,3pF/m
Impedância Característica Nom. desde 1MHz hasta 250MHz	100±15% Ω
Retraso de Propagación Máximo	54ns/100m @ 10MHz
Diferencia entre el atraso de propagación entre los pares - 1 a 500 Mhz Máximo	45ns/100m
Prueba de tensión eléctrica entre conductores	2500 VDC/3s
Velocidad de Propagación Nominal	68 %



Sistemas de Cableado Estructurado para transmisión de voz, datos e imágenes, según los requisitos de la norma ANSI/TIA/EIA-568B.2 e ISO/IEC 11.801 y especificaciones técnicas complementares de Furukawa, para cableado horizontal o secundario entre los paneles de distribución (Patch Panel) y los conectores en el sitio de trabajo

## Attenuation per 100ft for UTP/Coax



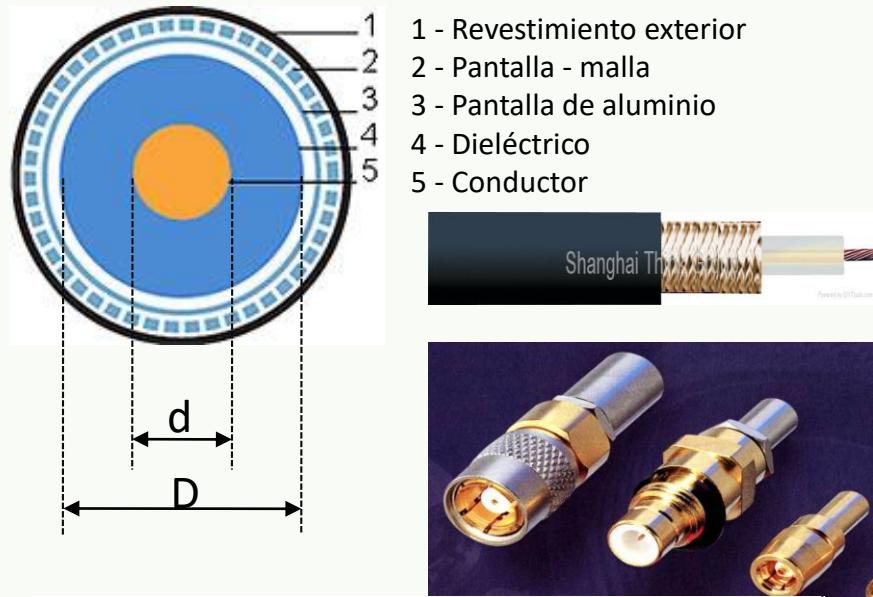


Los cables de comunicación a mediados de siglo pasado, eran en base a ...





# COAXIAL



## CARACTERÍSTICAS ELÉCTRICAS:

- Impedancia Nominal  $50 \pm 3$  Ohms
- Velocidad de Propagación Nominal 80%
- Capacidad pF/m  $52 \pm 3$
- Frecuencia de corte 41 Ghz
- Tensión máxima de resistencia 1000 VDC
- Potencia pico 2.5 KW
- Resistencia DC
- Conductor interno ohms  $7.6/1000' 24.94/\text{km}$
- Conductor Externo ohms  $4.9/1000' 16.08/\text{km}$
- Salto de arco en la vaina 3000VRMS  
Capacidad  $24.3\text{pF /ft}$   $79.7\text{pF/m}$
- Inductancia  $0.064\mu\text{H/ft}$   $0.21\mu\text{H/m}$
- Efectividad del blindaje NESS 90Db
- Estabilidad de fase 10ppm/C

# COAXIAL

**AC**

Symbol	Definition	Units	IMPEDANCE (ohms)	ELECTRICAL LENGTH (degrees)
$f_{co}$	Cutoff frequency	GHz	$Z_0 = 138 V_p \log \left( \frac{D}{d \cdot k_s} \right) = 60 V_p \ln \left( \frac{D}{d \cdot k_s} \right)$	$\phi = \frac{360 \cdot F \cdot L_{TH}}{984 \cdot V_p}$
$C$	Braid carriers	inches	$Z_0 = \frac{138}{\sqrt{\epsilon}} \log \left( \frac{D}{d \cdot k_s} \right) = \frac{60}{\sqrt{\epsilon}} \ln \left( \frac{D}{d \cdot k_s} \right)$	$\phi = \frac{360 \cdot F \cdot L_{TH} \cdot \sqrt{\epsilon}}{984}$
$N$	Braid ends per carrier	inches	$Z_0 = \sqrt{L/C}$	
$t$	Flat strip thickness	inches		
$w$	Flat strip width	inches		
SRL	Return loss	dB		
VSWR	Voltage standing wave ratio	dB		
FWD	Forward power	dB		
RFL	Reflected power	dB		
MML	Mismatch loss	dB		
ME	Match efficiency	%		
$k_s$	= 1.0 for solid center conductor			
	= 0.939 for 7 strand center conductor			
	= 0.97 for 19 strand center conductor			
log	logarithm to base 10			
ln	logarithm to base e			
$k_1$	resistive loss constant			
$k_2$	dielectric loss constant			
Symbol	Definition	Units	TIME DELAY (nS/foot)	PHASE TEMPERATURE COEFFICIENT (ppm/C°)
$\alpha$	Attenuation in dB/100 feet	dB/100 feet	$Td = \frac{1.016}{V_p} = 1.016 \sqrt{\epsilon}$	$PTC = \frac{\Delta\phi \cdot 1 \times 10^6}{\phi \cdot \Delta T}$
$\epsilon$	Dielectric constant			
$\Gamma$	Reflection coefficient			
$\phi$	Electrical length	degrees		
$C$	capacitance	pF/foot		
$L$	Inductance	uH/foot		
$Z_0$	Impedance	ohms		
$V_p$	Velocity of propagation	%		
$df$	Dissipation factor			
$Td$	Time delay	nS/foot		
$F$	Frequency	MHz		
PTC	Phase temperature coefficient	ppm/C		
$\Delta T$	Change in temperature ( $t_2 - t_1$ )	C		
$L_{TH}$	Length	feet		
$\Delta\phi$	Change in electrical length ( $t_1 - t_2$ )	degrees		
$D$	dielectric diameter	inches		
$d$	center conductor diameter	inches		
$ds$	Braid wire size	inches		
Fbd	Braid factor			
Symbol	Definition	Units	CAPACITANCE (pF/foot)	RETURN LOSS (dB)
$\alpha$	Attenuation in dB/100 feet	dB/100 feet	$C = \frac{7.36 \epsilon}{\log \left( \frac{D}{d \cdot k_s} \right)} = \frac{16.95 \epsilon}{\ln \left( \frac{D}{d \cdot k_s} \right)}$	$RL = -20 \log \Gamma$
$\epsilon$	Dielectric constant		$C = \frac{7.36}{V_p^2 \log \left( \frac{D}{d \cdot k_s} \right)} = \frac{16.95}{V_p^2 \ln \left( \frac{D}{d \cdot k_s} \right)}$	$RL = -20 \log \frac{VSWR-1}{VSWR+1}$
$\Gamma$	Reflection coefficient		$C = \frac{1016}{Z_0 \cdot V_p}$	$RL = -10 \log \frac{RFL}{FWD}$
$\phi$	Electrical length	degrees		
$C$	capacitance	pF/foot		
$L$	Inductance	uH/foot		
$Z_0$	Impedance	ohms		
$V_p$	Velocity of propagation	%		
$df$	Dissipation factor			
$Td$	Time delay	nS/foot		
$F$	Frequency	MHz		
PTC	Phase temperature coefficient	ppm/C		
$\Delta T$	Change in temperature ( $t_2 - t_1$ )	C		
$L_{TH}$	Length	feet		
$\Delta\phi$	Change in electrical length ( $t_1 - t_2$ )	degrees		
$D$	dielectric diameter	inches		
$d$	center conductor diameter	inches		
$ds$	Braid wire size	inches		
Fbd	Braid factor			
Symbol	Definition	Units	INDUCTANCE (uH/foot)	VSWR
$\alpha$	Attenuation in dB/100 feet	dB/100 feet	$L = .140 \log \left( \frac{D}{d \cdot k_s} \right) = .0606 \ln \left( \frac{D}{d \cdot k_s} \right)$	$VSWR = \frac{1 + \Gamma}{1 - \Gamma}$
$\epsilon$	Dielectric constant		$L = \frac{Z_0^2 \cdot C}{1 \times 10^6}$	$VSWR = \frac{1 + 10^{RL/20}}{1 - 10^{RL/20}}$
$\Gamma$	Reflection coefficient			$VSWR = \frac{1 + \sqrt{RFL/FWD}}{1 - \sqrt{RFL/FWD}}$
$\phi$	Electrical length	degrees		
$C$	capacitance	pF/foot		
$L$	Inductance	uH/foot		
$Z_0$	Impedance	ohms		
$V_p$	Velocity of propagation	%		
$df$	Dissipation factor			
$Td$	Time delay	nS/foot		
$F$	Frequency	MHz		
PTC	Phase temperature coefficient	ppm/C		
$\Delta T$	Change in temperature ( $t_2 - t_1$ )	C		
$L_{TH}$	Length	feet		
$\Delta\phi$	Change in electrical length ( $t_1 - t_2$ )	degrees		
$D$	dielectric diameter	inches		
$d$	center conductor diameter	inches		
$ds$	Braid wire size	inches		
Fbd	Braid factor			
Symbol	Definition	Units	ATTENUATION (dB/100 feet)	REFLECTION COEFFICIENT
$\alpha$	Attenuation in dB/100 feet	dB/100 feet	$\alpha = \frac{4343}{Z_0 \cdot D} \left[ \frac{D}{d \cdot k_s} + Fbd \right] \sqrt{F} + \frac{2.78 \cdot df \cdot F}{V_p}$	$\Gamma = 10^{-RL/20}$
$\epsilon$	Dielectric constant		$\alpha = k_1 \sqrt{F} + k_2 F$	$\Gamma = \frac{VSWR - 1}{VSWR + 1}$
$\Gamma$	Reflection coefficient			$\Gamma = \sqrt{RFL/FWD}$
$\phi$	Electrical length	degrees		
$C$	capacitance	pF/foot		
$L$	Inductance	uH/foot		
$Z_0$	Impedance	ohms		
$V_p$	Velocity of propagation	%		
$df$	Dissipation factor			
$Td$	Time delay	nS/foot		
$F$	Frequency	MHz		
PTC	Phase temperature coefficient	ppm/C		
$\Delta T$	Change in temperature ( $t_2 - t_1$ )	C		
$L_{TH}$	Length	feet		
$\Delta\phi$	Change in electrical length ( $t_1 - t_2$ )	degrees		
$D$	dielectric diameter	inches		
$d$	center conductor diameter	inches		
$ds$	Braid wire size	inches		
Fbd	Braid factor			
Symbol	Definition	Units	BRAID FACTOR	MATCH EFFICIENCY (%)
Round Wire Braid:			$Fbd = \frac{8D + 16 ds}{C \cdot N \cdot ds}$	$ME = (1 - \Gamma^2) \cdot 100$
Flat Strip Braid:			$Fbd = \frac{2\pi (D + 2t)}{C \cdot W}$	$ME = [1 - \left( \frac{VSWR - 1}{VSWR + 1} \right)^2] \cdot 100$
Solid Tube:			$Fbd = 1.0$	$ME = \left( \frac{FWD - REL}{FWD} \right) \cdot 100$
Symbol	Definition	Units	CUTOFF FREQUENCY (GHz)	MISMATCH LOSS (dB)
$f_{co}$	Cutoff frequency	GHz	$F_{co} = \frac{7.5 \cdot V_p}{(D + (d \cdot k_s))}$	$MML = -10 \log (1 - \Gamma^2)$
$\epsilon$	Dielectric constant		$F_{co} = \frac{7.5}{\sqrt{\epsilon} (D + (d \cdot k_s))}$	$MML = -10 \log [1 - \left( \frac{VSWR - 1}{VSWR + 1} \right)^2]$
$D$	dielectric diameter	inches		
$d$	center conductor diameter	inches		
$ds$	Braid wire size	inches		
Fbd	Braid factor			

# COAXIAL

## CABLES COAXILES

# 93/125 OHMS

Para instalaciones en sistemas de transmisión de datos

### CARACTERISTICAS: (tabla 1)

COAXIL TIPO	Constructivas					De Instalación		
	Conductor Interno (MAT. y N° x mm Ø)	Dielectrico (MAT. y Ø nom. mm)	Conductor Externo (MAT. de BLIND)	Vaina (MAT. y Ø ext. mm)	Peso Neto Aproximado (Kg/Km)	Radio Minimo de Curvatura (mm)	Doblados Reiterados	Acondicionamiento Normal(*)
						Instalac. Fijas		
RG 62 A/U	ACw 0,64	PEA 3,70	C —	PVC 6,15	50	30	123	R 100 m B 1000 m
RFA 62 A/U	AC 0,64	PEA 3,70	C —	PVC 6,15	50	30	123	R 100 m B 1000 m
RG 71 A/U	ACw 0,64	PEA 3,70	CE CE	PVC 6,35	60	30	123	R 100 m B 1000 m
RG 63 B/U	ACw 0,64	PEA 7,25	C —	PVC 10,30	124	50	210	R 100 m B 1000 m

### CARACTERISTICAS: (tabla 2)

COAXIL TIPO	Eléctricas				Operativas					
	IMPEDANCIA $Z_o = [\Omega]$ $\pm 5\Omega$	CAPACIDAD $C = [pF/m]$	VELOC. PROP. $V_o = [\%]$	TENSION MAX. $U_{max} = [KV]$	ATENUACION A 20°C $\alpha = [dB/100 m]$					
					10	50	100	200	400	1000
										f = [MHz]
RG 62 A/U	93	43	84	0,75	3	6,5	9	12	17	26
RFA 62 A/U	93	43	84	0,75	3	6,5	9	12	17	26
RG 71 B/U	93	43	84	0,75	2,8	6,2	8,9	12,5	17,4	28,5
RG 63 B/U	125	32	84	1	1,7	3,6	4,9	7,5	15	19,1

(\*) Consultar por acondicionamientos de mayor longitud.

ACw Alambre Copperweld

AC Alambre de cobre

CCE Cuerda de cobre estañado

CC Cuerda de cobre

C Blindaje de trenza de cobre

CE Blindaje de trenza de cobre estañado

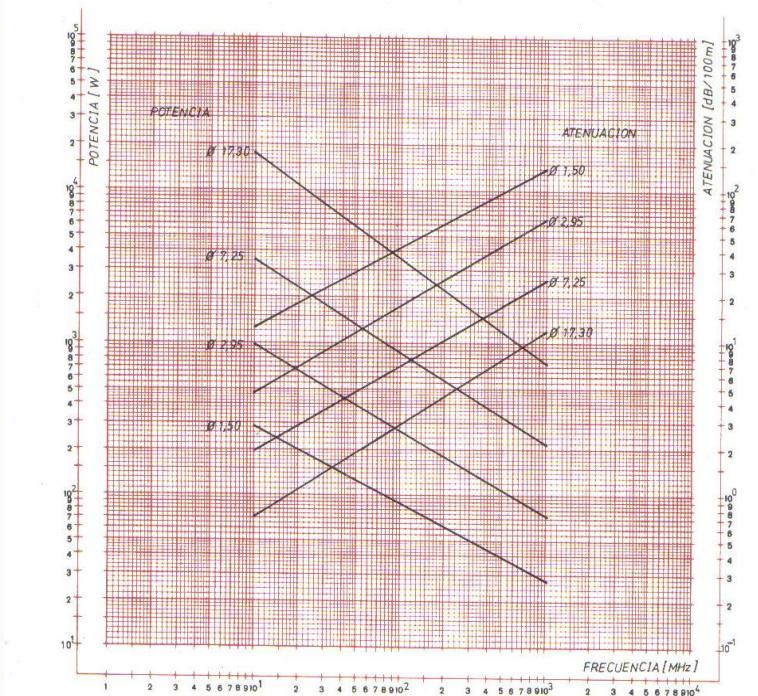
PE Polietileno compacto

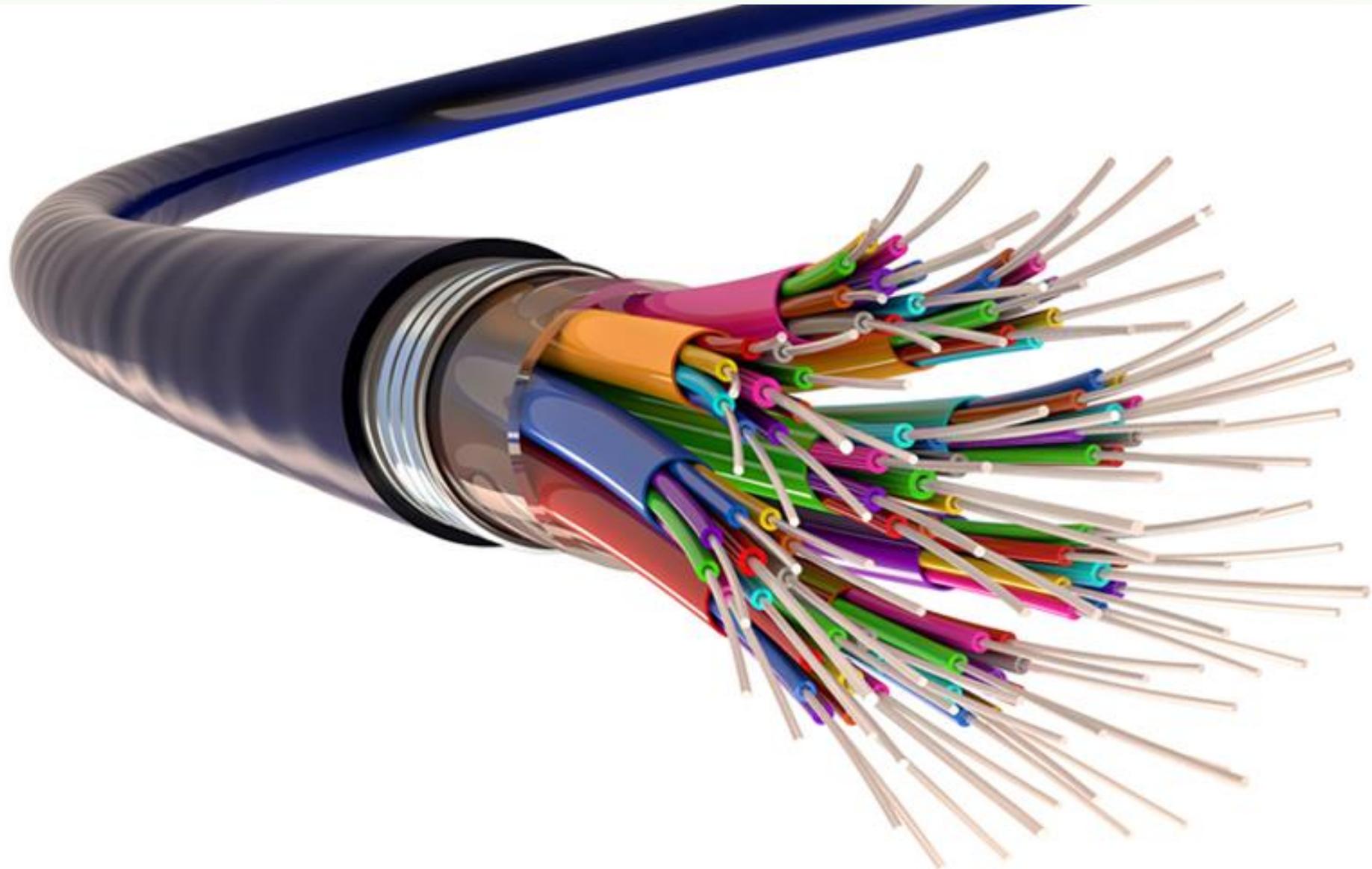
PEA Polietileno y aire

PVC Policloruro de vinilo no migrante

### CARACTERISTICAS: (tabla 2)

COAXIL TIPO	Eléctricas				Operativas					
	IMPEDANCIA $Z_o = [\Omega]$ $\pm 2 \Omega$	CAPACIDAD $C = [pF/m]$	VELOC. PROP. $V_o = [\%]$	TENSION MAX. $U_{max} = [KV]$	ATENUACION A 20°C $\alpha = [dB/100 m]$					
					10	50	100	200	400	1000
RG 174 A/U	50	101	66	1,5	12,8	23	29,2	39,4	61	98,4
RG 122/U	50	101	66	1,9	5,9	14,2	23	36,1	56	95,2
RG 58 C/U	50	101	66	1,9	4,9	12	17	26	38	65
RFA 58 C/U	50	101	66	1,9	4,3	10	14	20	29	45
RG 223/U	50	101	66	1,9	3,9	9,5	15,8	23	33	54,2
RG 213/U	50	101	66	5	2	4,9	7	10,5	15,5	26
RFA 9 B/U	50	101	66	5	2,2	5,4	7,6	11,5	17,5	30
RG 214/U	50	101	66	5	2,2	5,4	7,6	10,9	17	28,9
RG 218/U	50	101	66	11	0,75	1,8	3	4,6	7	12
RG 177/U	50	101	66	11	0,78	1,8	3,1	4,9	7,9	14,5





## Los comienzos para conducir la luz

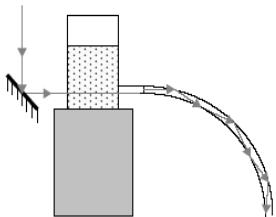
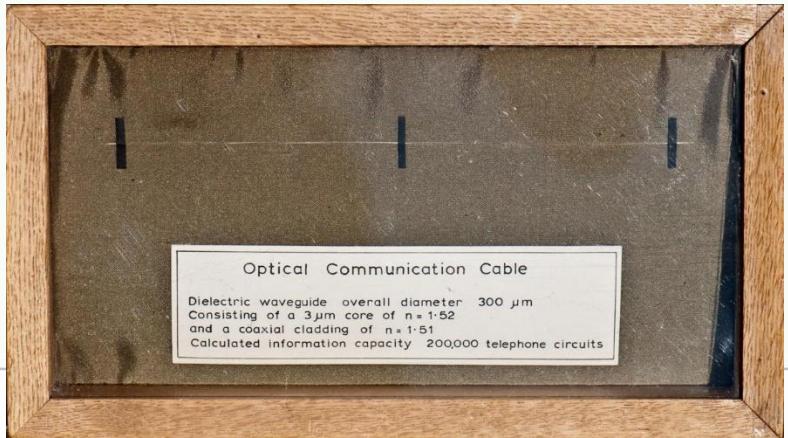
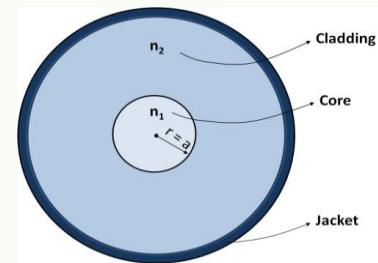


FIGURE 2.12 Light guidance through a water jet, demonstrating the phenomenon of total internal reflection; this was first demonstrated by Daniel Colladon in 1841.



Charles Kao Propone el uso de FO para telecomunicaciones 1966

"Una fibra dieléctrica con un índice de refracción más alto que su región circundante es una forma de dieléctrico quía de onda que representa un posible medio para la transmisión guiada de energía a frecuencias ópticas." .....



2009 Premio Novel de física

"Theoretical and experimental studies indicate that a fibre of glassy material constructed in a cladded structure with a core diameter of about 1 and an overall diameter of about 100A<sub>0</sub>represents a possible practical optical waveguide with important potential as a new form of communication medium. The refractive index of the core needs to be about 1 % higher than that of the cladding. This form of waveguide operates in a single HE<sub>n</sub>, E<sub>n</sub> or H<sub>n</sub> mode and has an information capacity in excess of 1 Gc/s." .....

Charles Kao, 1966.

# FIBRA OPTICA

**AC**

## Principios ..: Análisis óptico/ Electromagnético

Velocidad de fase  $v_f$

$$V_f = \frac{c}{n}$$

$$V_{phase} = \frac{c}{n_{effective}}$$

Velocidad de grupo

$$V_g = \frac{d\omega}{d\beta}$$

$$V_g = \frac{d\omega}{d\beta}$$

### Indices of Refraction<sup>a</sup>

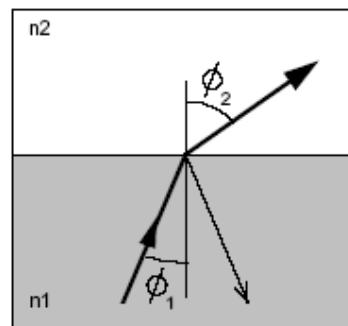
Substance	Index of Refraction	Substance	Index of Refraction
<i>Solids at 20°C</i>			
Cubic zirconia	2.20	Liquids at 20°C	
Diamond (C)	2.419	Benzene	1.501
Fluorite ( $\text{CaF}_2$ )	1.434	Carbon disulfide	1.628
Fused quartz ( $\text{SiO}_2$ )	1.458	Carbon tetrachloride	1.461
Gallium phosphide	3.50	Ethyl alcohol	1.361
Glass, crown	1.52	Glycerin	1.473
Glass, flint	1.66	Water	1.333
Ice ( $\text{H}_2\text{O}$ )	1.309	<i>Gases at 0°C, 1 atm</i>	
Polystyrene	1.49	Air	1.000 293
Sodium chloride ( $\text{NaCl}$ )	1.544	Carbon dioxide	1.000 45

<sup>a</sup> All values are for light having a wavelength of 589 nm in vacuum.

## Ley de Snell

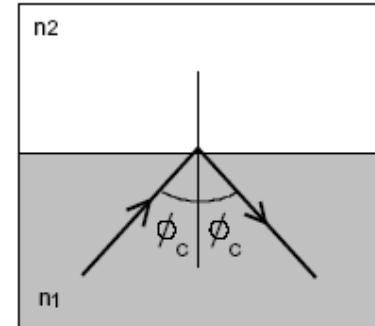
$$n_0 \sin \theta_{\text{em}} = n_1 \sin \theta_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$



$$n_1 > n_2$$

$$\theta_1 > \theta_c = 1/\sin(n_2/n_1)$$

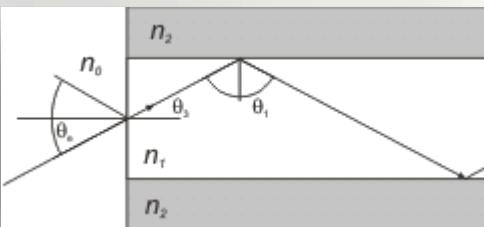


$$n = \text{refractive index of material}$$

## Apertura numérica

$$NA = n \sin \theta$$

$$\sin \theta_{e\max} = n_1 \frac{\sqrt{n_1^2 - n_2^2}}{n_1} = \sqrt{n_1^2 - n_2^2}$$



FIBER TYPE	NA
Single-mode	0.14
Multimode 50/125μm	0.20
Multimode 62.5/125μm	0.275
Multimode 200/230μm	0.37
Multimode 980/1000μm	0.47

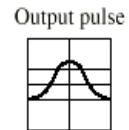
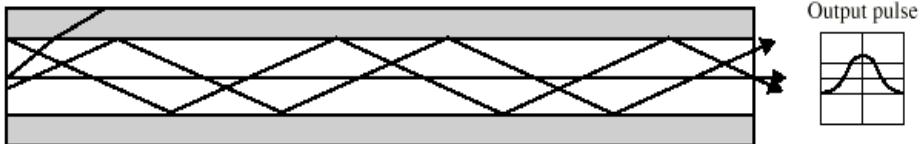
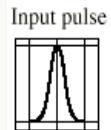
V number is sometimes called the normalized frequency.

**NORMALIZED FREQUENCY.**—Electromagnetic waves bound to an optical fiber are described by the fiber's normalized frequency. The normalized frequency determines how many modes a fiber can support. Normalized frequency is a dimensionless quantity. Normalized frequency is also related to the fiber's cutoff wavelength. Normalized frequency (V) is defined as:

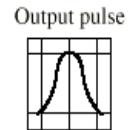
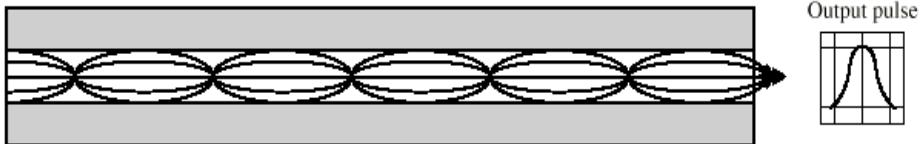
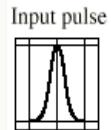
$$V = \frac{2 \pi a}{\lambda} (n_1^2 - n_2^2)^{\frac{1}{2}}$$



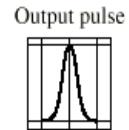
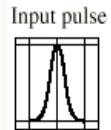
## Tipos de fibra óptica..



(a) Step-index multimode



(b) Graded-index multimode



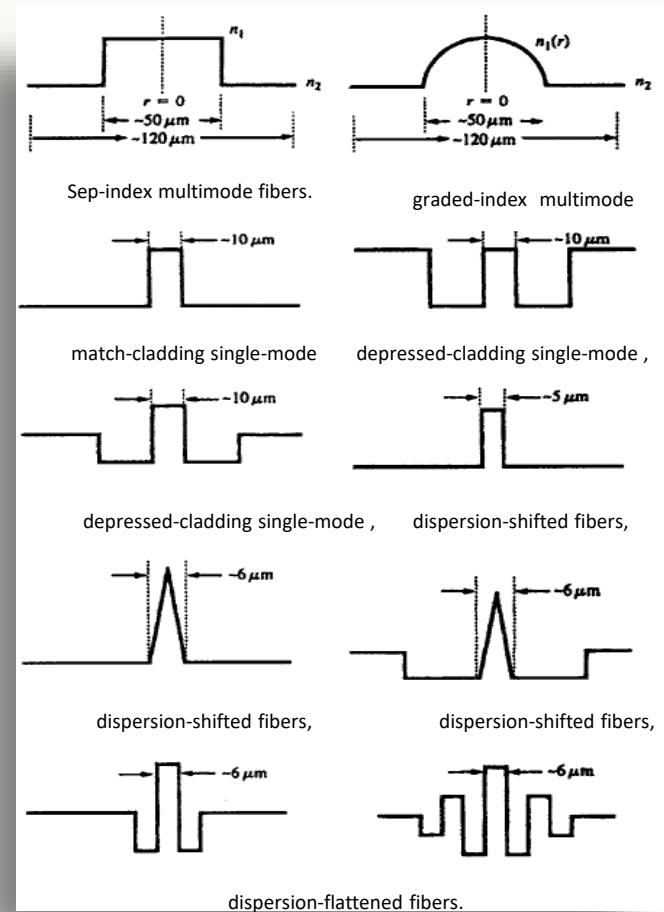
(c) Single mode

**Single-Mode Glass**8-10  $\mu\text{m}$ 125  $\mu\text{m}$ 50  $\mu\text{m}$ 125  $\mu\text{m}$ **Multimode Glass**62.5  $\mu\text{m}$ 125  $\mu\text{m}$ 

## Tipos de fibra óptica.. Segundo diámetros y perfiles de N



FIBER TYPE	NA
Single-mode	0.14
Multimode 50/125 $\mu\text{m}$	0.20
Multimode 62.5/125 $\mu\text{m}$	0.275
Multimode 200/230 $\mu\text{m}$	0.37
Multimode 980/1000 $\mu\text{m}$	0.47



# FIBRA OPTICA



## Desde el análisis electromagnético.....

### Ecuaciones de Maxwell

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \times \dot{\mathbf{H}} = \epsilon \ddot{\mathbf{E}}$$

$$\nabla \times \nabla \times \mathbf{E} = -\nabla \times \dot{\mathbf{B}}$$

$$= \mu \nabla \times \dot{\mathbf{H}}$$

$$= \mu \epsilon \ddot{\mathbf{E}}$$

$$\nabla \times (\nabla \times \mathbf{E}) = \nabla (\nabla \cdot \mathbf{E}) - \nabla^2 \mathbf{E}$$

$$\nabla^2 \mathbf{E} = \mu \epsilon \ddot{\mathbf{E}}$$

$$\nabla^2 \mathbf{H} = \mu \epsilon \ddot{\mathbf{H}}$$

Expresándolo en ejes cilíndricos:

$$\mathbf{E} = E_0(r, \phi) e^{j(\omega t - \beta z)}$$

Utilizando el método de separación de variables, se llega a la conocida ecuación diferencial de Bessel.

Si consideramos que la fibra es un medio lineal, isótropo, sin corrientes, ni cargas libres, se puede obtener la ecuación de onda  $\mathbf{E}$  y  $\mathbf{H}$  para una guía de onda cilíndrica [5-7]:

$$\frac{\partial^2 E_z}{\partial r^2} + \frac{1}{r^2} \frac{\partial^2 E_z}{\partial \phi^2} + \frac{1}{r} \frac{\partial E_z}{\partial r} + q^2 E_z = 0 \quad (1)$$

$$\frac{\partial^2 H_z}{\partial r^2} + \frac{1}{r^2} \frac{\partial^2 H_z}{\partial \phi^2} + \frac{1}{r} \frac{\partial H_z}{\partial r} + q^2 H_z = 0 \quad (2)$$

Aplicando las condiciones de contorno y resolviendo la ec. Dif de Bessel por las funciones de Bessel se tiene:

$$r < a \quad E_z(r, \phi, z) = AJ_V(\kappa \cdot r)e^{jV\phi}e^{-j\beta z} + c.c.$$

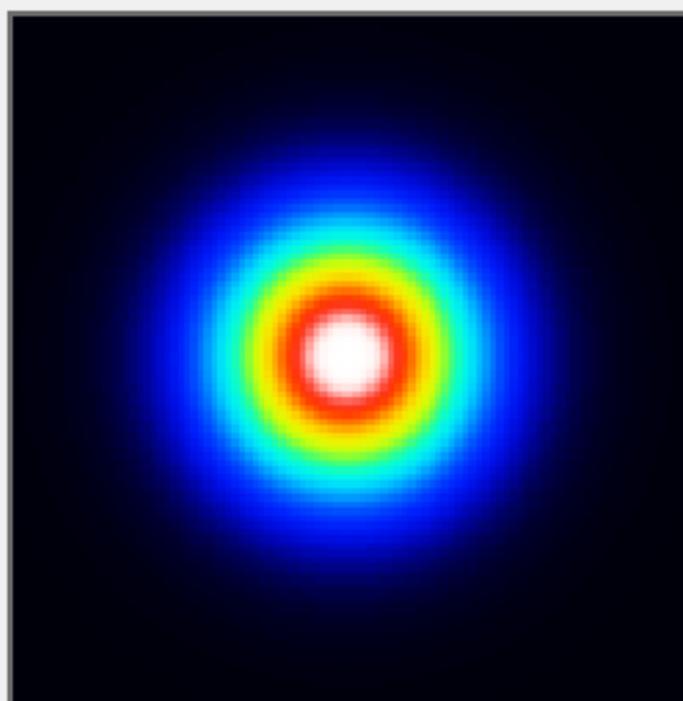
$$H_z(r, \phi, z) = BJ_V(\kappa \cdot r)e^{jV\phi}e^{-j\beta z} + c.c.$$

$$r > a \quad E_z(r, \phi, z) = CK_V(\gamma \cdot r)e^{jV\phi}e^{-j\beta z} + c.c.$$

$$H_z(r, \phi, z) = DK_V(\gamma \cdot r)e^{jV\phi}e^{-j\beta z} + c.c.$$



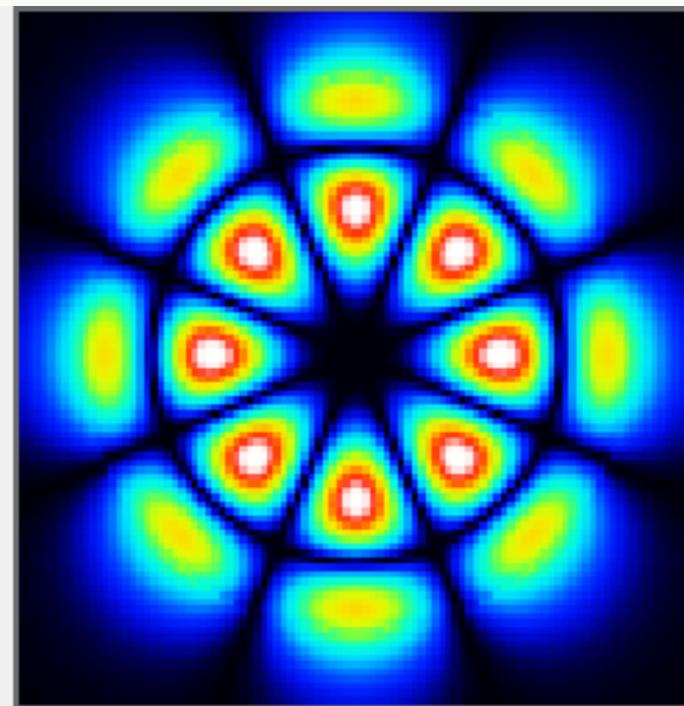
Transmisión en modo monomodo



A preview of the composed field



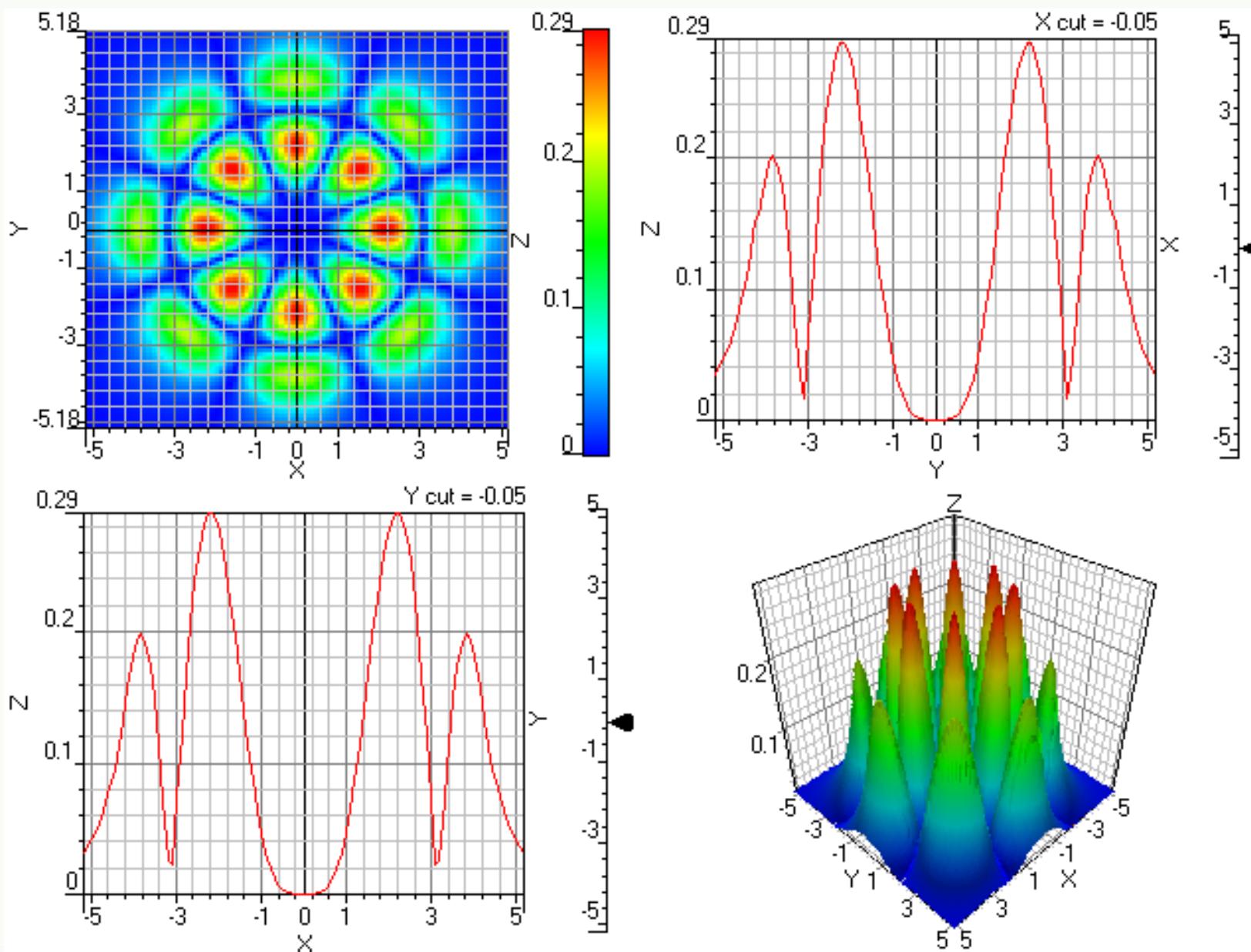
Transmisión en modo multimodo

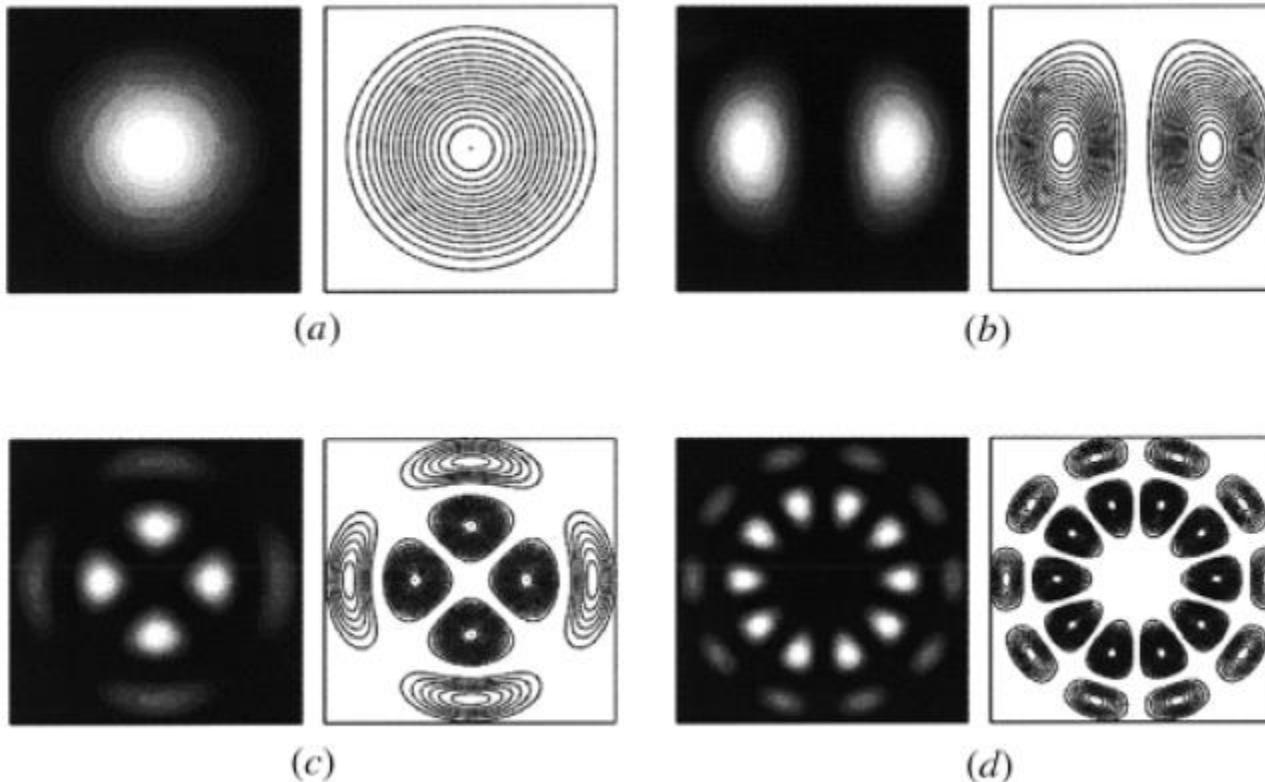


A preview of the composed field



# Modos de transmisión dentro de la fibra óptica



**Tipos de transmisión (modos) dentro de una guía de onda (fibra óptica)**

**FIGURE 2.6.** Field distributions for the LP mode ( $v = 20$ ): (a)  $LP_{0,1}$ ; (b)  $LP_{1,1}$ ; (c)  $LP_{2,2}$ ; (d)  $LP_{5,2}$ .

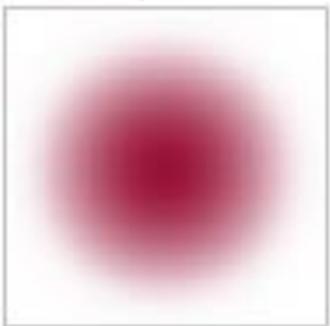
The number of potential modes the light can take is determined by the diameter of the optical fiber core, the refractive indices of the fiber core and cladding, and the wavelength of the light.

$$N \approx V^2 / 4$$

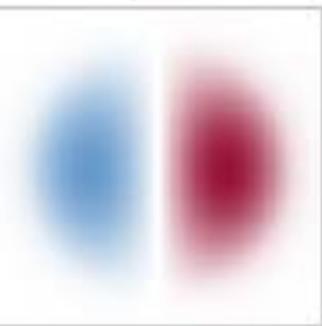
Transverse electromagnetic (TEM modes)	$\tilde{E}_z = 0, \tilde{H}_z = 0$	plane waves, transmission line modes
Transverse electric (TE modes)	$\tilde{E}_z = 0, \tilde{H}_z \neq 0$	waveguide modes
Transverse magnetic (TM modes)	$\tilde{E}_z \neq 0, \tilde{H}_z = 0$	waveguide modes
Hybrid (EH or HE modes)	$\tilde{E}_z \neq 0, \tilde{H}_z \neq 0$	waveguide modes



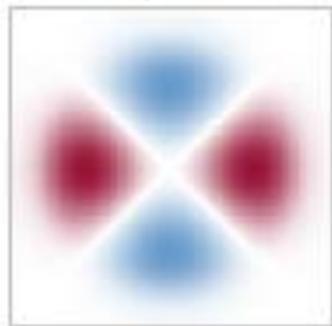
$|l = 0, m = 1|$



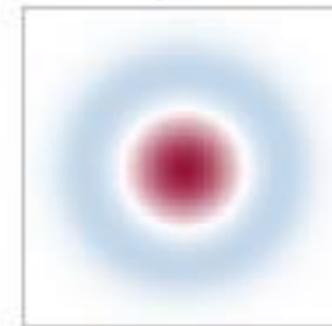
$|l = 1, m = 1|$



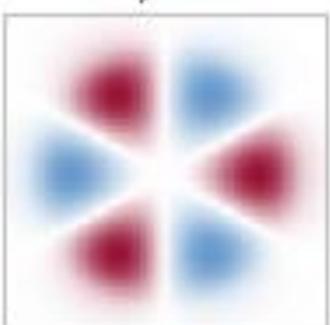
$|l = 2, m = 1|$



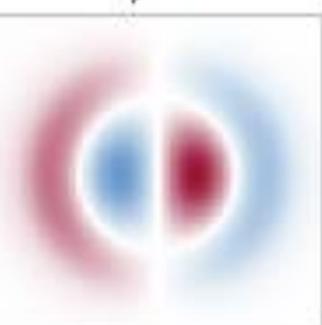
$|l = 0, m = 2|$



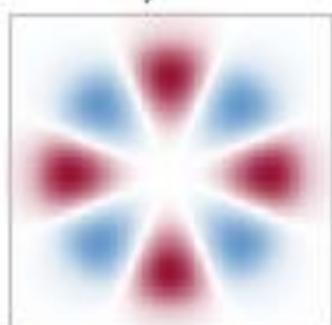
$|l = 3, m = 1|$



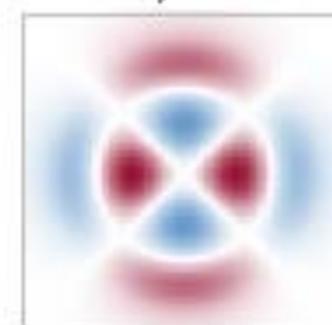
$|l = 1, m = 2|$



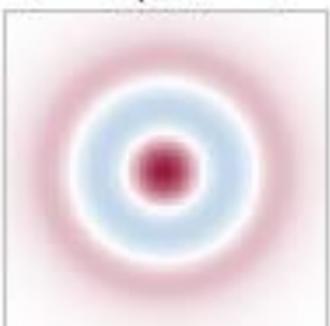
$|l = 4, m = 1|$



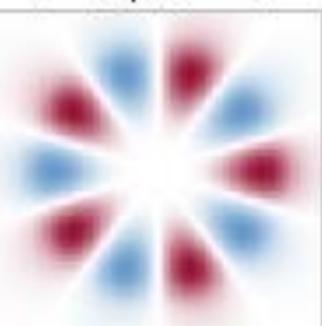
$|l = 2, m = 2|$



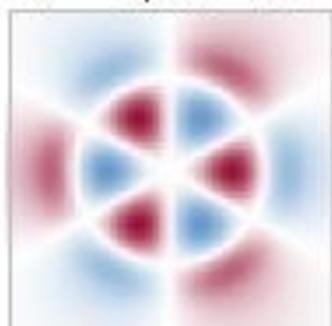
$|l = 0, m = 3|$



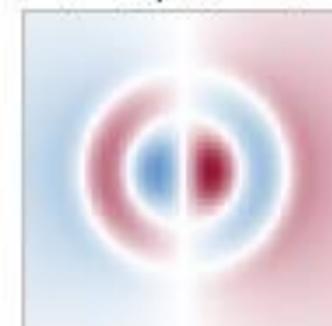
$|l = 5, m = 1|$



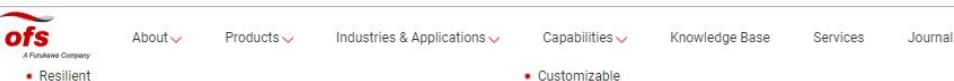
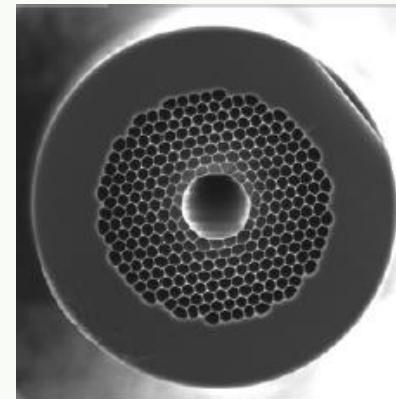
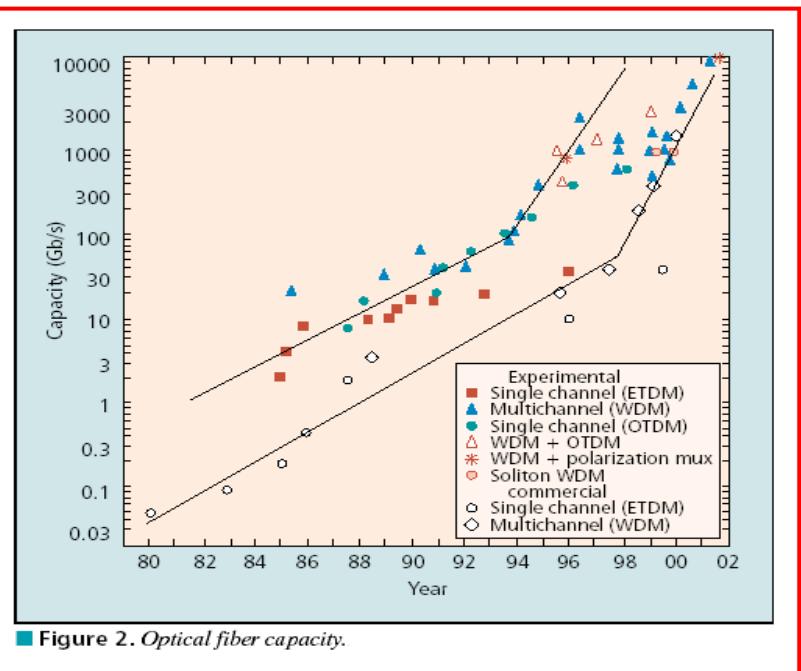
$|l = 3, m = 2|$



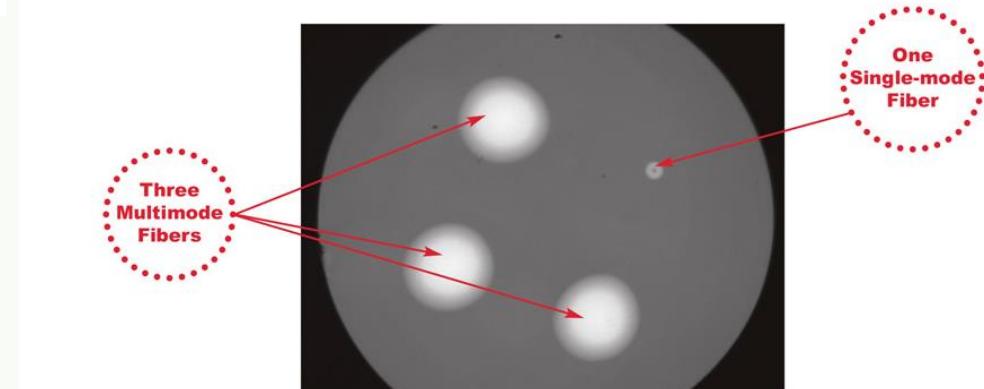
$|l = 1, m = 3|$



## Evolución de la capacidad de transferencia de una fibra óptica y formas de construcción



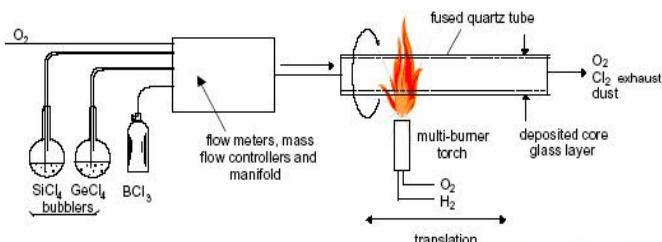
OFS is continually developing new optical fiber technology. If your company has ideas that OFS can help with, we would love to start a conversation. [Contact OFS](#) and one of our optical fiber experts will be more than happy to assist you.



# FIBRA OPTICA

**AC**

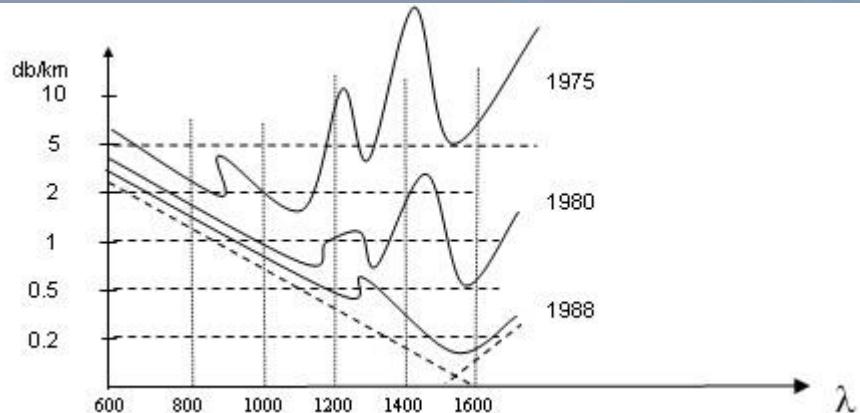
## Fabrication of Optical Fibers



A preform is made out of pure silica glass. Pure silica can only be made by chemical reactions (at 1500°C). The refractive index of the core is changed by adding Germanium (Ge).

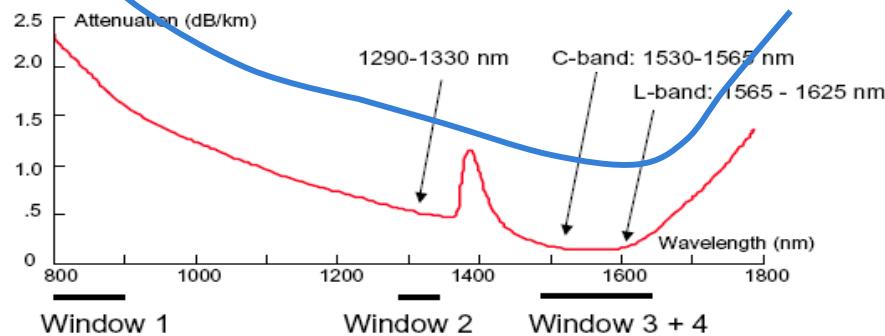


7



## Attenuation

- Attenuation is caused by Scattering, Absorption, Bending
- Attenuation is Wavelength Dependent
- Typical 0.35 dB/km at 1310 nm and 0.25 dB/km at 1550 nm



## Overview:

Non Dispersion Shifted  
Non Dispersion Shifted  
Zero Dispersion Shifted  
Cut-off Shifted Single Mode  
Non Zero Dispersion Shifted  
Non Zero Dispersion Shifted  
Non Zero Dispersion Shifted  
Non Zero Dispersion Shifted

ITU-T G.652 Matched cladding  
ITU-T G.652 Depressed cladding  
ITU-T G.653  
ITU-T G.654 Low Loss Fiber  
ITU-T G.655 TrueWave fiber (Lucent)  
ITU-T G.655 LEAF fiber (Corning)  
ITU-T G.655 MetroCor fiber (Corning)  
ITU-T G.655 Freelite (Pirelli)  
ITU-T G.655 Teralight (Alcatel)

Optimized for 1310 nm  
Optimized for 1310 nm  
Optimized for 1550 nm  
Optimized for 1550 nm  
Optimized for 1530-1620 nm  
Optimized for 1530-1625 nm  
Optimized for 1530-1625 nm  
Optimized for 1530-1625 nm  
Optimized for 1530-16?? nm



## Imperfecciones (limitaciones) de la fibra óptica.....

- Atenuación
    - Pérdidas por absorción.
    - Pérdidas por dispersión de Rayleigh o materiales.
    - Pérdidas de radiación.
  - Dispersión modas .
  - Dispersión cromática o de longitud de onda .
- 
- Pérdidas por empalme , acoplamiento .

### Atenuación

#### Factors Affecting Attenuation<sup>a</sup>.

##### Intrinsic loss mechanisms

Tail of infrared absorption by Si–O coupling

Tail of ultraviolet absorption due to electron transitions in defects

Rayleigh scattering due to spatial fluctuations of the refractive index

##### Absorption by impurities

Absorption by molecular vibration of OH

Absorption by transition metals

##### Structural imperfections

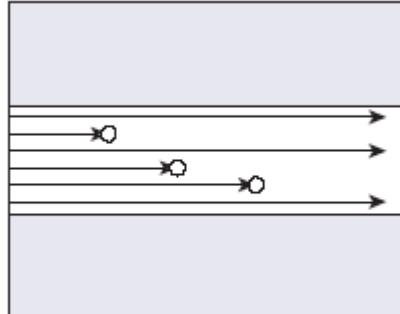
Geometrical nonuniformity at core–cladding boundary

Imperfection at connection or splicing between fibers

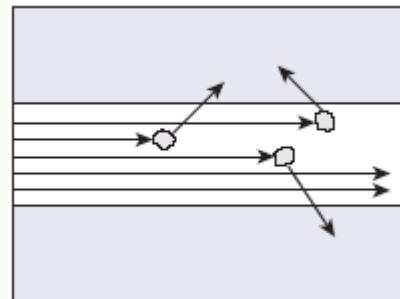


## Atenuación

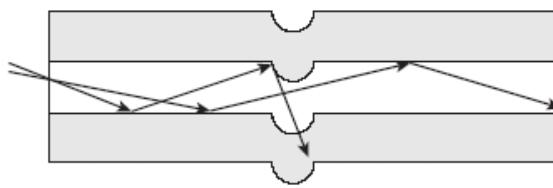
Absorption in optical fiber



Scattering in optical fiber

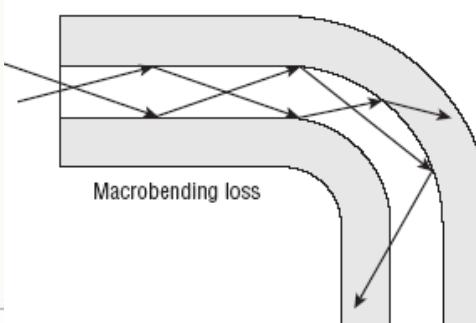


*90 % causante de la atenuación*



Microbending loss

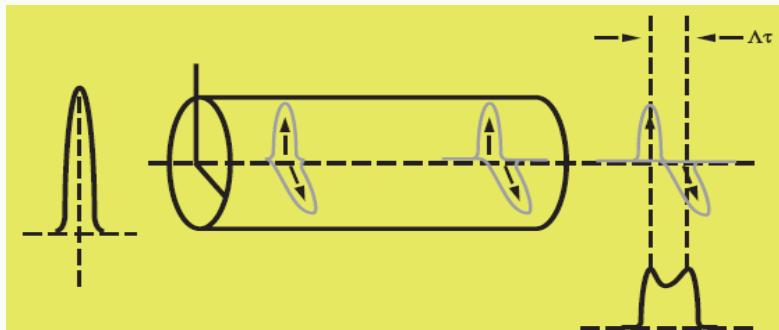
Atenuación por micro y macro bending



Macrobending loss

# FIBRA OPTICA

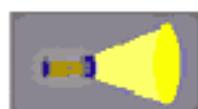
## Dispersión por modo de polarización



Maximum PMD values allowed for digital signal transmission:

Bit rate per channel	SDH	SONET	Equivalent timeslot	Max. PMD delay	Max. PMD coefficient for a 100 km fiber length
1.2 Gbps	—	OC-24	803 ps	80 ps	8 ps/ $\sqrt{\text{km}}$
2.5 Gbps	STM-16	OC-48	401 ps	40 ps	4 ps/ $\sqrt{\text{km}}$
10 Gbps	STM-64	OC-192	100 ps	10 ps	1 ps/ $\sqrt{\text{km}}$
40 Gbps	STM-256	OC-768	25.12 ps	2.5 ps	0.25 ps/ $\sqrt{\text{km}}$

$$\text{PMD} = \text{PMD}_c \times \sqrt{L}$$



Distance →



Perfect pulse



Attenuation +  
chromatic dispersion

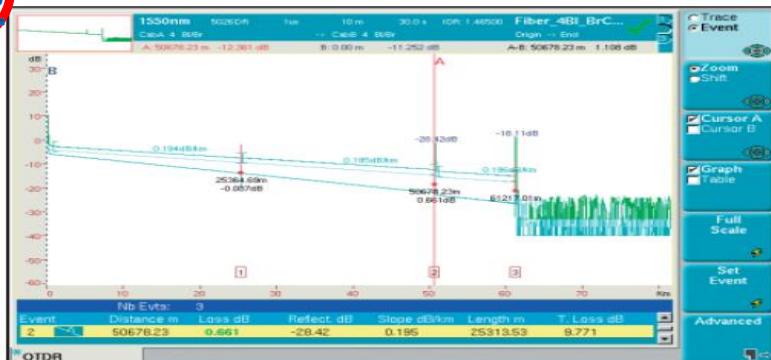


Real pulse

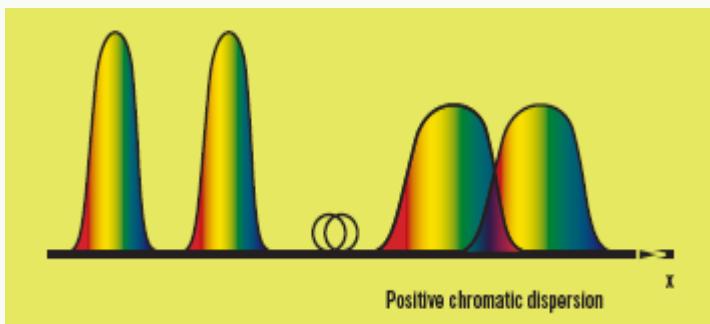


## Imperfecciones de la fibra óptica... Resumen...

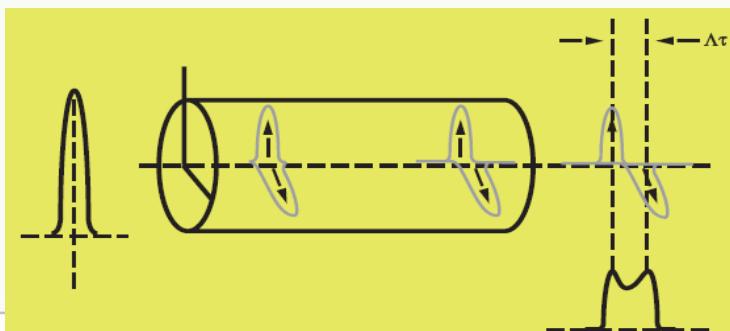
### Atenuación



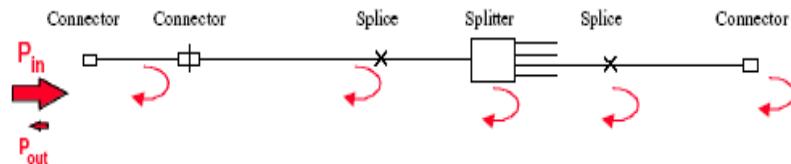
### Dispersión cromática



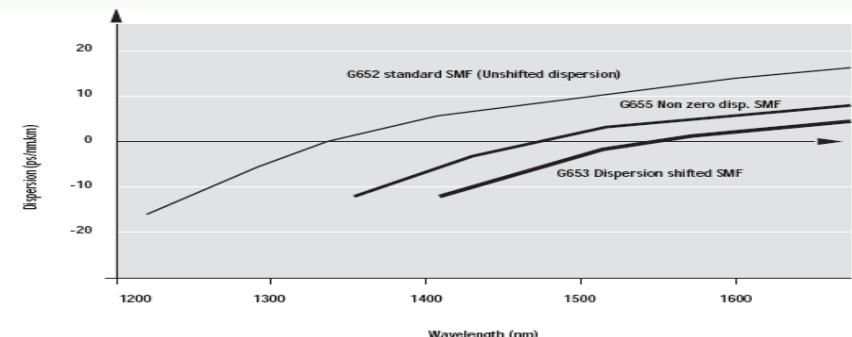
### Dispersión por modo de polarización



### Return Loss:



The return loss is created by the reflections in the fibers, splices, connector, optical devices and is measured at the entrance of the optical line.



### Maximum PMD values allowed for digital signal transmission:

Bit rate per channel	SDH	SONET	Equivalent timeslot	Max. PMD delay	Max. PMD coefficient for a 100 km fiber length
1.2 Gbps	—	OC-24	803 ps	80 ps	$8 \text{ ps}/\sqrt{\text{km}}$
2.5 Gbps	STM-16	OC-48	401 ps	40 ps	$4 \text{ ps}/\sqrt{\text{km}}$
10 Gbps	STM-64	OC-192	100 ps	10 ps	$1 \text{ ps}/\sqrt{\text{km}}$
40 Gbps	STM-256	OC-768	25.12 ps	2.5 ps	$0.25 \text{ ps}/\sqrt{\text{km}}$



## Atenuación

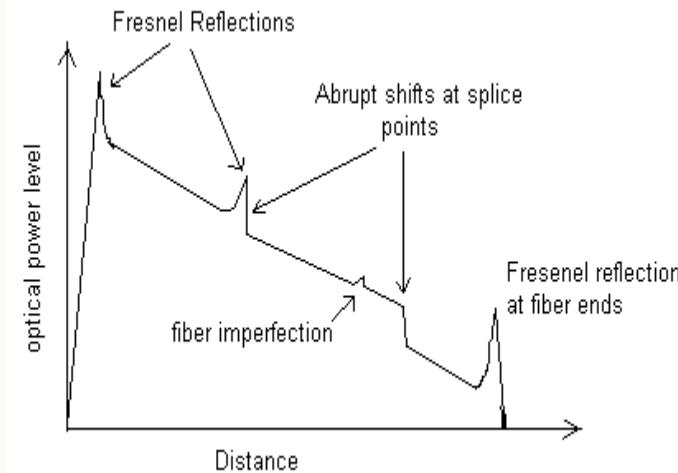
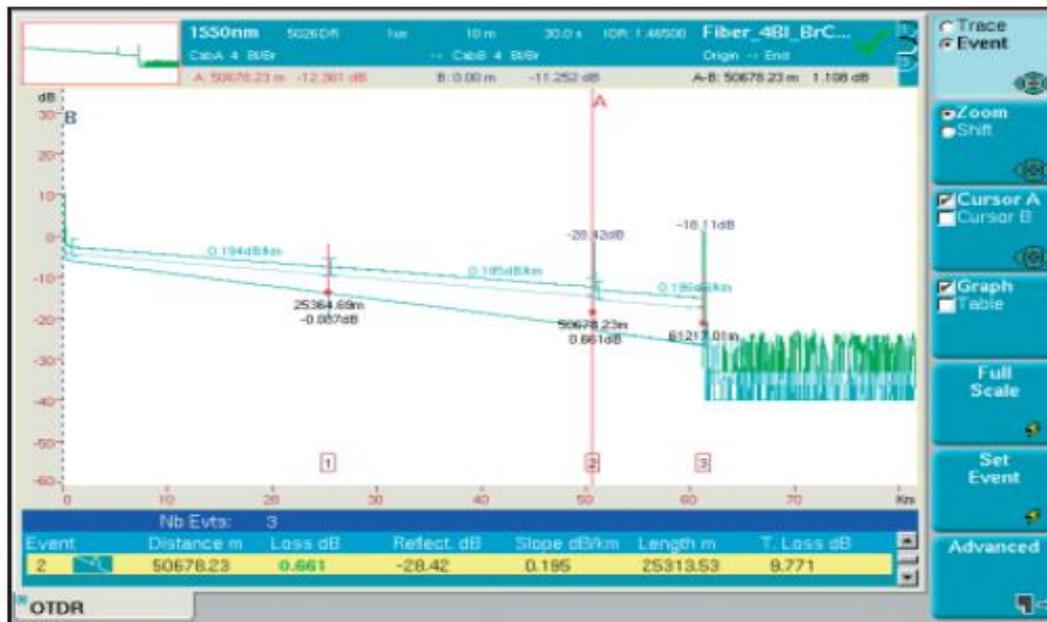
- Pérdidas por absorción
- Pérdidas por dispersión de Rayleigh o materiales
- Dispersión cromática o de longitud de onda
- Pérdidas de radiación
- Dispersión modas

Pérdidas por empalme , acoplamiento

## Limitación de ancho de banda .

Esta dado básicamente por la dispersión , que “ensancha” el pulso a lo largo de la fibra óptica

## Optical time –domain reflectometer OTDR



### 1.1.1 Optical Transmission System Concepts

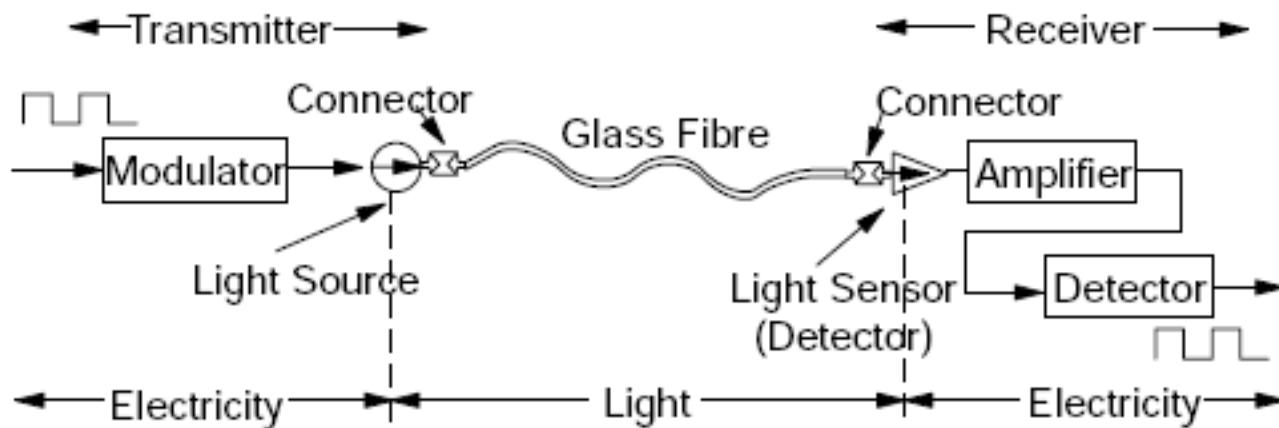
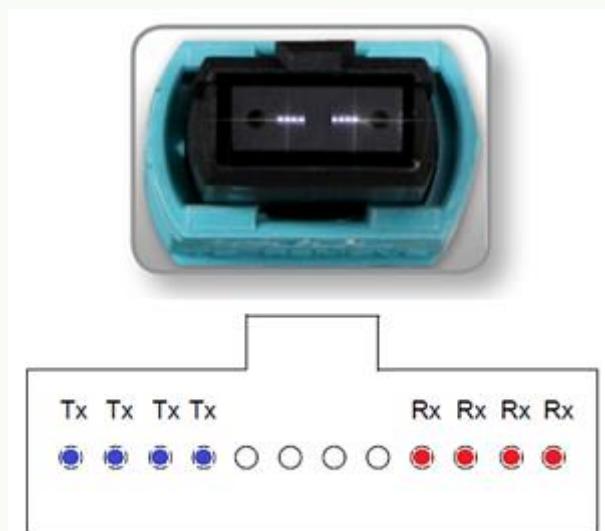


Figure 1. Optical Transmission - Schematic



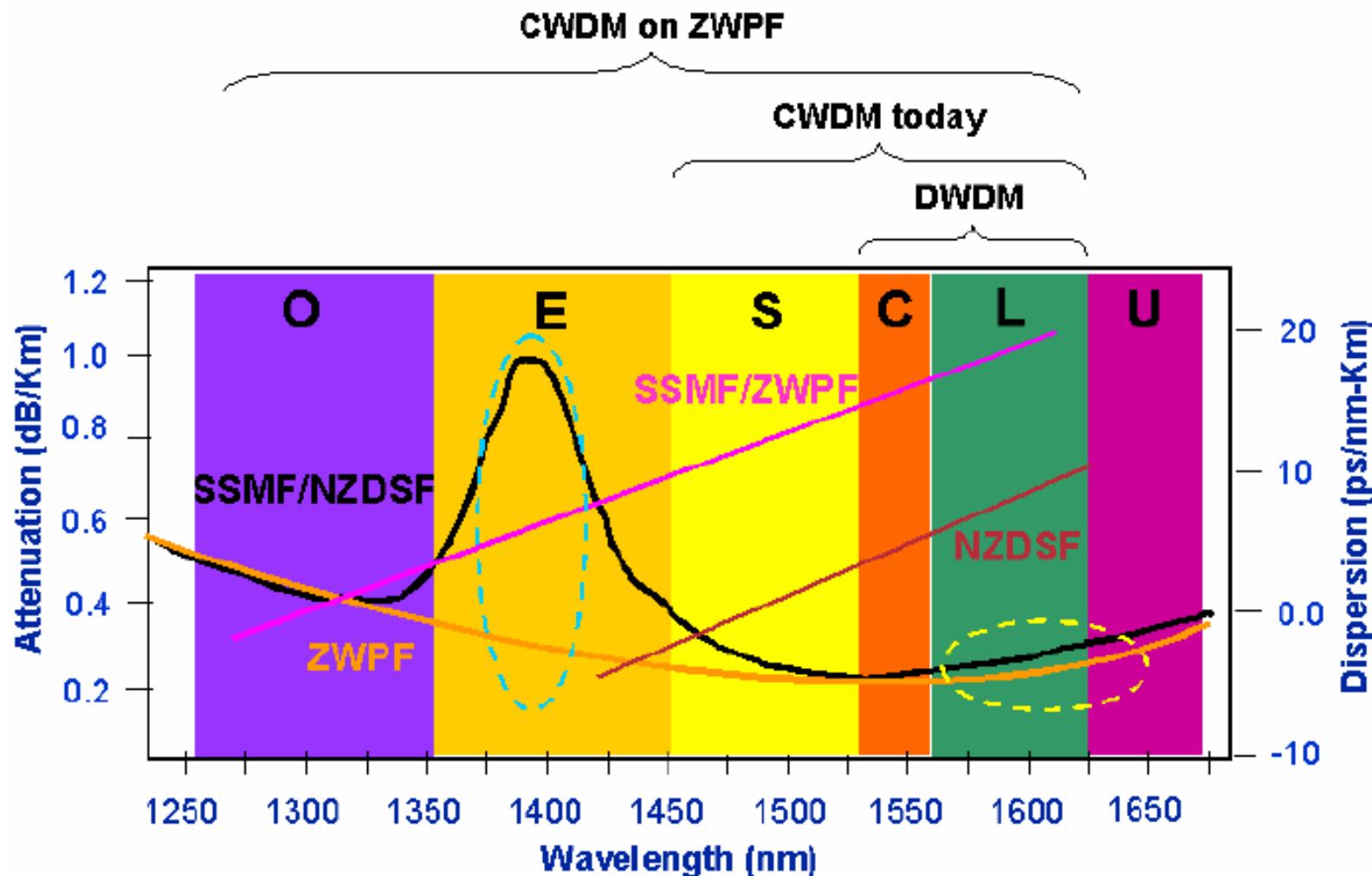
# Tipos de Cables multifibras



Fiber cable type ISO/IEC 11801	Glass fiber specification TIA-492AAAx	Core diameters (μm)	Max refractive index difference $\Delta n$	Minimum modal bandwidth (MHz-km)				Maximum glass fiber attenuation (dB/km)			Maximum fiber cable attenuation (dB/km)			IEEE 802.3 link distance					
				Overfilled launch (OFL) bandwidth			Effective modal bandwidth		TIA-492AAAx IEC 60793-2-10			TIA 568-3-D ISO/IEC 11801			1000-SR	10G-SR	40G-SR4 & 100G-SR10	100G-SR4 & 400G-SR16	50G-SR & 200G-SR4*
				850nm	953nm	1300nm	850nm	953nm	850nm	953nm	1300nm	850nm	953nm	1300nm					
OM1	TIA-492AAAA	62.5	0.02	200			500			3.2		0.9	3.5		1.5	275m	33m		
OM2	TIA-492AAAB	50	0.01	500			500			3		1	3.5		1.5	550m	82m		
OM3	TIA-492AAC	50	0.01	1500			500	2000		2.5		0.8	3.0		1.5	300m	100m	70m	70m
OM4	TIA-492AAD	50	0.01	3500			500	4700		2.5		0.8	3.0		1.5	400m	150m	100m	100m
OM5	TIA-492AAAE (WBMMF)	50	0.01	3500	1850	500	4700	2470	2.5	1.8	0.8	3.0	2.3	1.5	no spec	400m	150m	100m	100m

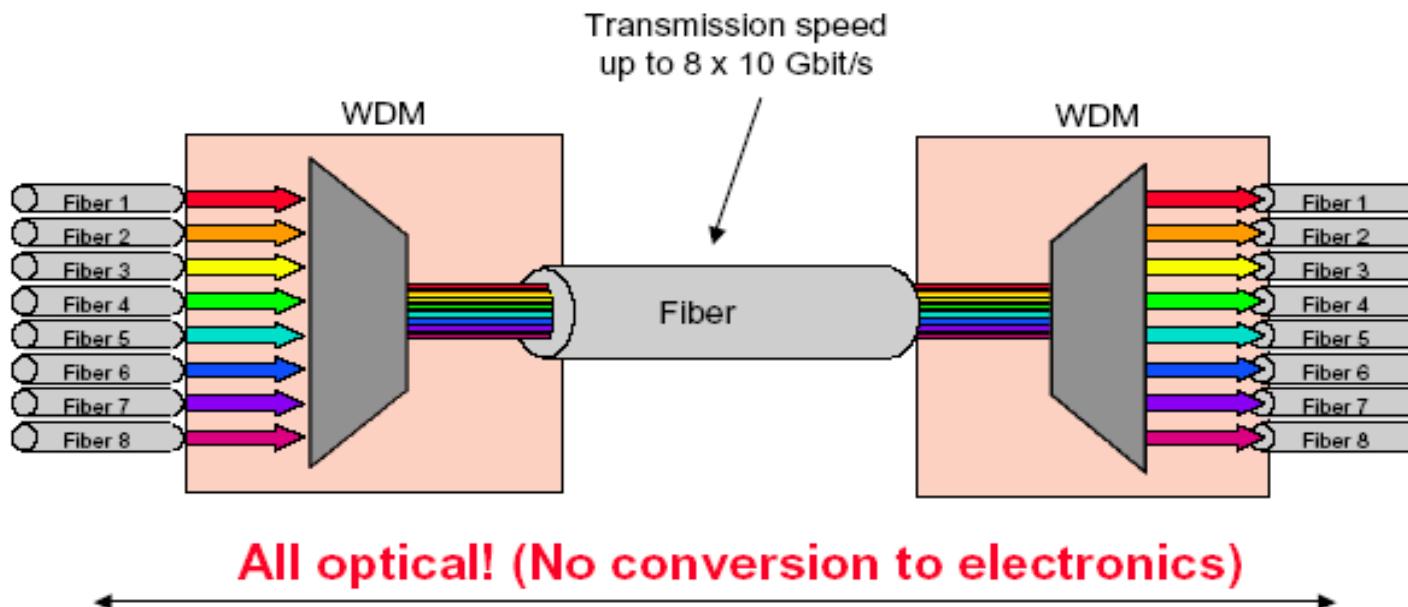
## Rango de longitudes de onda y sus bandas

Cisco.cc



**AC**

## Transmisión de varias longitudes de onda dentro de una FIBRA OPTICA





**AI**

## Especificaciones de una fibra óptica.....

Cuadro 2/G.652 – G.652.B

La subcategoría de cable de fibra óptica monomodo es adecuada para los sistemas de transmisión de hasta STM-64 de UIT-T G.957 [5], UIT-T G.691 [3] y UIT-T G.692 [4]. La dispersión cromática deberá en general acomodarse a sistemas de transmisión de alta velocidad en la región de longitud de onda de 1550 nm.

Atributos de la fibra		
Atributo	Dato	Valor
Diámetro de campo modal	Longitud de onda	1310 nm
	Gama de valores nominales	8,6-9,5 $\mu$ m
	Tolerancia	$\pm 0,7 \mu$ m
Diámetro del revestimiento	Nominal	125,0 $\mu$ m
	Tolerancia	$\pm 1 \mu$ m
Error de concentricidad del núcleo	Máximo	0,8 $\mu$ m
No circularidad del revestimiento	Máximo	2,0%
Longitud de onda de corte del cable	Máximo	1260 nm
Pérdida de macroflexión	Radio	37,5 mm
	Número de vueltas	100
	Máximo a 1550 nm	0,50 dB
	Máximo a 16XX nm (nota 1)	0,50 dB
Prueba de tensión	Mínimo	0,69 GPa
Coeficiente de dispersión cromática	$\lambda_{0\text{min}}$	1300 nm
	$\lambda_{0\text{máx}}$	1324 nm
	$S_{0\text{max}}$	0,093 ps/nm <sup>2</sup> ·km
Coeficiente de PMD de fibra no cableada	Máximo	ps/ $\sqrt{\text{km}}$ (nota 2)
Atributos del cable		
Coeficiente de atenuación	Máximo a 1310 nm	0,4 dB/km
	Máximo a 1550 nm	0,35 dB/km
	Máximo a 16XX nm (nota 1)	0,4 dB/km
Coeficiente de PMD	M	20 cables
	Q	0,01%
	PMD <sub>Q</sub> máximo (nota 2)	0,5 ps/ $\sqrt{\text{km}}$

NOTA 1 – La longitud de onda superior de esta banda no se ha determinado completamente. Sin embargo, XX es menor o igual a 25 nm.

NOTA 2 – Los fabricantes de cable pueden especificar un coeficiente de PMD máximo facultativo de fibra no cableada para soportar los requisitos primarios de PMD<sub>Q</sub> del cable si ésta ha sido verificada para un tipo de construcción de cable específica.



oldSTLnegs-1206.jpg (1200x600) | ITUSearch | G.652 : Characteristics of a sing... | ITU-T Rec. G.652 (11/2016) Ch... | Fibra Óptica monomodo con b... | + | - | X

← → C fs.com/mx/products/72737.html | ☆ | LinkedIn | ABO | ☰

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Identificate

Cesta

INICIO / WDM y Acceso Óptico / Mux Demux y OADM / CWDM Mux Demux / 72737



## Fibra Óptica monomodo con bajo pico de agua G.652.D, 20km #72737

★★★★★ 0 Comentario | 1 Pregunta | Compartir

**US\$ 2,200.00**

FS P/N: SM-LWP-G.652.D-20KM

Disponible, necesita tránsito. ⓘ

Enviar a Argentina

US\$ 61.00 por FedEx IE, se enviará el vier. 15 de nov.

1  
^  
v

Añadir a la cesta

Haz clic para ampliar la imagen

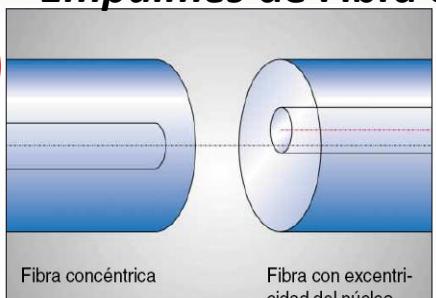
Envío y devolución Soporte de productos

Solicitud de presupuesto

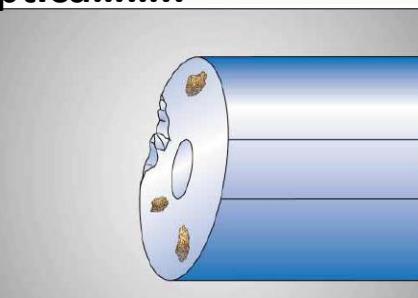
# FIBRA OPTICA

## Empalmes de Fibra óptica.....

AT



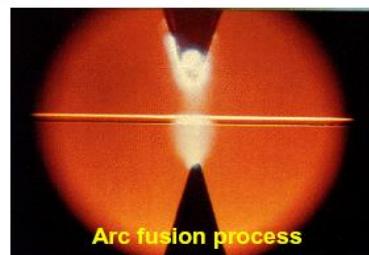
Fibra concéntrica y fibra con excentricidad del núcleo



### Características

- Desviación típica del ángulo de corte < 0,5° en condiciones de campo
- Corte rápido y sencillo: la fibra se sujetá, se tensa, se raya y se quiebra simplemente presionando con un dedo
- Filo de diamante para cortes de excelente calidad y larga vida útil (> 10.000 cortes)
- Guiafibras intercambiables (accesorios)
- Su diseño garantiza poca susceptibilidad a las interferencias y a la suciedad y facilita su limpieza

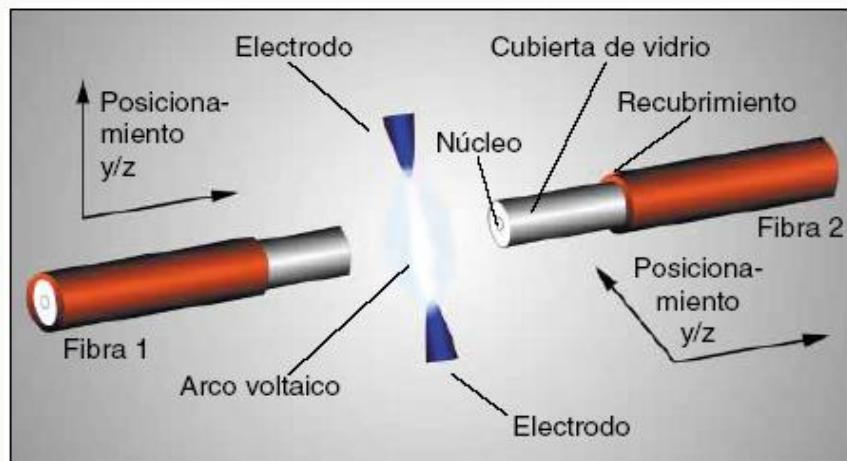
## Fusion Splicing of Fibers



Splice protector



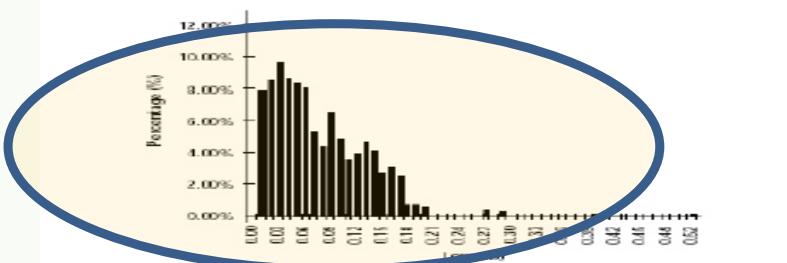
Typical splice loss: 0.02 dB



## Empalmes mecánicos ...



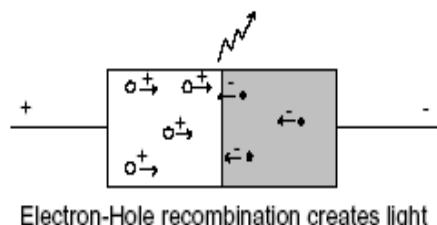
### Pérdida de Inserción



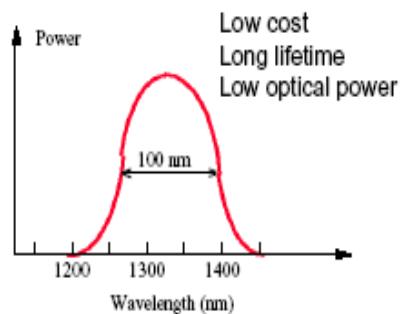
*Fuente de iluminación en la fibra :*

## Optical Components - Light Sources

### Light Emitting Diodes (LED)

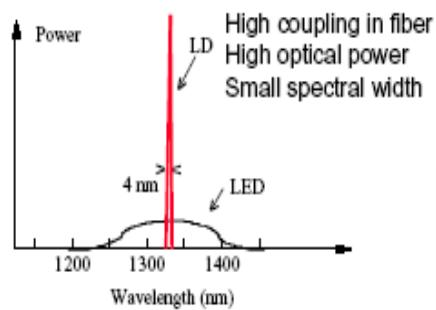
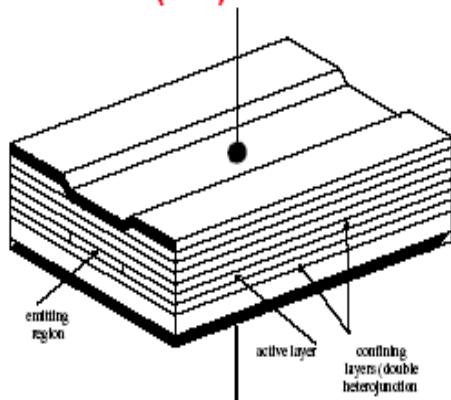


Electron-Hole recombination creates light



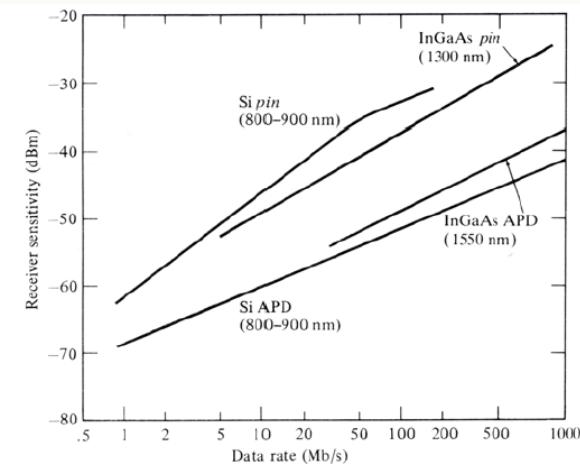
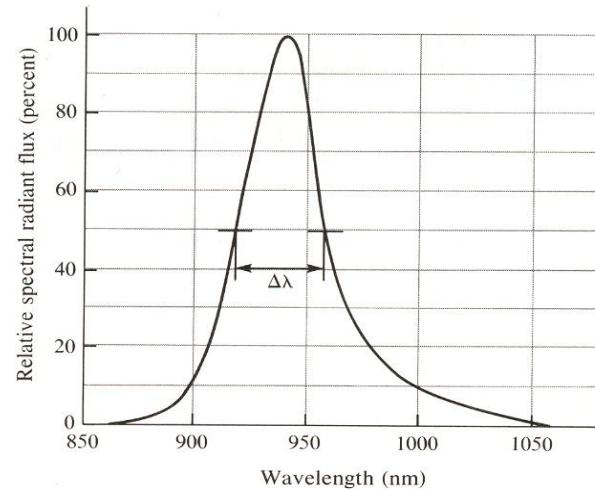
Low cost  
Long lifetime  
Low optical power

### LASER Diode (LD)

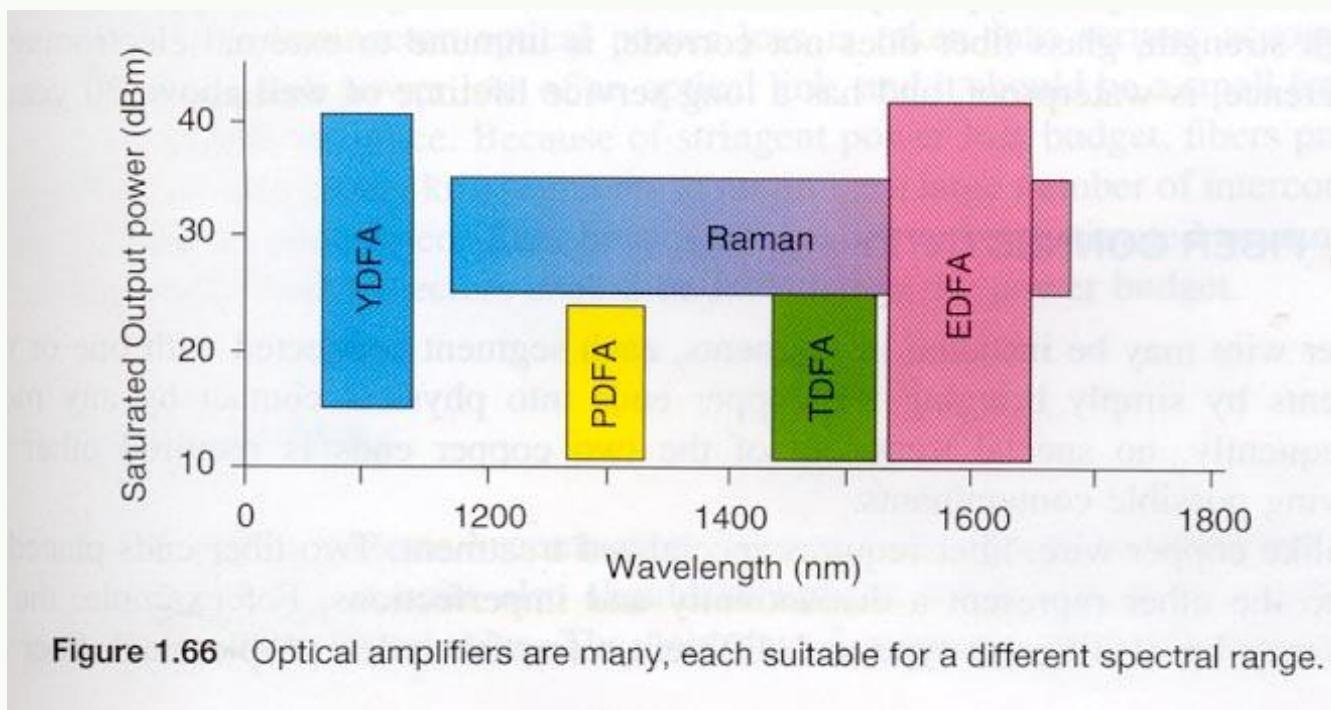


High coupling in fiber  
High optical power  
Small spectral width

**“Fibra oscura .....**



## *Amplificadores ópticos*



## ERBIUM DOPED OPTICAL FIBRE AMPLIFIER , EDFA.

The most important type of amplifier is the erbium doped fibre amplifier because it is low in cost (relatively), highly efficient and low in noise.

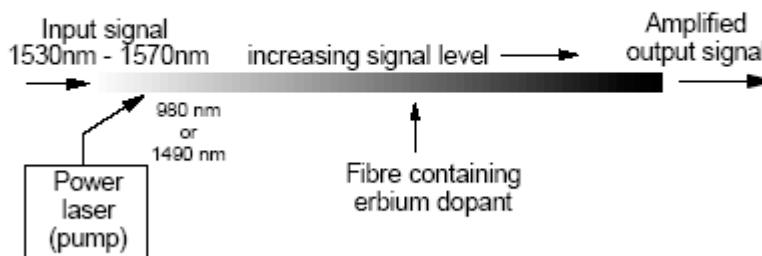


Figure 113. Erbium Doped Fibre Amplifier (EDFA) - Function

### 5.2.1.2 Gain Characteristics of EDFA

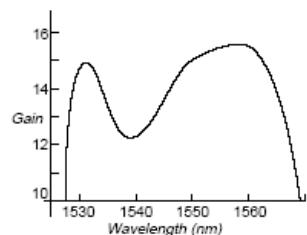


Figure 116. Gain Curve of a Typical EDFA

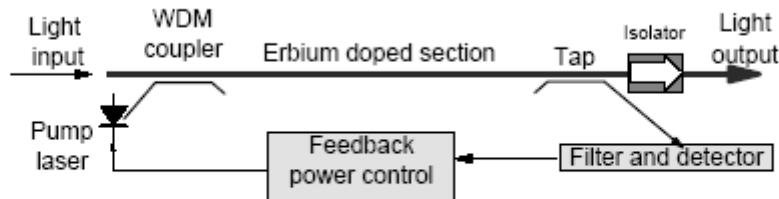
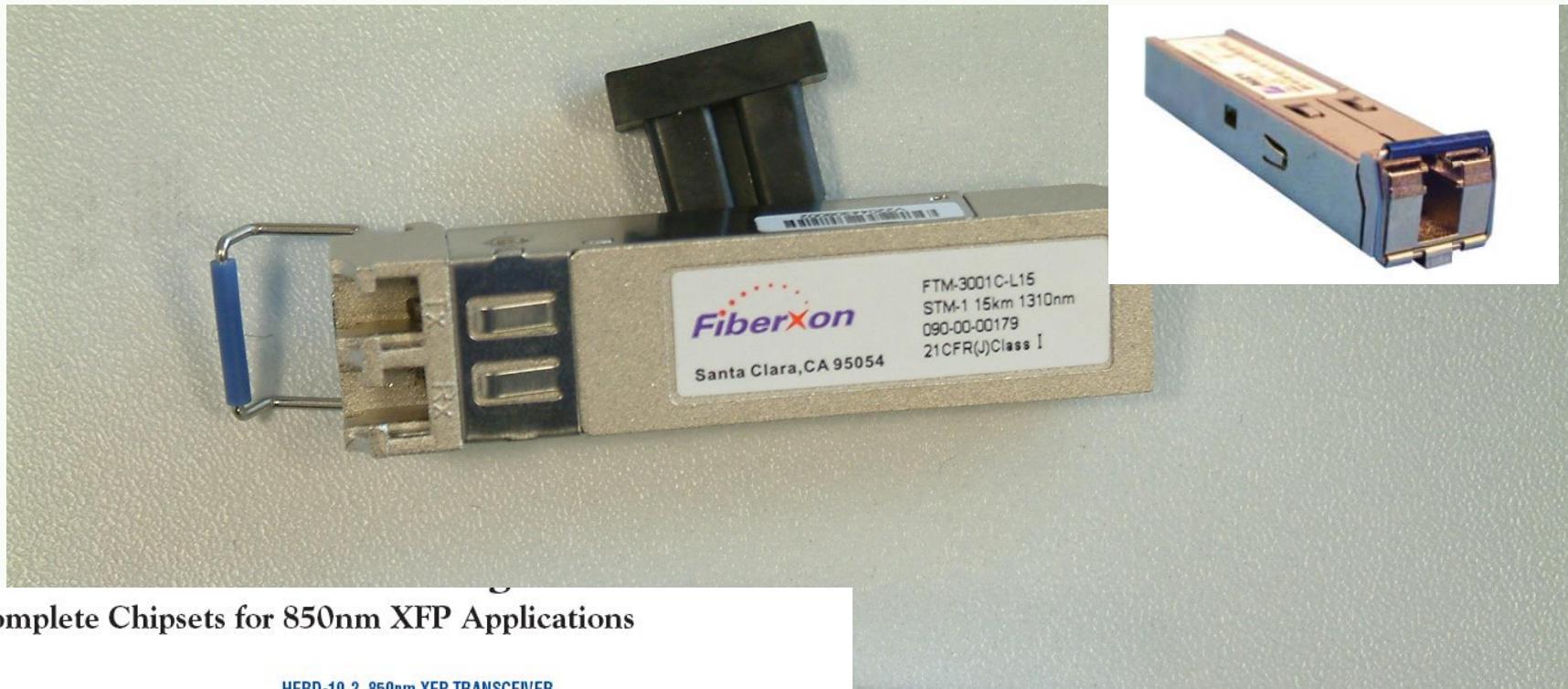


Figure 114. Erbium Doped Optical Fibre Amplifier. Although the device is powered electrically, the amplification process is totally optical and takes place within a short section of rare earth doped, single-mode fibre.

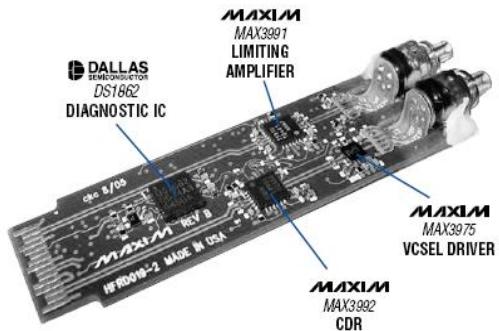


## Los SFP (small form-factor pluggable ) y los XFP



Complete Chipsets for 850nm XFP Applications

HFRD-19.2 850nm XFP TRANSCEIVER



(10 Gigabit Small Form Factor Pluggable Module)



# FIBRA OPTICA

## Utilización de uno o dos pelos de fibra..

Transmisión dentro de la fibra óptica

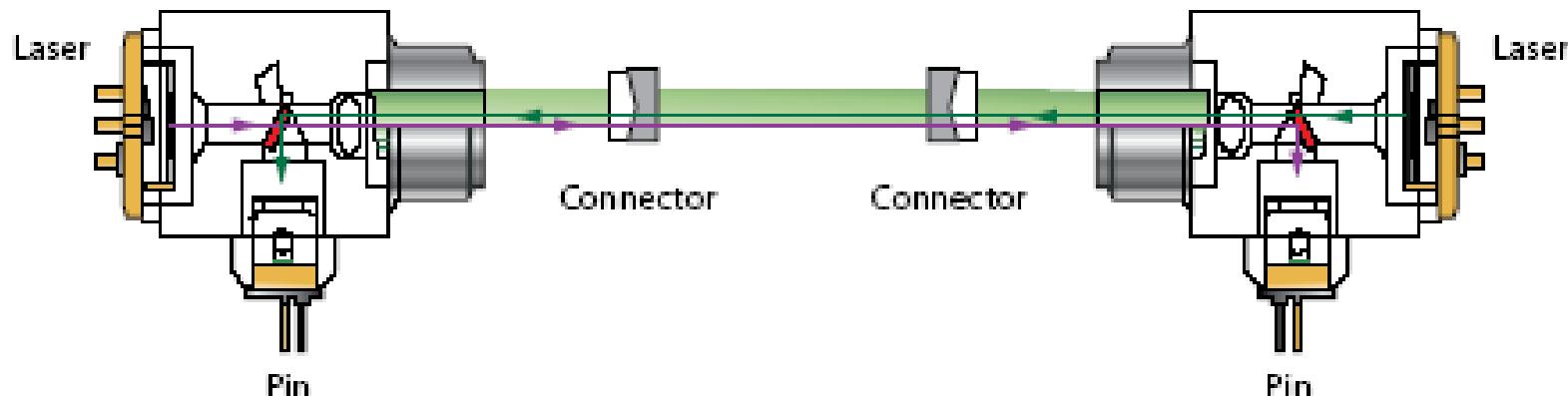
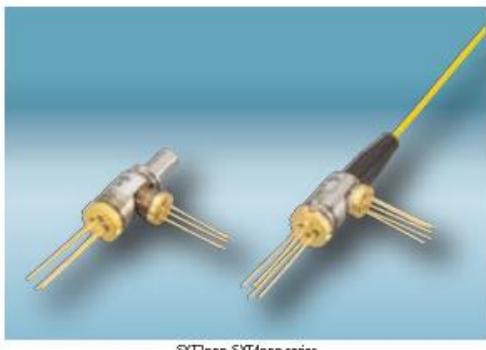


Figure 1: Single fiber, two wavelength integrated transceiver



### Diplexer (Receptacle Type)

Part Number	Laser Type	Pout	Tx Rate	Rx Rate
SXT2730	1310nm FP-LD	-2 to +3dBm	1.25Gbps	1.25Gbps
SXT2730	1310nm FP-LD	-9 to -3dBm	1.25Gbps	1.25Gbps
SXT2432	1490nm DFB-LD	-9 to -3dBm	1.25Gbps	1.25Gbps



## Features

- ◆ Up to 155Mbps data-rate
- ◆ 1310nm FP laser and PIN photodetector for 15km and 40km transmission
- ◆ 1550nm uncooled DFB laser and PIN photodetector for 80km transmission
- ◆ Digital diagnostic monitor interface Compatible with SFF-8472
- ◆ SFP MSA package with duplex LC connector
- ◆ With lever latch for easily removing
- ◆ Very low EMI and excellent ESD protection
- ◆ +3.3V single power supply
- ◆ Operating case temperature: 0 to +70°C

Part No.	Wavelength	Clasp Color Code	Distance
SFP-CWDM-80-47D	1470 nm	Gray	80Km
SFP-CWDM-80-49D	1490 nm	Violet	80Km
SFP-CWDM-80-51D	1510 nm	Blue	80Km
SFP-CWDM-80-53D	1530 nm	Green	80Km
SFP-CWDM-80-55D	1550 nm	Yellow	80Km
SFP-CWDM-80-57D	1570 nm	Orange	80Km
SFP-CWDM-80-59D	1590 nm	Red	80Km
SFP-CWDM-80-61D	1610 nm	Brown	80Km

19-3161; Rev 1; 7/04

EVALUATION KIT  
AVAILABLE**MAXIM**

## 155Mbps to 622Mbps SFF/SFP Laser Driver with Extinction Ratio Control

### Features

- ◆ Single +3.3V Power Supply
- ◆ 47mA Power-Supply Current
- ◆ 85mA Modulation Current
- ◆ 100mA Bias Current
- ◆ Automatic Power Control (APC)
- ◆ Modulation Compensation
- ◆ On-Chip Temperature Compensation
- ◆ Self-Biased Inputs for AC-Coupling
- ◆ Ground-Referenced Current Monitors
- ◆ Laser Shutdown and Alarm Outputs
- ◆ Enable Control and Laser Safety Feature

### General Description

The MAX3646 is a +3.3V laser driver designed for multirate transceiver modules with data rates from 155Mbps to 622Mbps. Lasers can be DC-coupled to the MAX3646 for reduced component count and ease of multirate operation.

Laser extinction ratio control (ERC) combines the features of automatic power control (APC), modulation compensation, and built-in thermal compensation. The APC loop maintains constant average optical power. Modulation compensation increases the modulation current in proportion to the bias current. These control loops, combined with thermal compensation, maintain a constant optical extinction ratio over temperature and lifetime.

The MAX3646 accepts differential data input signals. The wide 5mA to 60mA (up to 85mA AC-coupled) modulation current range and up to 100mA bias current range, make the MAX3646 ideal for driving FP/DFB lasers in fiber optic modules. External resistors set the required laser current levels. The MAX3646 provides transmit disable control (TX\_DISABLE), single-point fault tolerance bias current monitoring, and shutdown

**MAX3646**

### Ordering Information

PART	TEMP	PIN-	PKG
------	------	------	-----





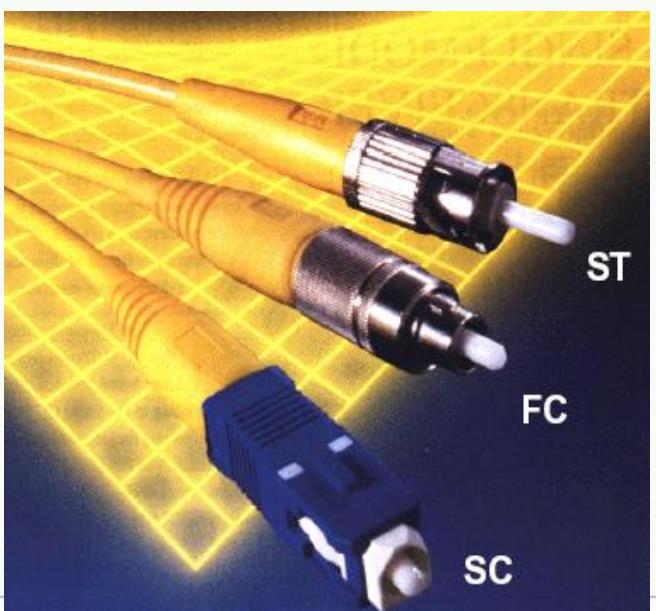
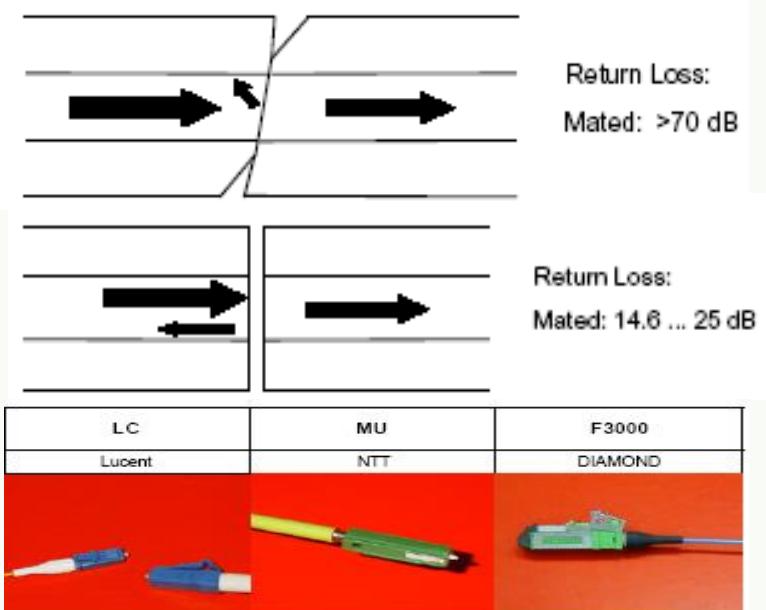
# FIBRA OPTICA

En equipos



**AT**

## Conectores



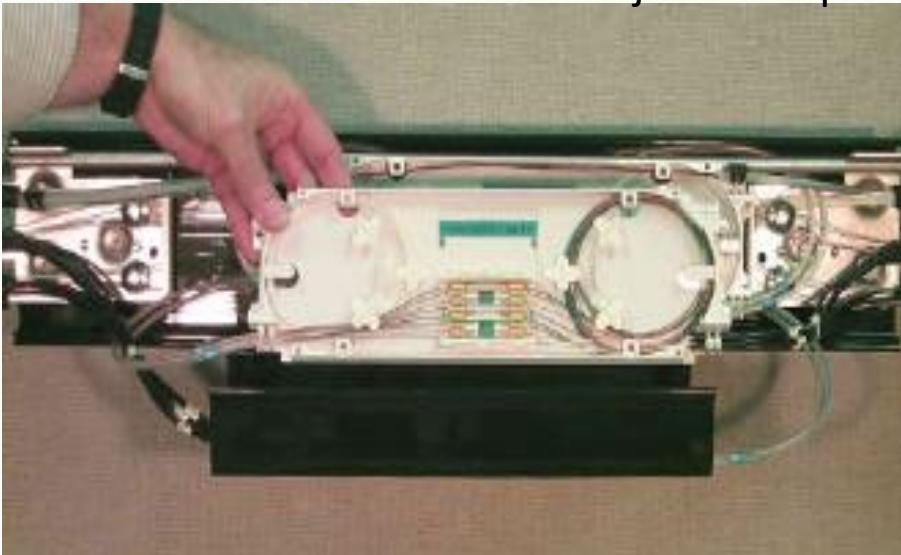
Connector Types	
Jacketed Fiber	900 $\mu$ m Fiber
FC Ultra PC Blue boot represents $\leq -55$ dB reflectance	FC Ultra PC   Drawing ZA-1441
FC Angled PC Green boot represents $\leq -70$ dB reflectance	FC Angled PC   Drawing ZA-1446
SC Ultra PC Blue boot represents $\leq -55$ dB reflectance	SC Ultra PC   Drawing ZA-1447
SC Angled PC Green boot represents $\leq -70$ dB reflectance	SC Angled PC   Drawing ZA-1451
LC Ultra PC Blue boot represents $\leq -55$ dB reflectance	LC Ultra PC   Drawing ZA-2387
LC Angled PC Green boot represents $\leq -70$ dB reflectance	LC Angled PC   Drawing ZA-2463
ST® Compatible Ultra PC Blue boot represents $\leq -55$ dB reflectance	ST Compatible Ultra PC   Drawing ZA-1457
MTP® Angled Connector Green boot represents $-55$ dB reflectance	MTP Angled Connector   Drawing ZA-2386
MT-RJ Reflectance of $-35$ dB	MT-RJ   Drawing ZA-2385

*Note: Drawings are not to scale.*

# FIBRA OPTICA : cajas de empalmes

## Cajas de empalme

AT

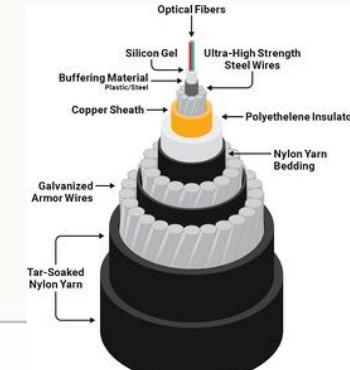
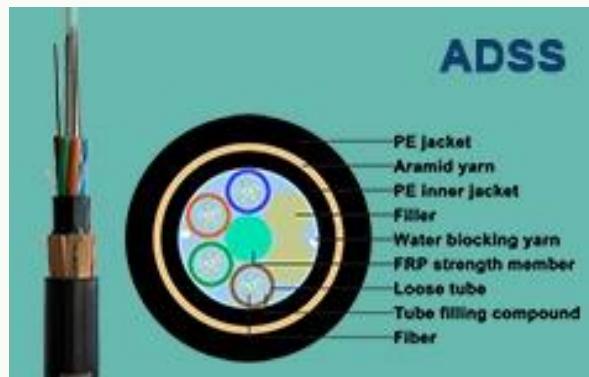
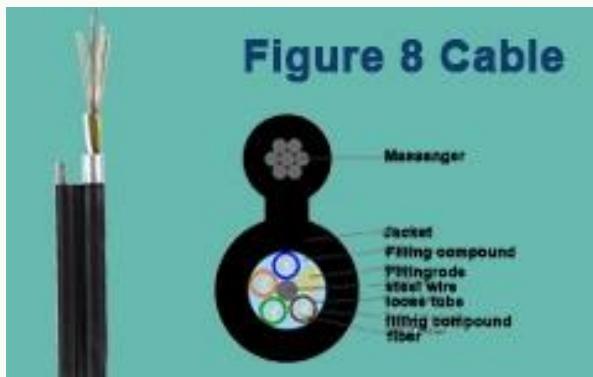


# TIPOS DE CABLES de FIBRA OPTICA

## Tipos de cables

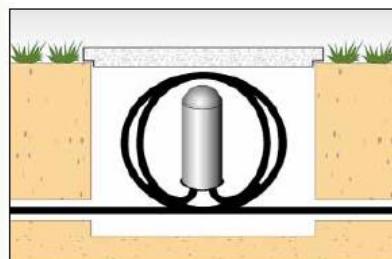
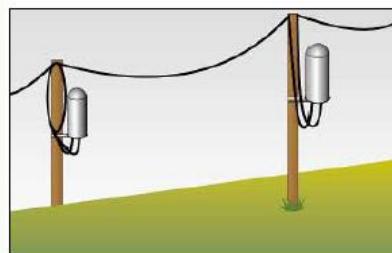
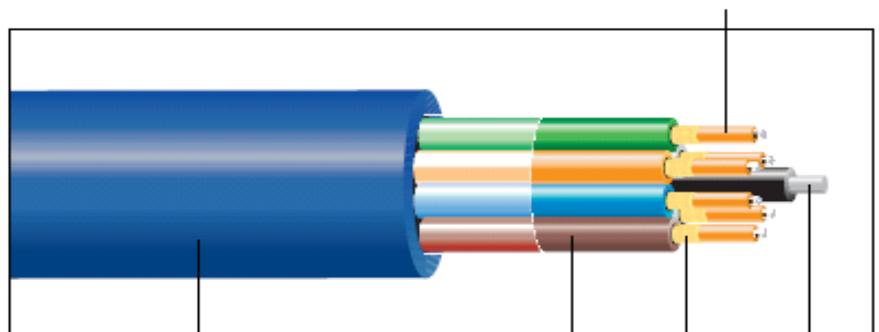
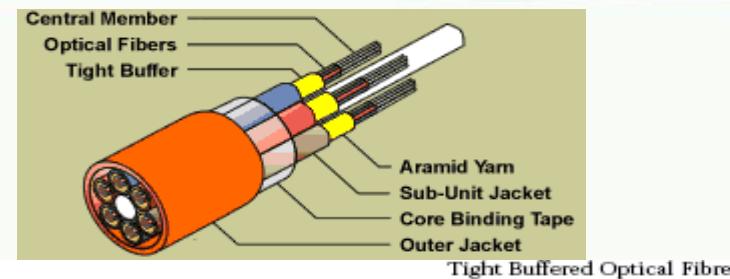
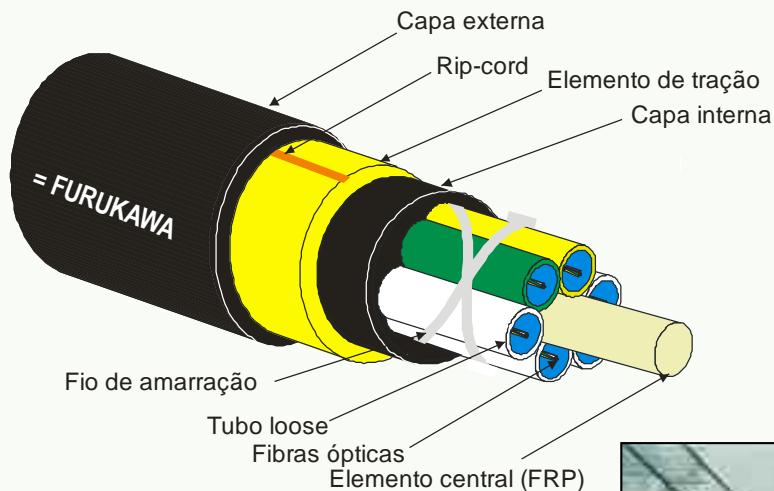
- Internos :  
Antillama /bajo emisión de humo sin alógenos
- Externos:  
depende de sus usos e instalación

- Aéreos:
  - Auto soportados
  - Figura 8
  - ADDS (totalmente dieléctrico ,ej debajo de redes eléctrica)
  - OPGW (por el hilo de guardia en redes eléctricas)
- Subterráneos
- Marítimos





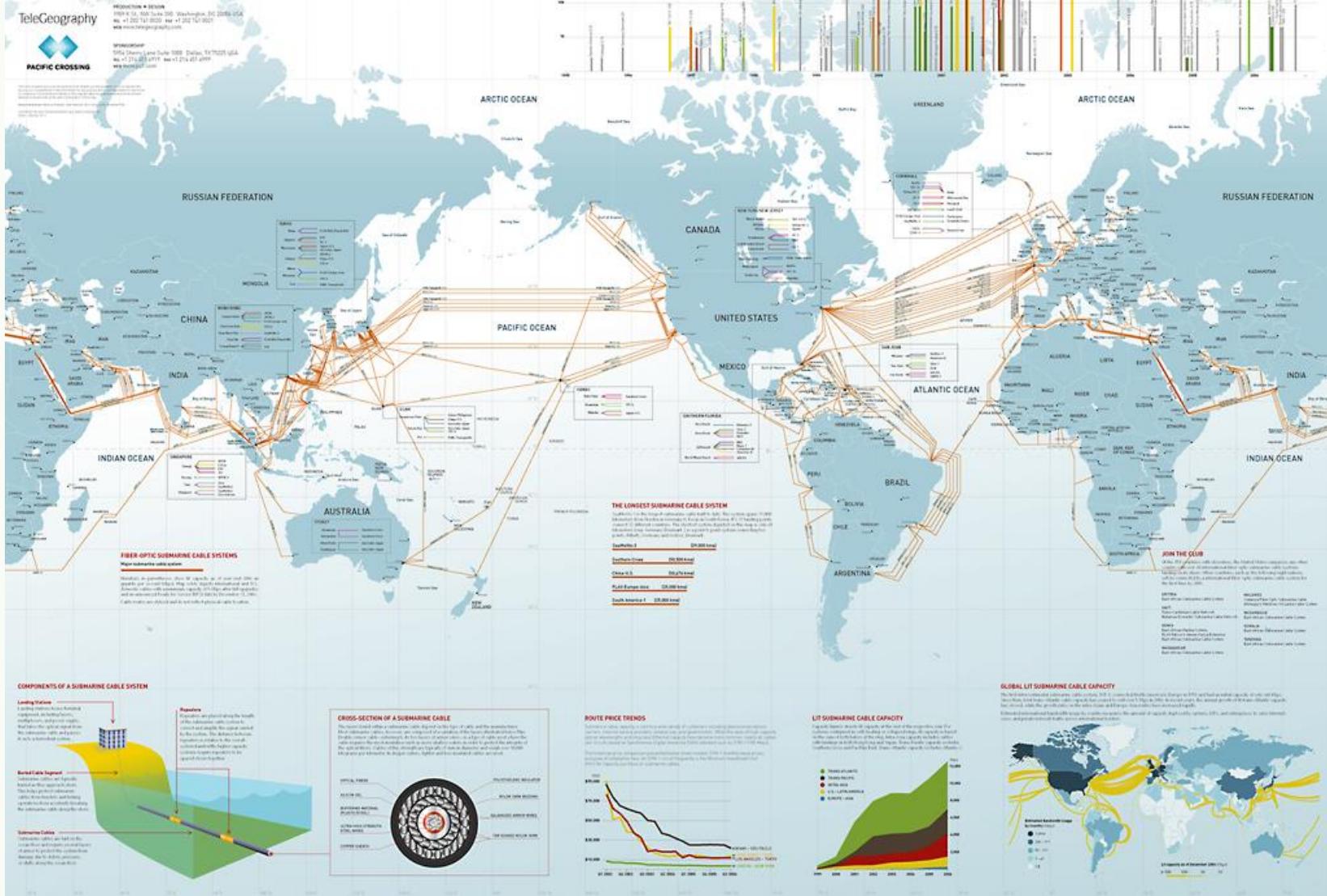
## Cables de Fibra Óptica....



# FIBRA OPTICA



## SUBMARINE CABLE MAP 2007

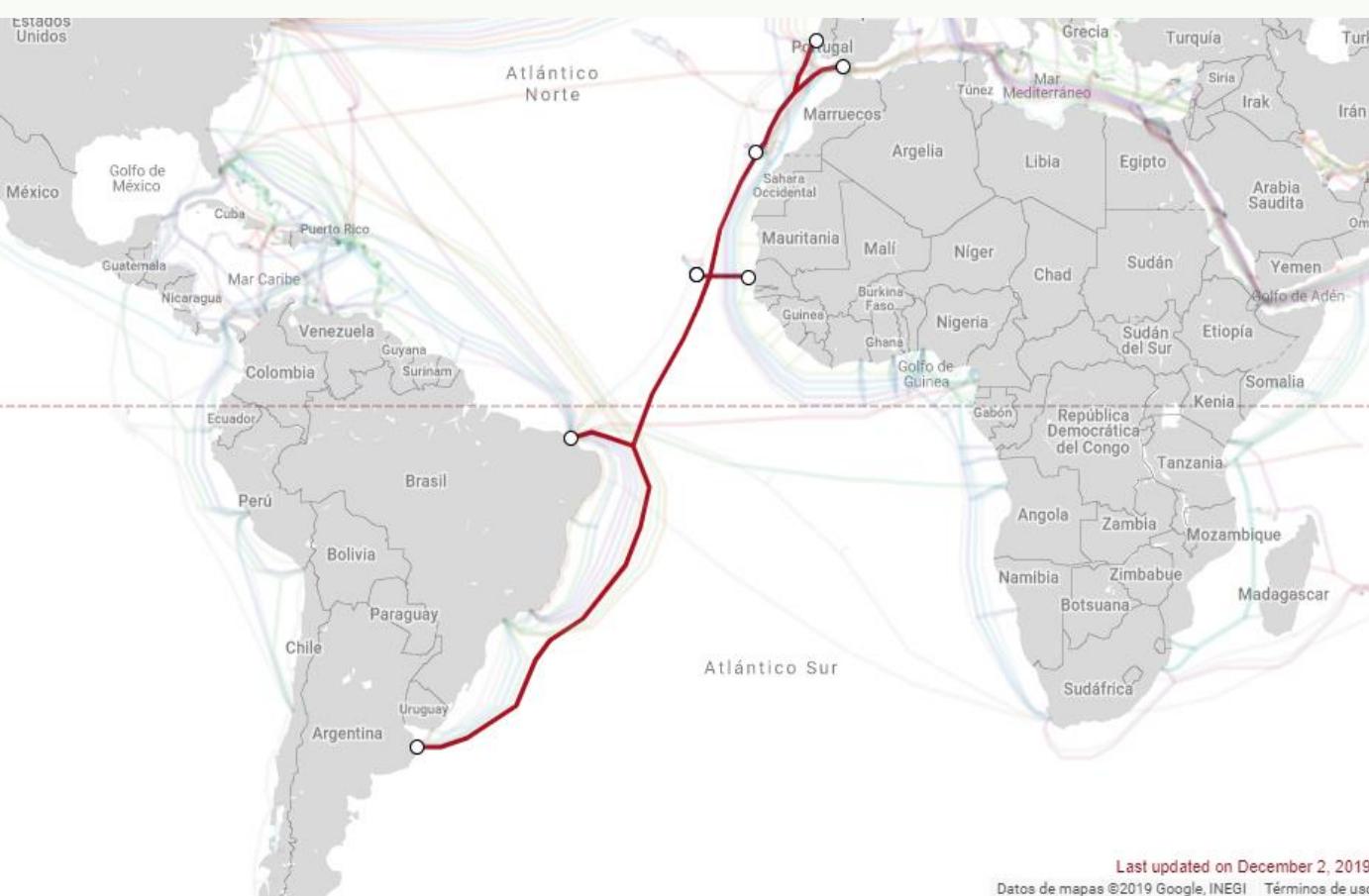


# FIBRA OPTICA

**AI**

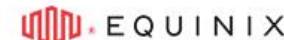


<https://www.submarinecablemap.com>



This submarine cable map is the most comprehensive, updated resource from TeleGeography.

Got a question about how we make this map? Or about how submarine cables work? Look no further.



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## Submarine Cable List

### Atlantis-2

[Email link](#)

RFS: 2000 February

Cable Length: 8,500 km

Owners: Embratel, Deutsche Telekom, Telecom Italia Sparkle, Telecom Argentina, Telxius, Portugal Telecom, Orange, Telefónica Larga Distancia de Puerto Rico, AT&T, BICS, KT, Singtel, Sprint, Tata Communications, Verizon, BT, Orange Polska  
URL: n.a.

## Landing Points

Carcavelos, Portugal

Conil, Spain

Dakar, Senegal

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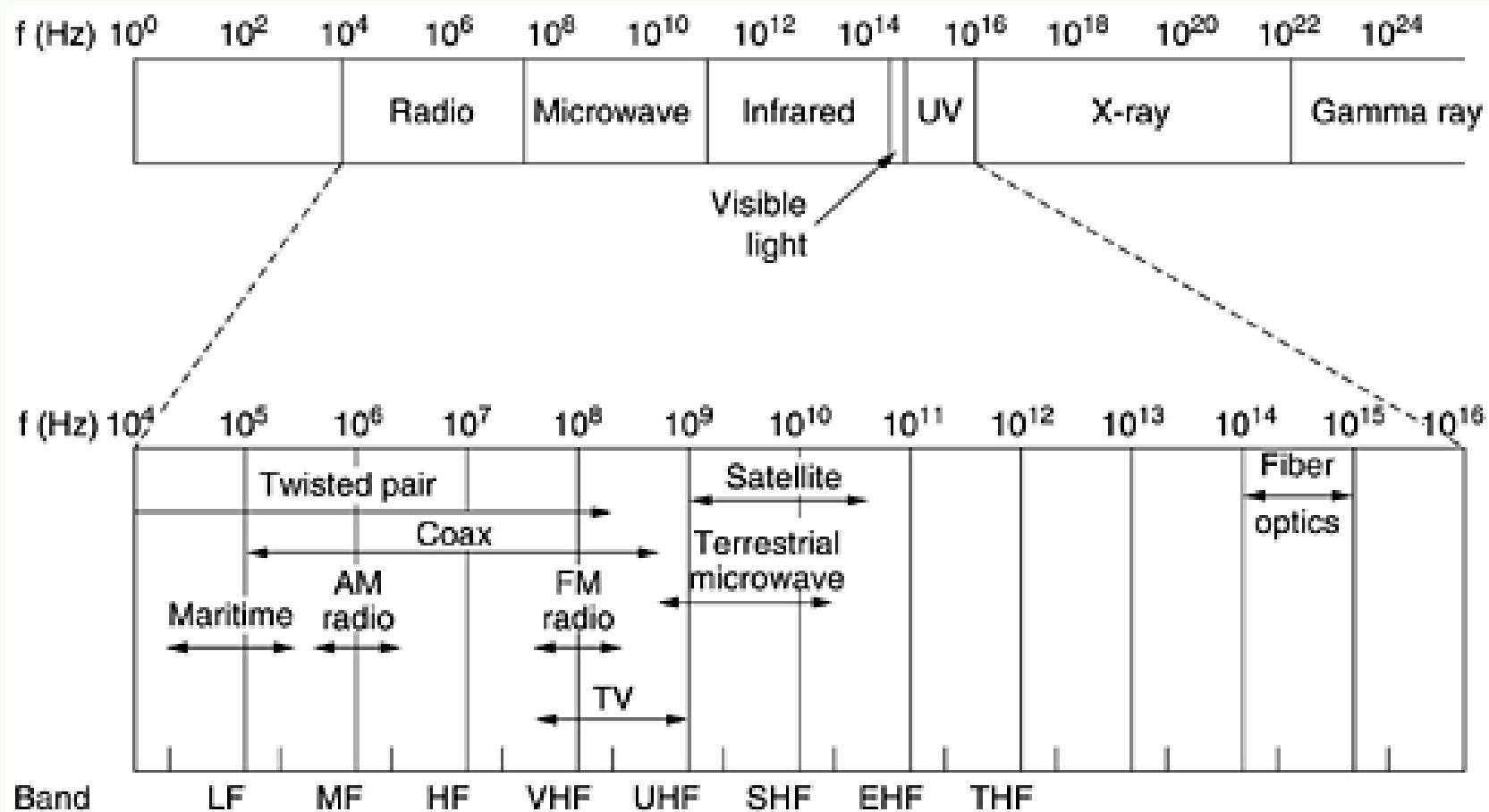
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Ministerio de Comunicaciones  
Presidencia de la Nación

## Principios que regirán la Ley de Comunicaciones Convergentes

- 10) El espectro radioeléctrico forma parte del patrimonio común de la humanidad y el Estado debe administrarlo conforme los criterios y parámetros que garanticen la pluralidad, diversidad y el respeto de los acuerdos y recomendaciones de la Unión Internacional de Telecomunicaciones (UIT). El procedimiento de adjudicación de licencias en servicios en competencia y que ocupen espectro radioeléctrico debe ser razonable, estar debidamente motivado, no incurrir en desviaciones de poder y posibilitar un adecuado control judicial. La cantidad de licencias y el ancho de banda que un prestador pueda ocupar serán establecidos conforme a la evolución de las tecnologías de la información y la comunicación, de modo tal de asegurar la competencia y el pluralismo.





# Nomenclatura en Radio Frecuencia, RF.

RF Spectrum				Microwave Bands	
band designations		frequency	wavelength	band	frequency
ELF	Extremely Low Frequency	30-300 Hz	1-10 Mm	L	1-2 GHz
VF	Voice Frequency	300-3000 Hz	100-1000 km	S	2-4 GHz
VLF	Very Low Frequency	3-30 kHz	10-100 km	C	4-8 GHz
LF	Low Frequency	30-300 kHz	1-10 km	X	8-12 GHz
MF	Medium Frequency	300-3000 kHz	100-1000 m	Ku	12-18 GHz
HF	High Frequency	3-30 MHz	10-100 m	K	18-27 GHz
VHF	Very High Frequency	30-300 MHz	1-10 m	Ka	27-40 GHz
UHF	Ultra High Frequency	300-3000 MHz	10-100 cm	V	40-75 GHz
SHF	Super High Frequency	3-30 GHz	1-10 cm		
EHF	Extremely High Frequency	30-300 GHz	1-10 mm		
	Submillimeter	300-3000 GHz	100-1000 μm		

band	wavelength	frequency
infrared	100-1 μm	3-300 THz
ultraviolet	400-10 nm	750 THz-30 PHz
X-Ray	10 nm-100 pm	30 PHz-3 EHz
γ-ray	< 100 pm	> 3 EHz

Visible Spectrum		
color	wavelength	frequency
red	780-620 nm	385-484 THz
orange	620-600 nm	484-500 THz
yellow	600-580 nm	500-517 THz
green	580-490 nm	517-612 THz
blue	490-450 nm	612-667 THz
violet	450-380 nm	667-789 THz

RF

Microwave

3 MHz

300MHz

300GHz [Frequency]

WLAN



# UNITED

# STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

## RADIO SERVICES COLOR LEGEND

AERONAUTIC WORLD	WATER	RELAY/TELECOM
AERONAUTIC WORLD SAT	LAND/WORLD	RELAY/TELECOM SATELLITE
AERONAUTIC SATELLITE	LAND/WORLD SATELLITE	RELAY/TELECOM SATELLITE
AMATEUR	WATER MOBILE	RELAY/TELECOM MOBILE
AMATEUR SATELLITE	LAND/WORLD MOBILE	RELAY/TELECOM MOBILE
AMATEUR SATELLITE	LAND/WORLD SATELLITE	RELAY/TELECOM SATELLITE
EMERGENCY	WATER FREQUENCY	RELAY/TELECOM FREQUENCY
EMERGENCY SATELLITE	LAND/WORLD FREQUENCY	RELAY/TELECOM FREQUENCY
GOVERNMENT	WATER RESEARCH	RELAY/TELECOM RESEARCH
GOVERNMENT SATELLITE	LAND/WORLD RESEARCH	RELAY/TELECOM RESEARCH
FCC	WORLD	STANDAR FREQUENCY AND TIME SIGNAL
FCC SATELLITE	WORLD SATELLITE	STANDAR FREQUENCY AND TIME SIGNAL SATELLITE

## ACTIVITY CODE

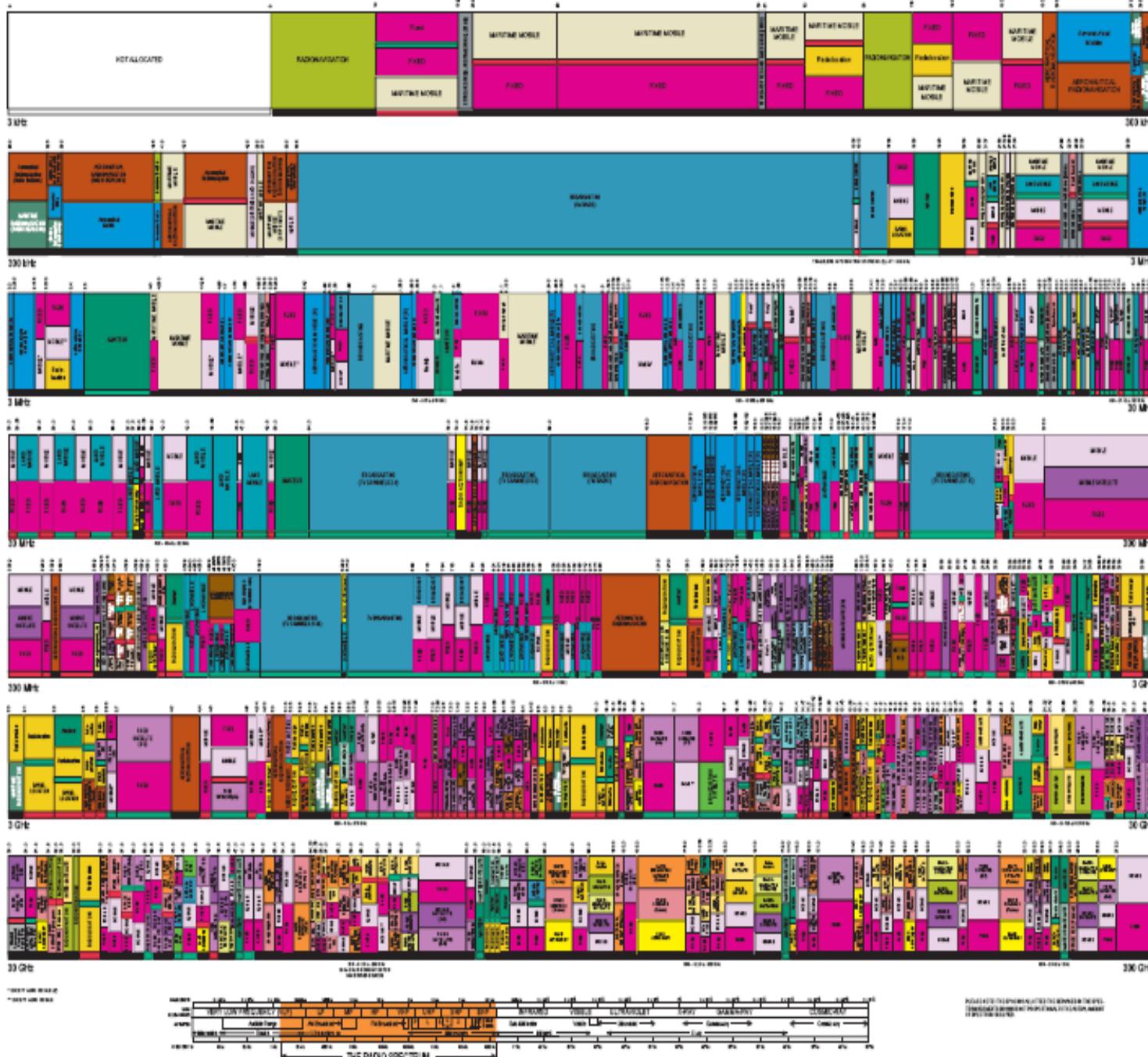
GOVERNMENT EXCLUSIVE	GOVERNMENT WITH COMMERCIAL USE
NON GOVERNMENT EXCLUSIVE	

## ALLOCATION USAGE DESIGNATION

SERVICE	CLASS	DESCRIPTION
Primary	Fixed	Capable of being used exclusively for fixed point-to-point communications.
Secondary	Mobile	Capable of being used exclusively for mobile point-to-point communications.

This document is provided as a service by the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce. It is not a formal publication of the NTIA or the U.S. Government. It is intended to provide general information about frequency allocations and usage designations. It is not a substitute for the Radio Frequency Allocation Tables published in the Federal Communications Commission's (FCC) Rules and Regulations. The FCC's Rules and Regulations are the official source of frequency allocation and usage information.

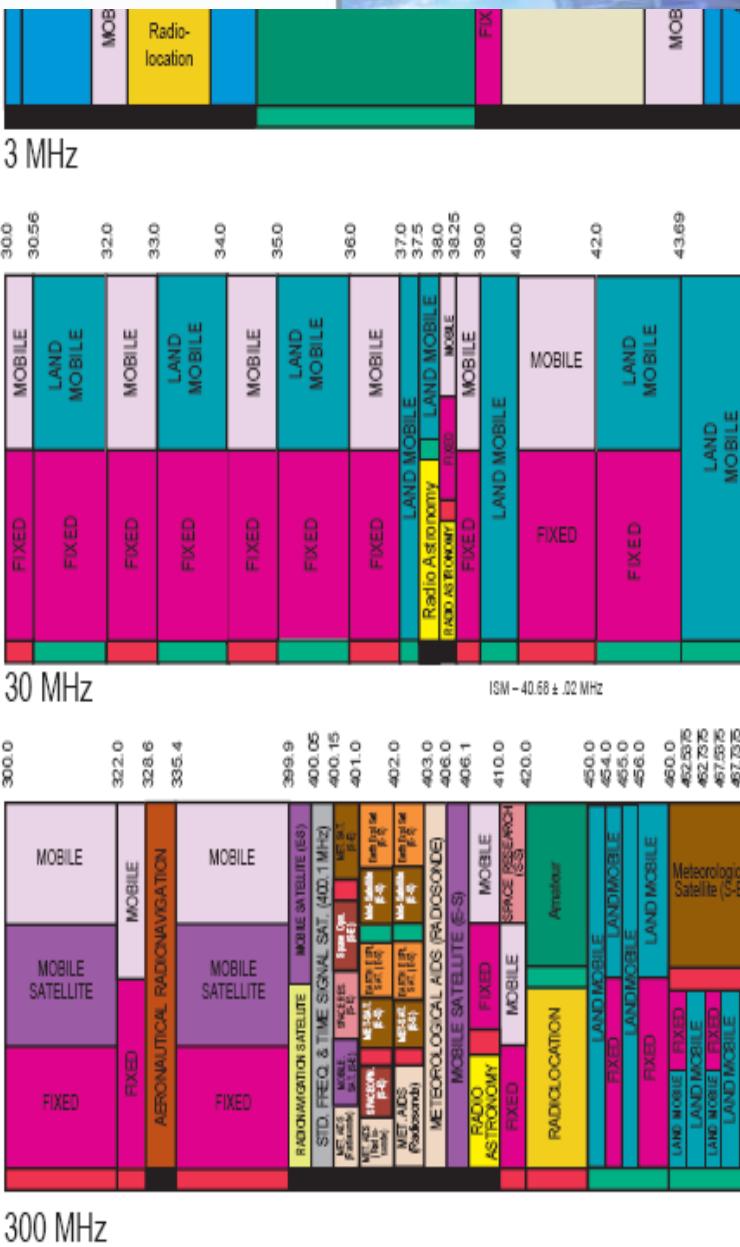
# Comunicaciones por Radio frecuencias



# THE RADIO SPECTRUM

## RADIO SERVICES COLOR LEGEND

AERONAUTICAL MOBILE	INTER-SATELLITE	RADIO ASTRONOMY
AERONAUTICAL MOBILE SATELLITE	LAND MOBILE	RADIODETERMINATION SATELLITE
AERONAUTICAL RADIONAVIGATION	LAND MOBILE SATELLITE	RADIOLOCATION
AMATEUR	MARITIME MOBILE	RADIOLOCATION SATELLITE
AMATEUR SATELLITE	MARITIME MOBILE SATELLITE	RADIONAVIGATION
BROADCASTING	MARITIME RADIONAVIGATION	RADIONAVIGATION SATELLITE
BROADCASTING SATELLITE	METEOROLOGICAL AIDS	SPACE OPERATION





# El organismo que controla el uso de RF en Argentina

COMISIÓN NACIONAL DE COMUNICACIONES INSTITUCIONAL USUARIOS INFORMACIÓN TÉCNICA GUÍA DE TRÁMITES

INFORMACIÓN TÉCNICA VOLVER

ESPECTRO RADIOELECTRICO | USO DEL ESPECTRO



SERVICIOS

- Servicio Fijo de Datos
- Sistemas Troncalizados
- Radio Taxi
- Banda 450 MHz
- Celulares
- Localización de Vehículos

USO PRIVADO

- Modalidad Compartida
- Modalidad Exclusiva

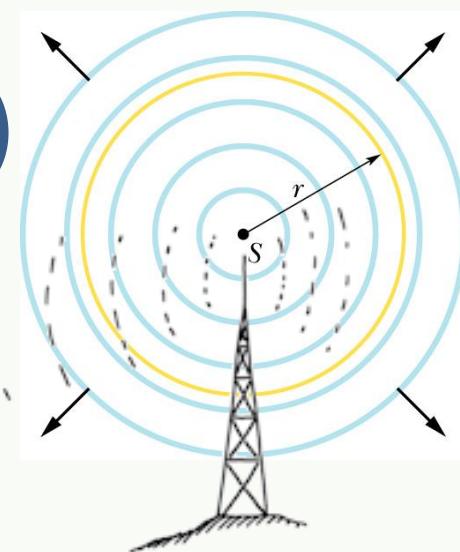
<http://www.enacom.gov.ar/>

# Fundamentos de RF

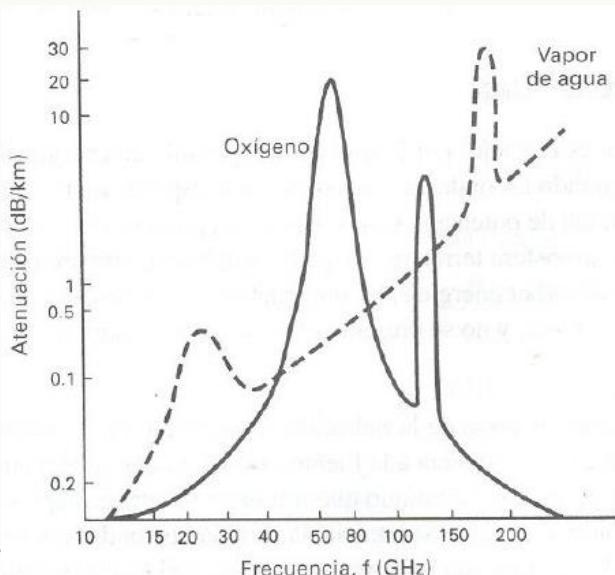
- **Velocidad de propagación :** ?
  - Afectado por :
    - Barometric pressure
    - Humidity
    - Molecular content
    - Density
  - No afectado por frecuencia

**Medio Isotrópico :**

$$I = \frac{P_s}{4\pi r^2}$$



## Atenuación



# Fundamentos de RF

- **Velocidad de propagación :** ?

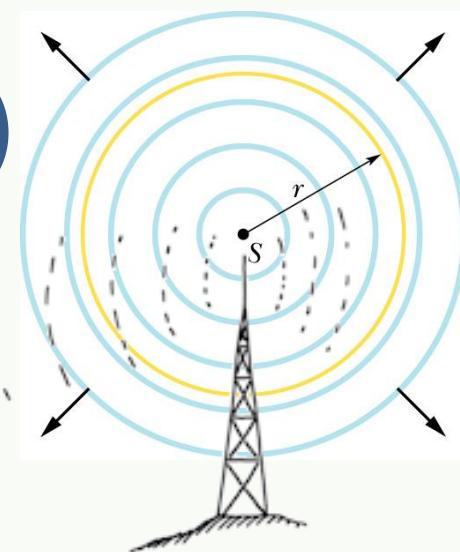
- Afectado por :

- Barometric pressure
  - Humidity
  - Molecular content
  - Density

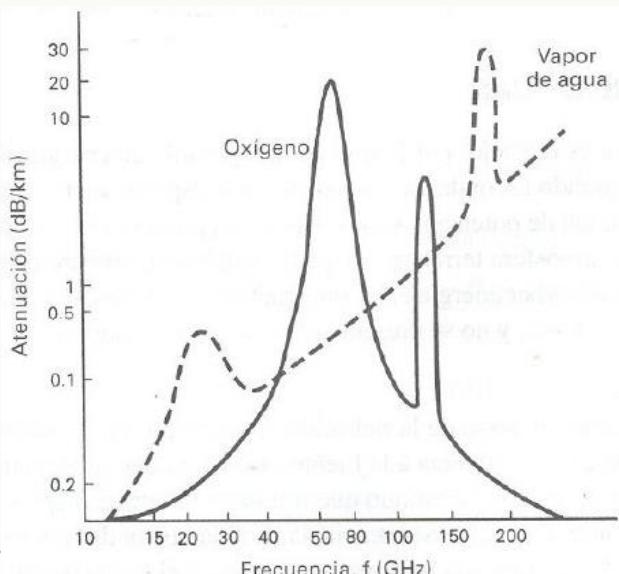
- No afectado por frecuencia

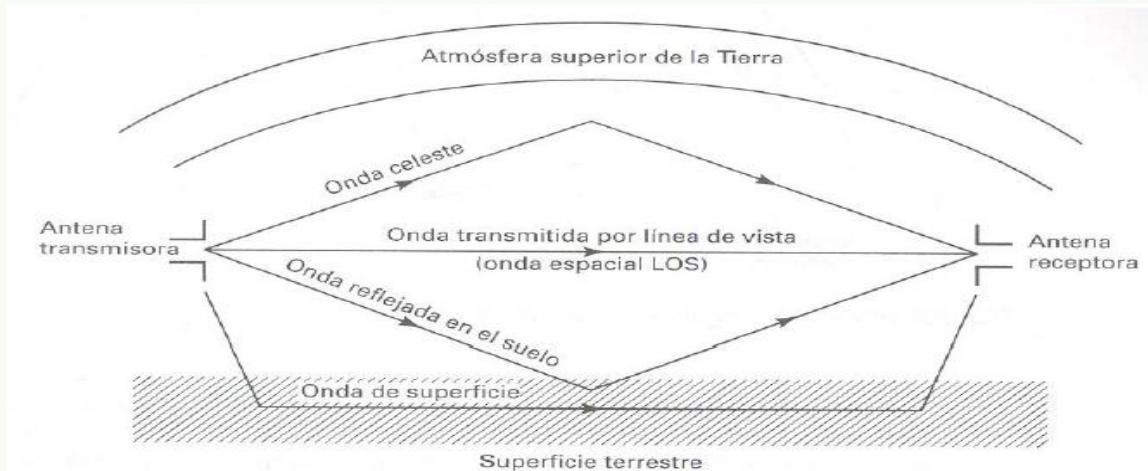
**Medio Isotrópico :**

$$I = \frac{P_s}{4\pi r^2}$$



## Atenuación





**Línea de vista (Line of Sight, LOS) :** (NLoS)non-line-of-sight

La curvatura de la tierra

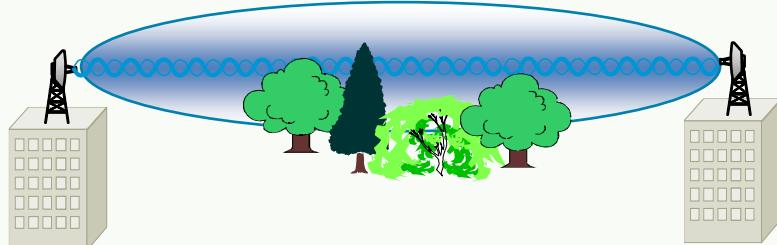
Reflexión

Difracción

Scattering



## Zona de Fresnel



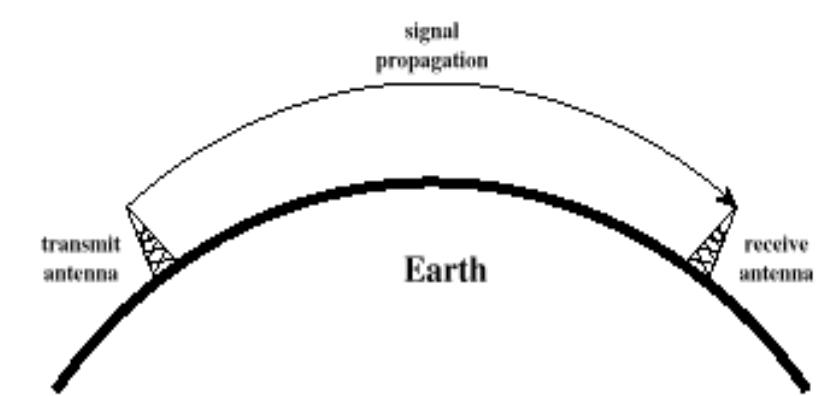
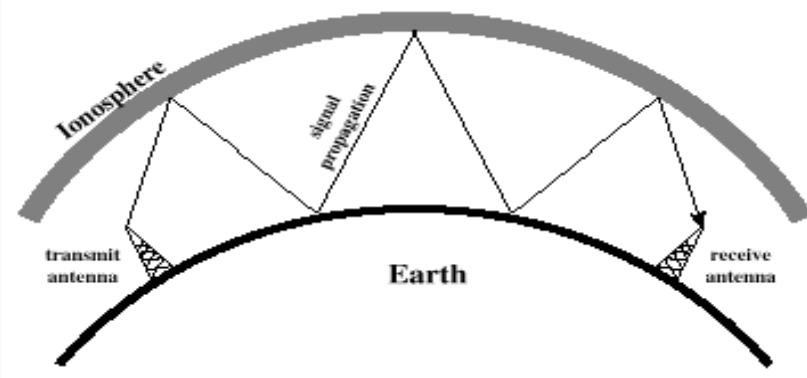
**Fadding:**

Signal fluctuations

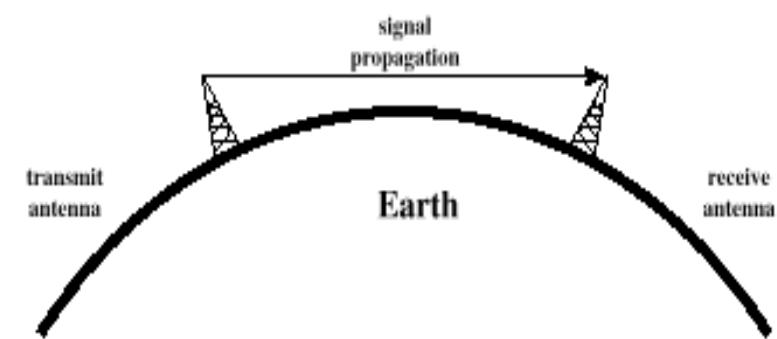
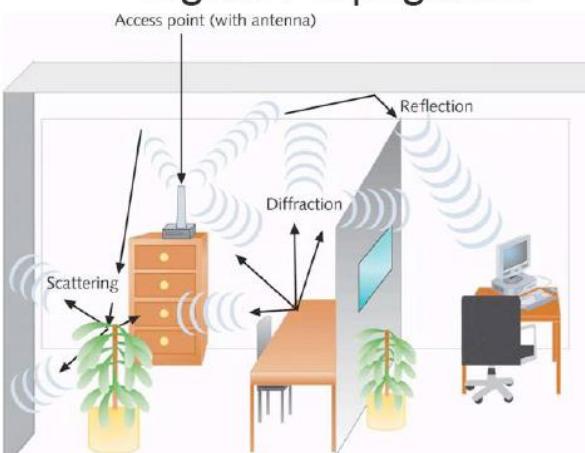
(En amplitud y fase)

**AC**

Formas de propagación de ondas electromagnéticas (depende de la frecuencia utilizada)



### Signal Propagation



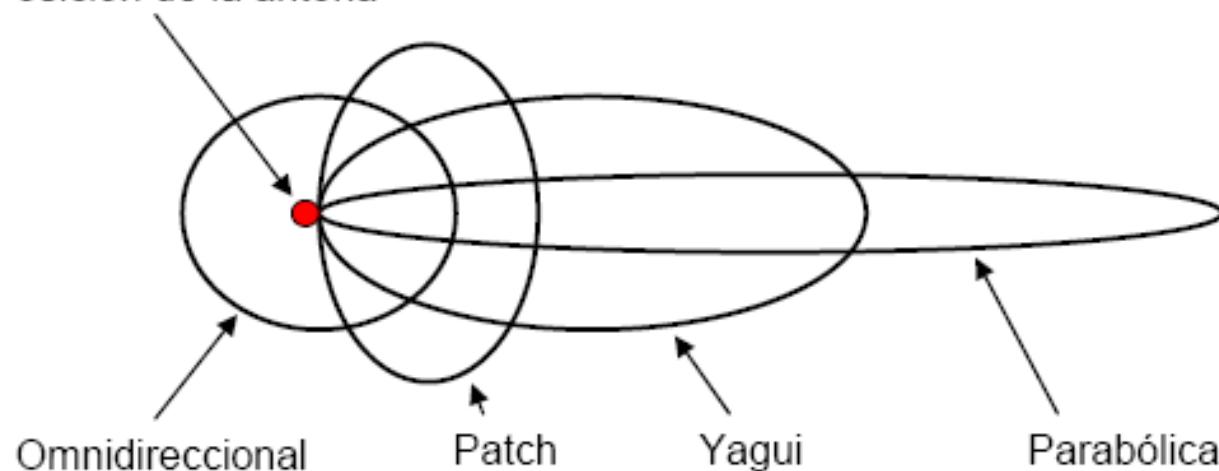


## ANTENAS

*Estructura de las Telecomunicaciones*

Distintos tipos de antenas según su radiación:

Posición de la antena





Esta terminología no es utilizada en nuestra legislación de comunicaciones, pero resulta corriente en la jerga del sector. En el ámbito nacional, tanto la circunstancia de que nuestro país se encuentre comprendido en la Región 2 (Américas) de UIT y, en consecuencia, comparta lo ordenado por el Reglamento de Radiocomunicaciones sobre el uso del espectro en esa Región, como las condiciones imperantes en el mercado de equipos y servicios, resultan determinantes en la orientación de las atribuciones de frecuencia de nuestra Administración. De ahí resulta que en nuestro país se hayan destinado varias bandas para esta modalidad de uso.

Conviene destacar que el Reglamento de Radiocomunicaciones de UIT ha destinado a nivel mundial (y en algún caso, regional) bandas para uso primario para las aplicaciones Industriales, Científicas y Médicas (ICM). La Nota de Pie 5.150 dice:

"Las bandas:

- 13.553-13.567 kHz (frecuencia central 13.560 kHz),
- 26.957-27.283 kHz (frecuencia central 27.120 kHz),
- 40,66-40,70 MHz (frecuencia central 40,68 MHz),
- 902-928 MHz en la Región 2 (frecuencia central 915 MHz),
- 2.400-2.500 MHz (frecuencia central 2.450 MHz),
- 5.725-5.875 MHz (frecuencia central 5.800 MHz) y
- 24-24,25 GHz (frecuencia central 24,125 GHz),

están designadas para aplicaciones industriales, científicas y médicas (ICM). Los servicios de radiocomunicación que funcionan en estas bandas deben aceptar la interferencia perjudicial resultante de estas aplicaciones."

InfoLEG Informaci  
Legislativa



Boletín Oficial de la  
República Argentina



REGIMEN COMPRE TRABAJO ARGE  
Argentina Compra

[www.tvdigitalargentina.gov.ar](http://www.tvdigitalargentina.gov.ar)



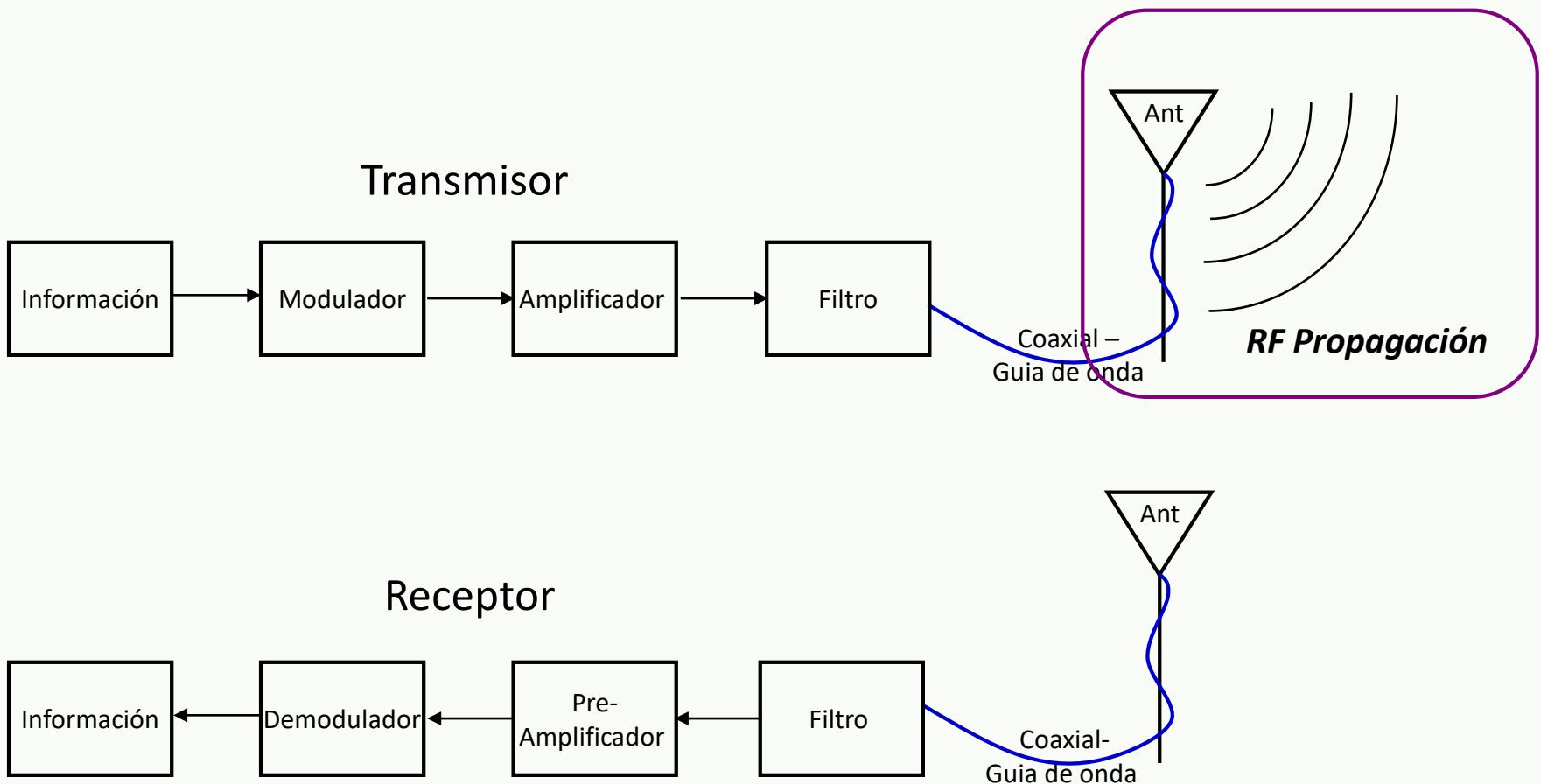
Argentin  
[www.argentina.gob.ar](http://www.argentina.gob.ar)

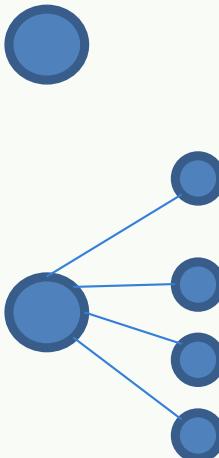
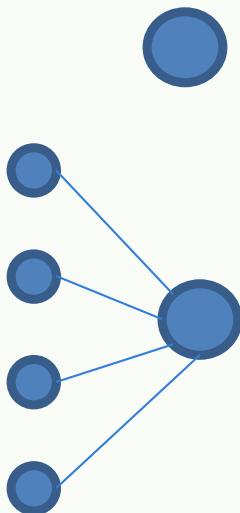


200 AÑOS  
BICENTENARIO  
ARGENTINO

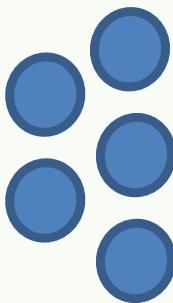


# Sistema de radio

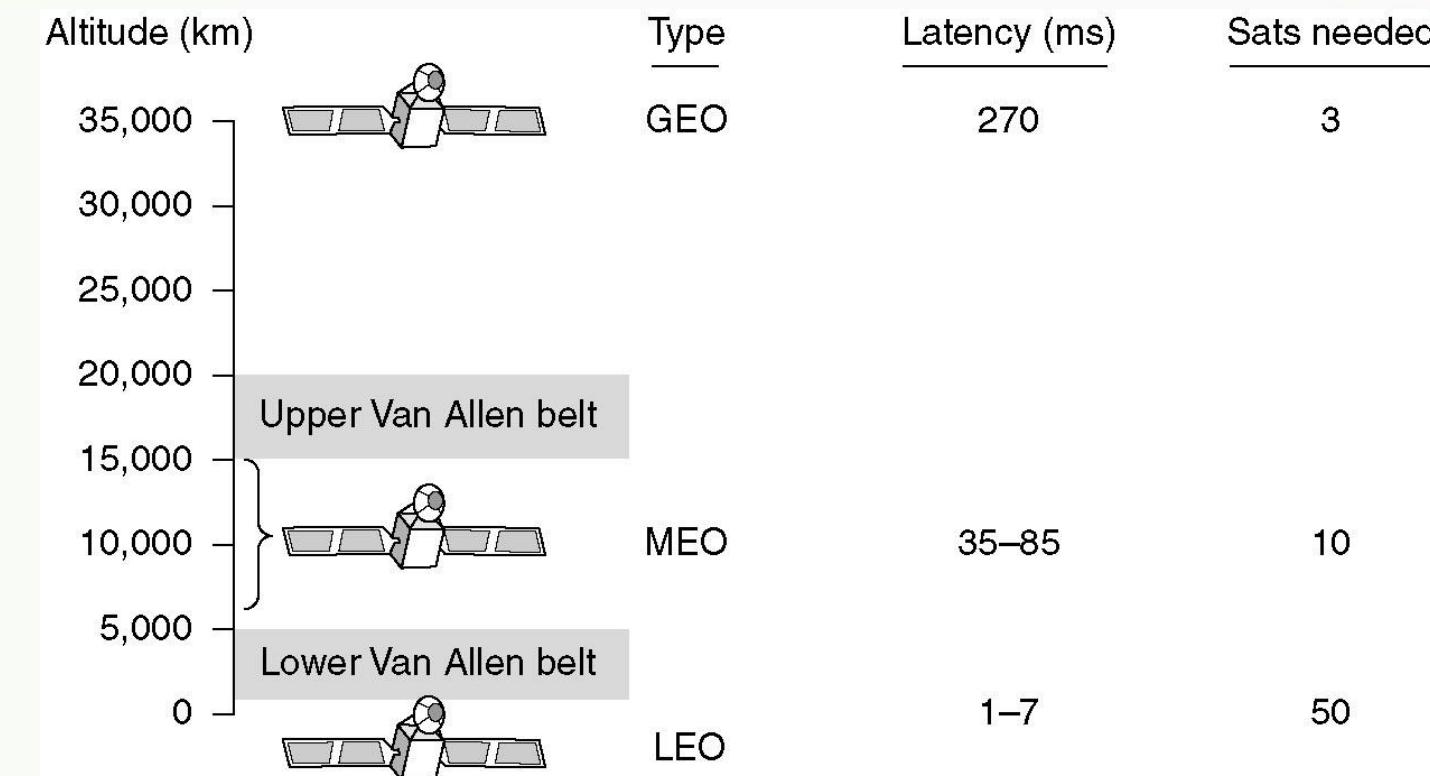




Punto a Punto



Multipunto



Band	Downlink	Uplink	Bandwidth	Problems
L	1.5 GHz	1.6 GHz	15 MHz	Low bandwidth; crowded
S	1.9 GHz	2.2 GHz	70 MHz	Low bandwidth; crowded
C	4.0 GHz	6.0 GHz	500 MHz	Terrestrial interference
Ku	11 GHz	14 GHz	500 MHz	Rain
Ka	20 GHz	30 GHz	3500 MHz	Rain, equipment cost



# Comunicaciones por Radio frecuencias

## The Satellite Size Spectrum

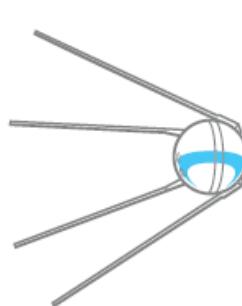
As space applications have grown, so has satellite diversity. The spacecraft shown here are all too large to effectively use planetary magnetic fields or solar pressure for propulsion. Sprites, if they could be made to weigh less than 50 milligrams, could do both.

### SPUTNIK 1

*First artificial satellite*

**MASS:** 83.6 kilograms

**SIZE:** 58-centimeter-diameter sphere, with whiskerlike antennas measuring 2.4 and 2.9 meters



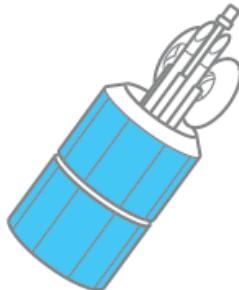
1957

### INTELSAT 4 F-3

*International communications satellite*

**MASS:** 1410 kg

**SIZE:** 5.3 meters long, with antenna



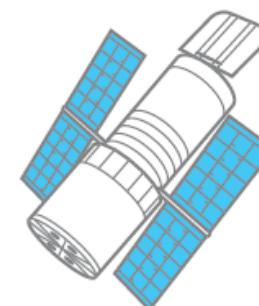
1971

### HUBBLE SPACE TELESCOPE

*World's most massive space telescope*

**MASS:** 11 110 kg

**SIZE:** 13.2 meters long



1990

42 INT • IEEE SPECTRUM • AUGUST 2011

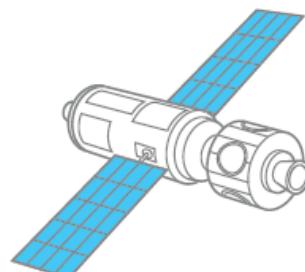
[SPECTRUM.IEEE.ORG](http://SPECTRUM.IEEE.ORG)

### ZARYA

*First International Space Station module*

**MASS:** 19 323 kg

**SIZE:** 12.6 meters long

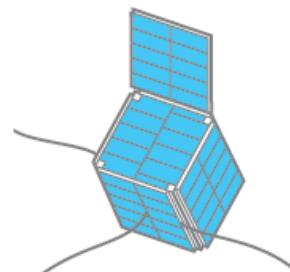


### CUTE-1

*One of the first standardized miniature CubeSats*

**MASS:** 1 kg

**SIZE:** 10-cm-wide cube

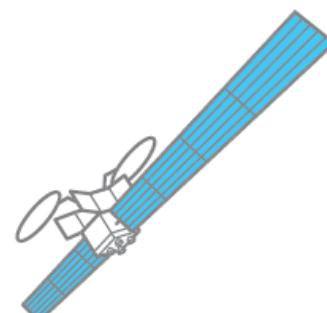


### XM-3

*Commercial radio satellite*

**MASS:** 2800 kg

**SIZE:** 47.9 meters from the end of one solar panel to the other

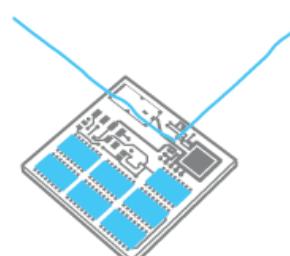


### SPRITE PROTOTYPES

*Test chips attached to International Space Station*

**MASS:** 10 grams

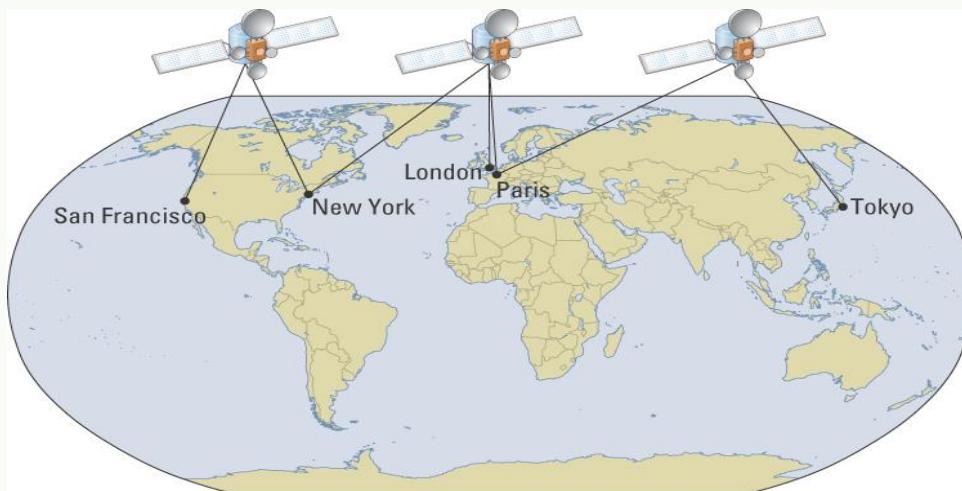
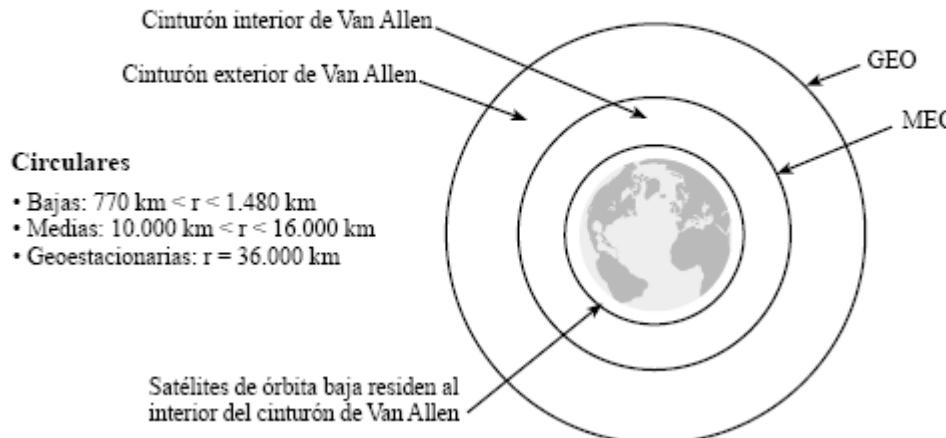
**SIZE:** 3.8- by 3.8-cm boards



# Comunicaciones por Radio frecuencias

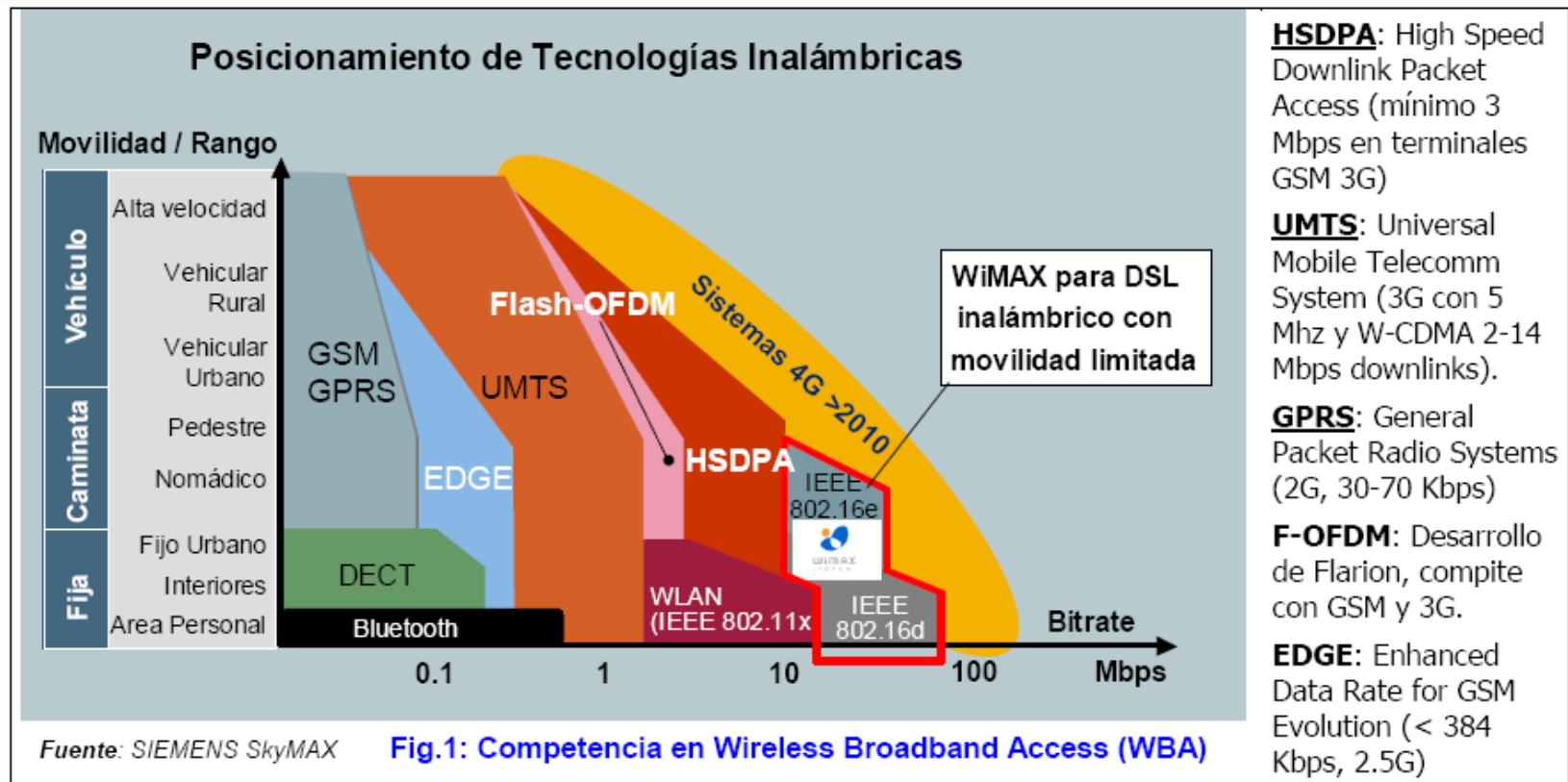


## Órbitas usadas por los sistemas satelitales



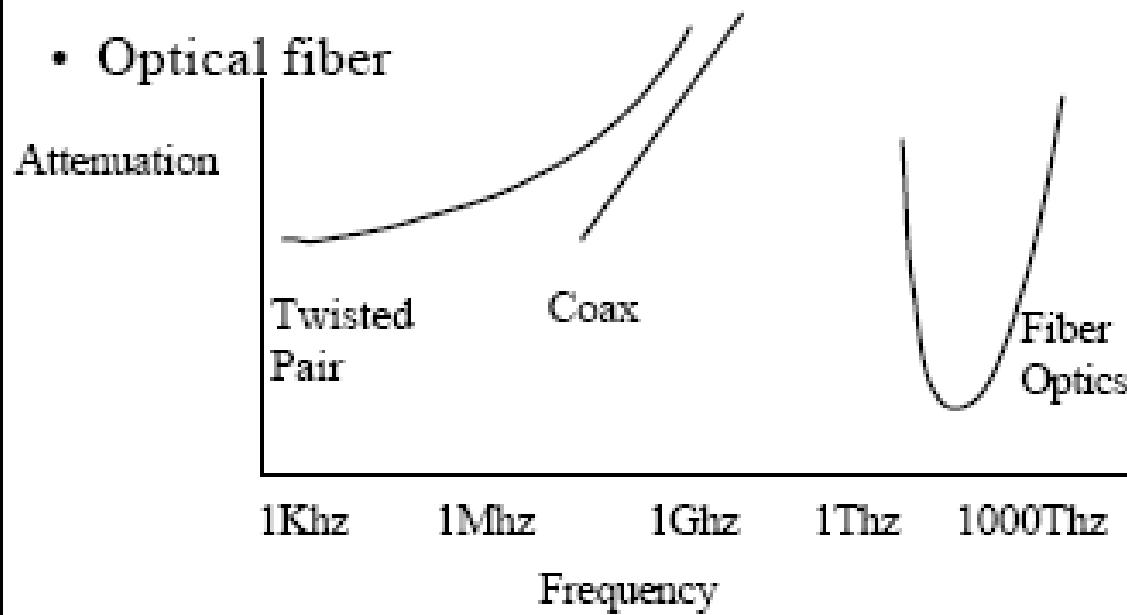
## GEOs, MEOs & LEOs

- GEO = Geostationary Satellites - 36,000 km. Intelsat, Inmarsat, Panamsat, Orion, etc.
- MEO = Orbita Media - 10.000 km.
  - Grandes MEOs operan sobre 1 GHz, principalmente voz. ICO (12 satélites)
- LEO = Satélites de órbita baja - 770 a 1.500 km.
  - Grandes LEOs operan sobre 1 GHz. Voz: IRIDIUM (66 satélites), GLOBALSTAR (48 satélites)
  - Multimedial: TELEDESIC (288 satélites), SKY-BRIDGE (80 satélites)
  - LEOs operan en VHF, sólo datos y posicionamiento. ORBCOMM (48 satélites), VITA (2 satélites), ISIS.



## Guided Transmission Media

- Twisted Pair
- Coaxial cable
- Optical fiber





## Especificaciones IEEE 802.11

IEEE 802.11	Nombre	Modulación	Streams	Canales	Banda	Mbps / stream	Incorporación Tecnologías
802.11a	WiFi 1	64 QAM	N/A	20 Mhz	5 Ghz	54 Mbps	
802.11b	WiFi 2	64 QAM	N/A	20 Mhz	2,4 Ghz	11 Mbps	
802.11g	WiFi 3	64 QAM	N/A	20 Mhz	2,4 Ghz	54 Mbps	
802.11n	WiFi 4	64 QAM	4	20, 40 Mhz	2,4 y 5 Ghz	150 Mbps	MIMO (SU-MIMO), Channel Bonding
802.11ac wave 1	WiFi 5	256 QAM	4	20, 40, 80 Mhz	5 Ghz	450 Mbps	MU-MIMO, Beamforming
802.11ac wave 2	WiFi 5	256 QAM	8	20, 40, 80, 160 Mhz	5 Ghz	450 Mbps	
802.11ax	WiFi 6	1024 QAM	8	20, 40, 80, 160 Mhz	2,4 y 5 Ghz	10,5 Gbps	OFDMA, TWT, Color BSS, 1024-QAM
802.11ad		256 QAM	N/A	160 Mhz	60 Ghz	6,7 Gbps	
802.11ay		256 QAM	4	8 Ghz	60 Ghz	20 Gbps	
802.11ah		256 QAM	4	16 Mhz	900 Mhz		

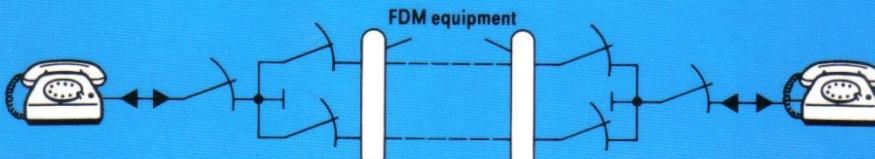
## Canal telefónico basado en las primeras tecnologías y hoy ..

1900



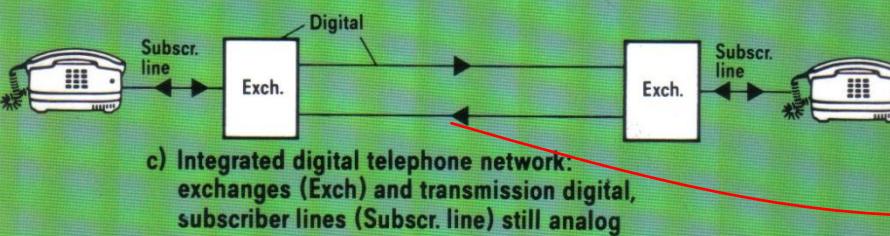
a) Direct line between subscribers

1930

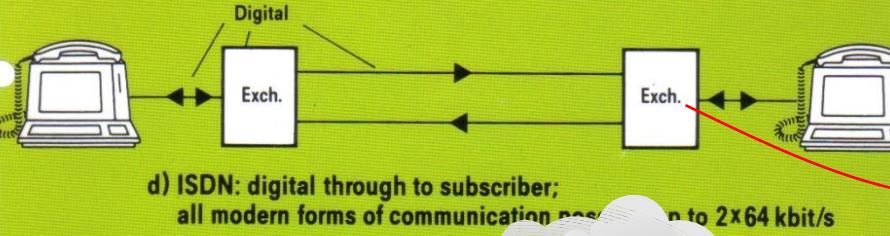


b) Analog switching (selectors), analog transmission

1950



1970



2000

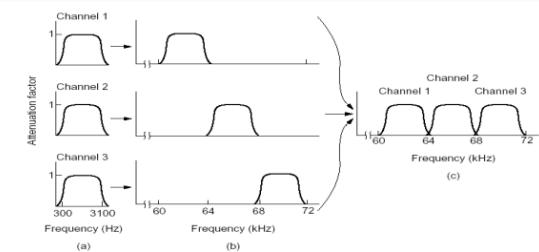


2020

## Tecnología.....

Tipo de multiplexado

FDM



TDM

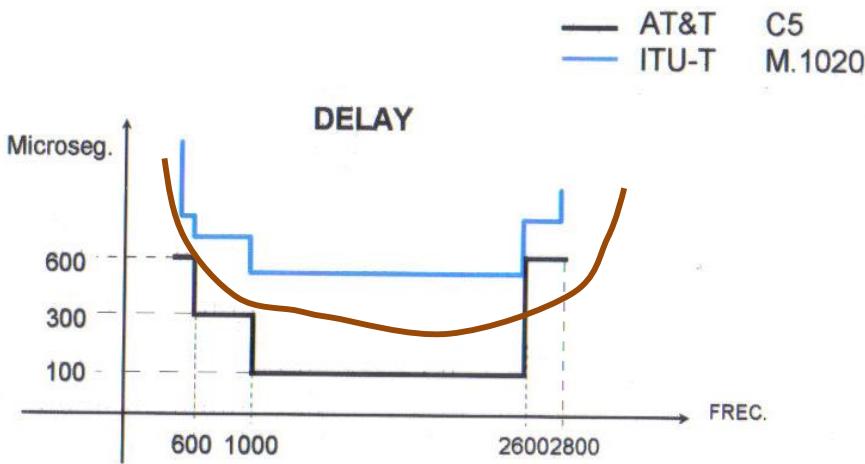
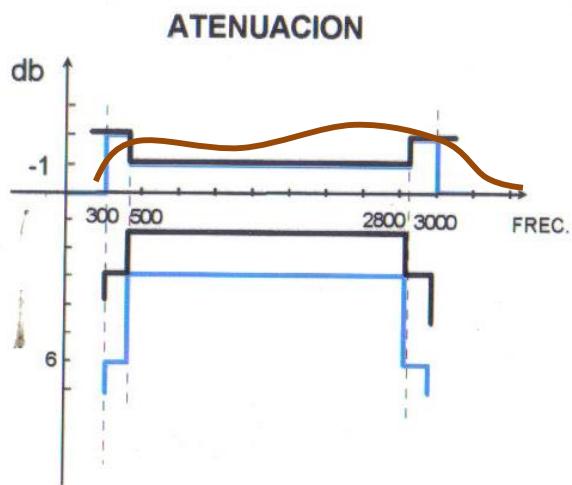
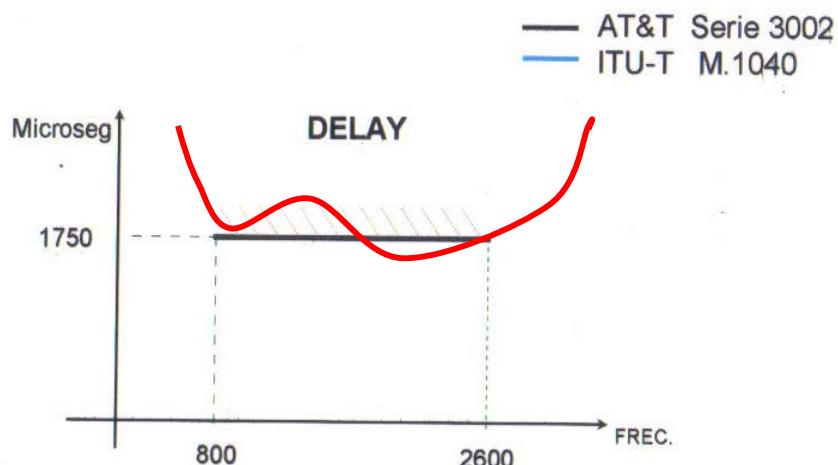
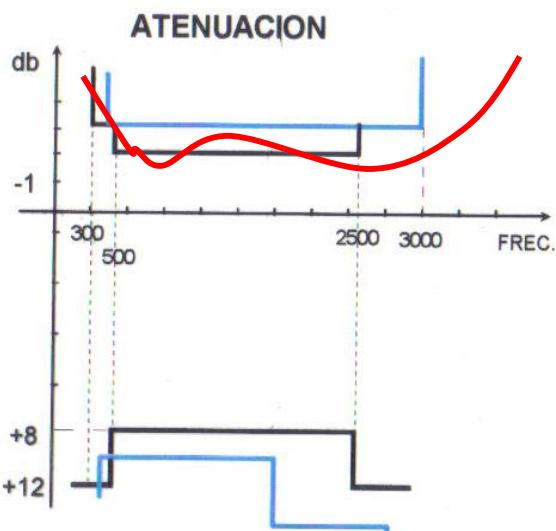


TDM

ISDN

IP, packet switching

## RECOMENDACIONES SOBRE CANAL TELEFONICO ( AT&amp;T y ITU-T)



### IMPERFECCIONES DE UN CANAL TELEFONICO..

#### Tipos..

1. **Ruido impulsivo.**
2. **Distorsión armónica.**
3. **Desviación de frecuencia.**
4. **Hit de ganancias o atenuación.**
5. **Jitter.**
6. **Retardo.**
7. **Diaphonía.**

Calidad de Servicio .....

**El ruido impulsivo** debe medirse con un aparato conforme a la Recomendación O.71 . Como límite provisional, en un periodo de 15 minutos no podrán producirse más de 18 impulsos de ruido con crestas superiores a –21 dBm0.

Cuando en el extremo de emisión de un circuito punto a punto se aplique una frecuencia de prueba de 700 Hz con un nivel de –13 dBm0, el nivel de **toda frecuencia armónica** en el extremo de recepción será, provisionalmente, 25 dB inferior, como mínimo, al nivel de la frecuencia fundamental recibida.

**El error de frecuencia** introducido por el circuito no podrá ser superior a  $\pm 5$  Hz. Se espera que en la práctica el error se mantendrá dentro de límites más estrechos.

**El valor de fluctuación de fase** medido en las instalaciones del arrendatario depende de la constitución real del circuito (por ejemplo, el número de equipos de modulación que intervengan). Es de esperar que en las medidas de fluctuación de

fase efectuadas con un aparato que satisfaga las cláusulas de la Recomendación O.91 [4], los valores no excedan normalmente de 10° cresta a cresta

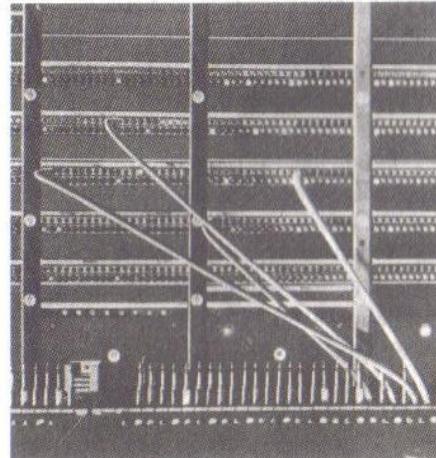
**La atenuación diafónica** en el extremo cercano (entre los sentidos de transmisión de ida y retorno del circuito arrendado) no debe ser inferior a 43 dB. La atenuación diafónica entre distintos circuitos (entre circuitos arrendados y entre un circuito arrendado y cualquier otro circuito de tipo telefónico) no debe ser inferior a 58 dB.

## Los comienzos en los servicios telefónicos ... : La conmutación de circuitos

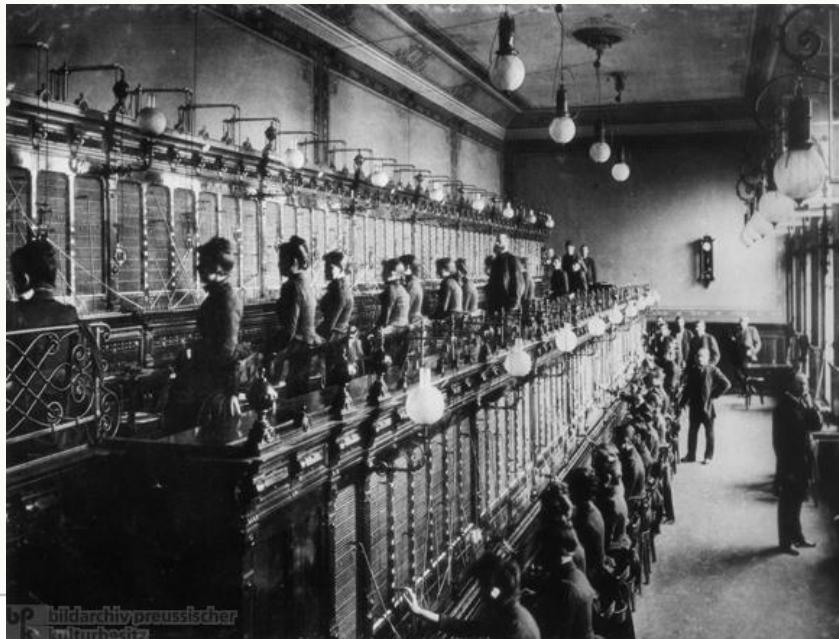
Ericsson "Eiffel Tower" Telephone  
ca. 1892



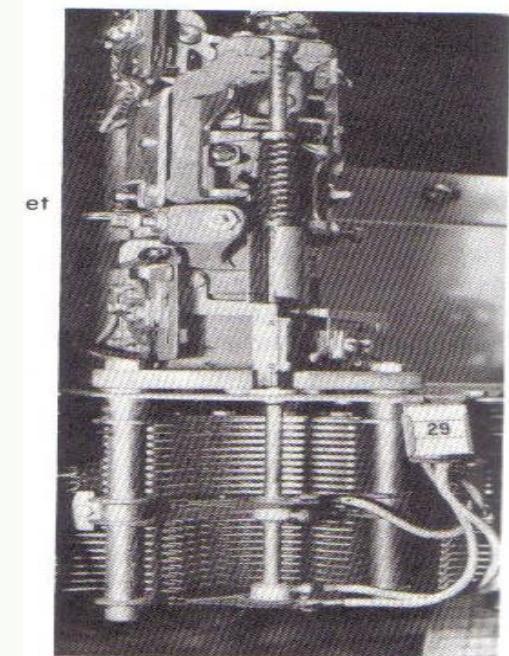
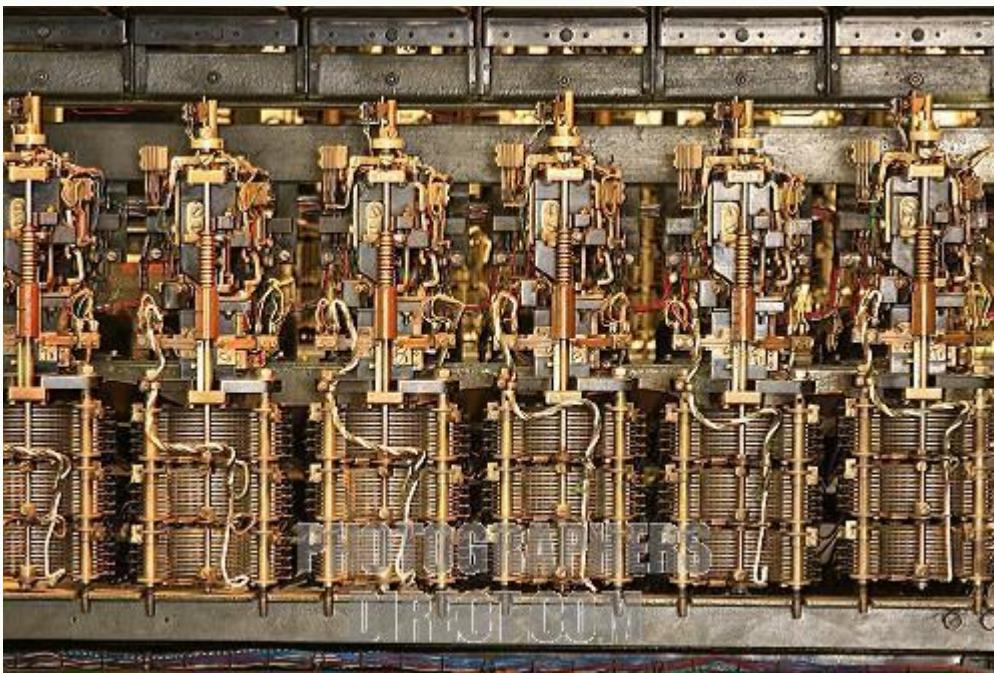
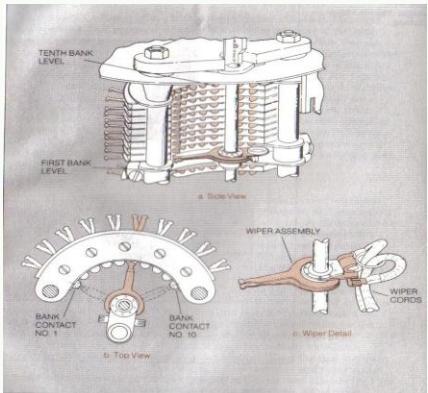
*Comutación  
Manual*



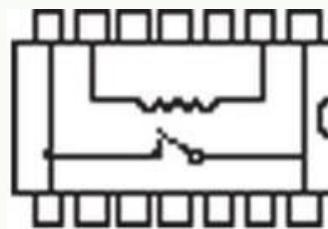
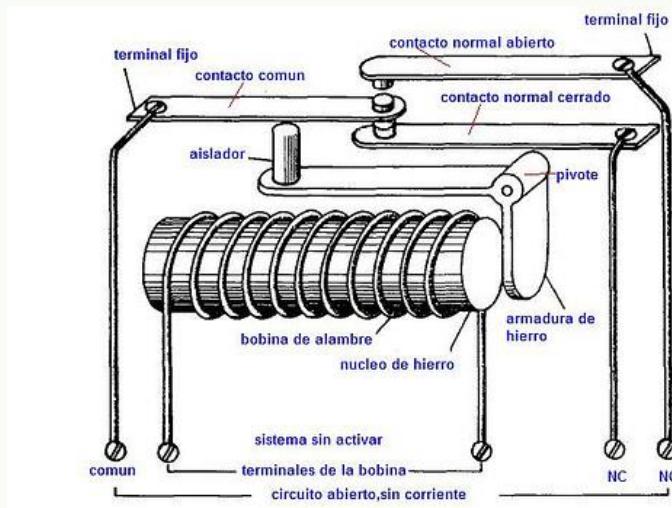
La central  
Telefónica tenía la  
capacidad de  
comutación de :  
*n* operadores....



## Comutación electromecánica ... Marcación mediante pulsos



## Comutación electrónica



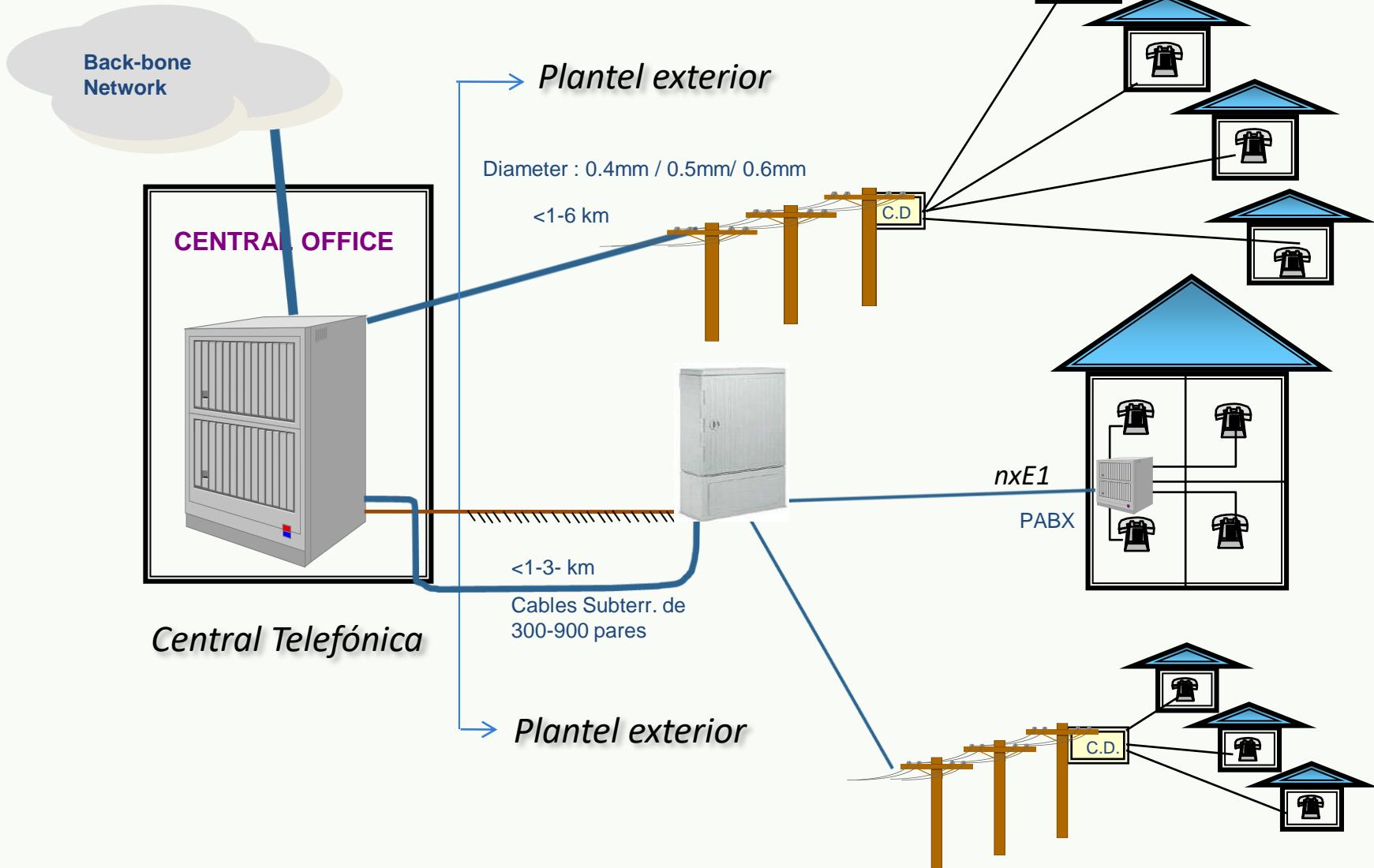


## *El entorno de un central telefónica*



## RED TELEFONICA : PSTN (Public Switch Telephone Network)

**“Telcos” “Telecom- Telefonica**



## Establecimiento de un canal telefónica en una PSTN

Abonado



Línea del abonado

End Office  
Switch

Transit  
Switch

Distant End  
Office Switch

Destination  
Station Set

Cable de cobre  
1-6 km

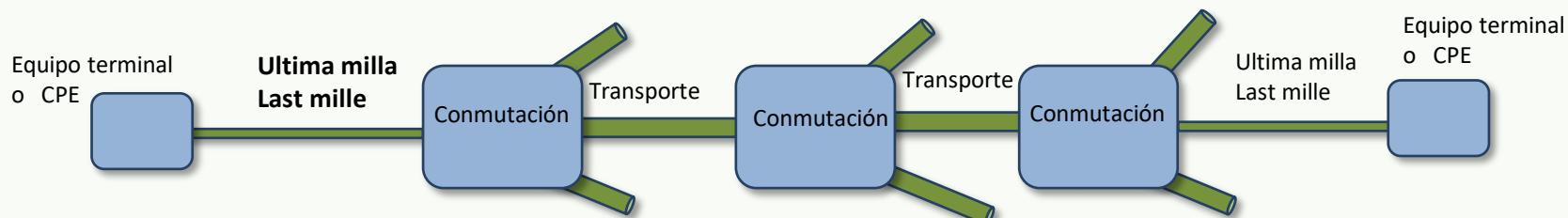
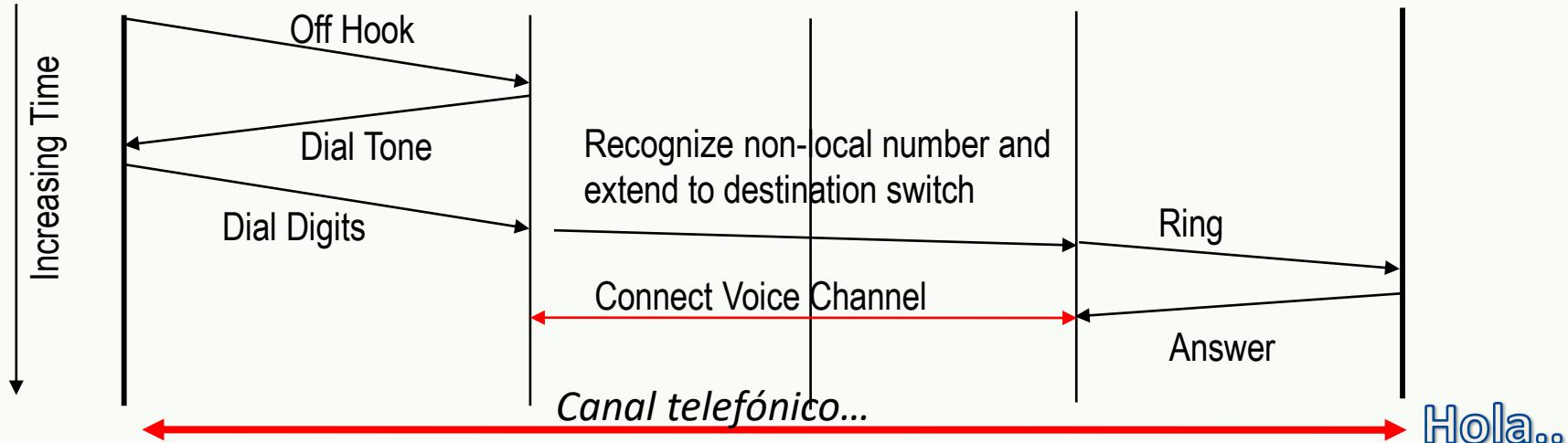
Enlace STM4/Gbps

Enlace nxE1/STM1

Cable de cobre  
1-6 km



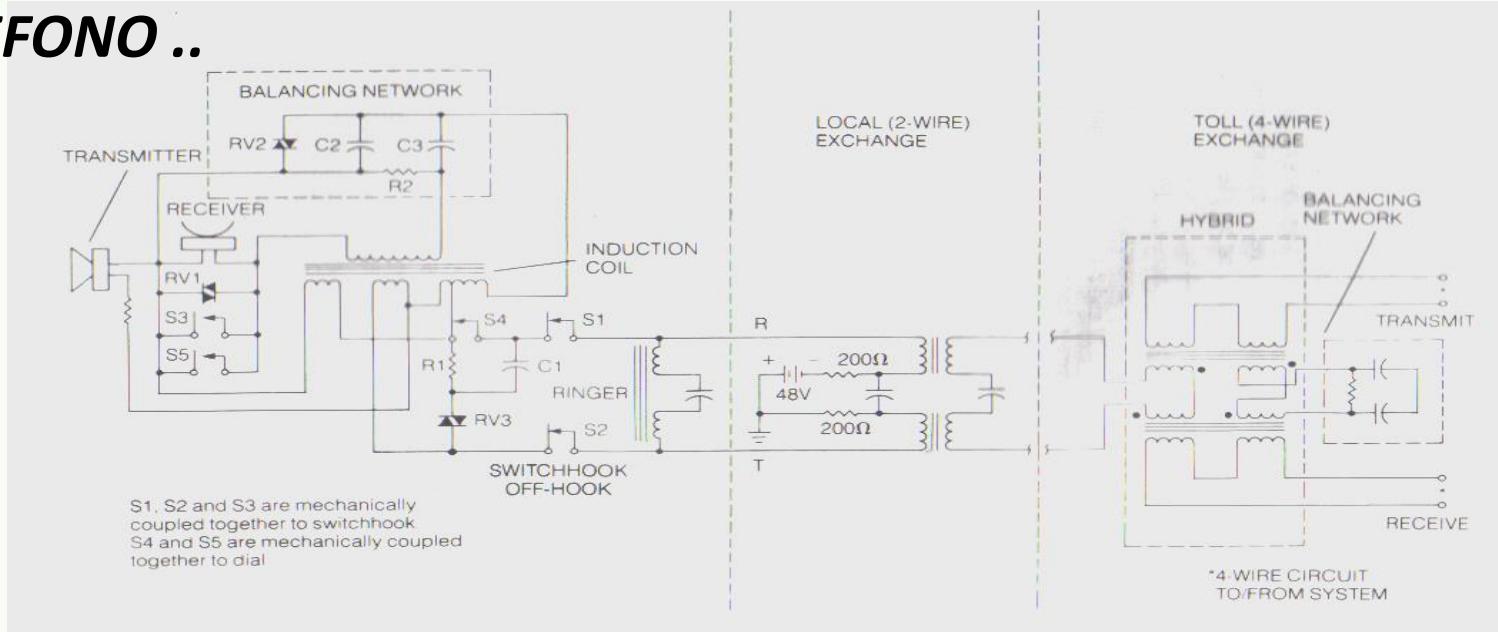
POTS





# Servicios de Comunicación : Servicio Telefónico

## EL TELEFONO ..



## TIPO DE DISCADO ...

Por pulsos..

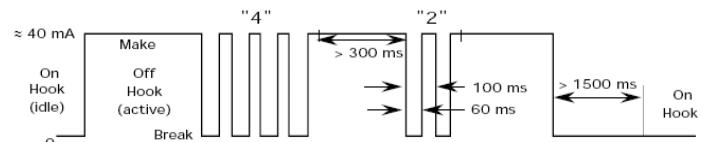
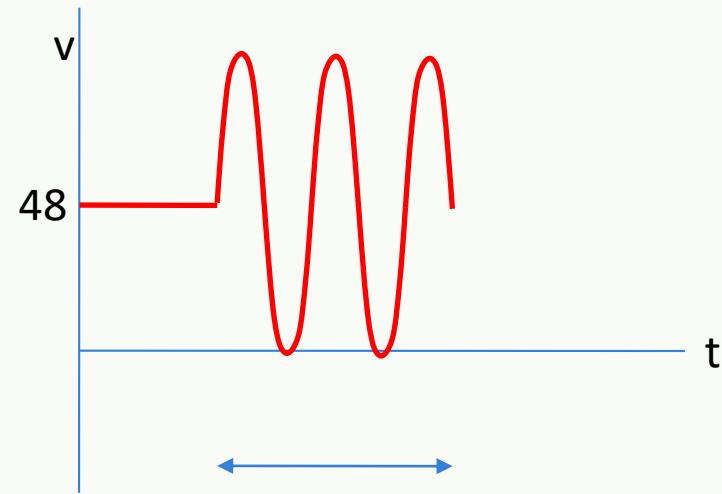
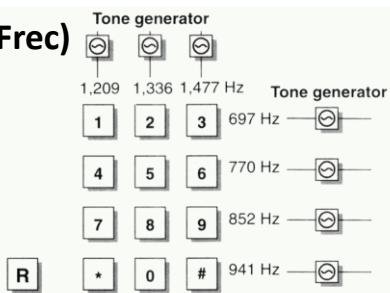


Fig. 2.2-2 Dial Pulse Address Signaling

Por DTMF (Dual Tone Multi Freq)

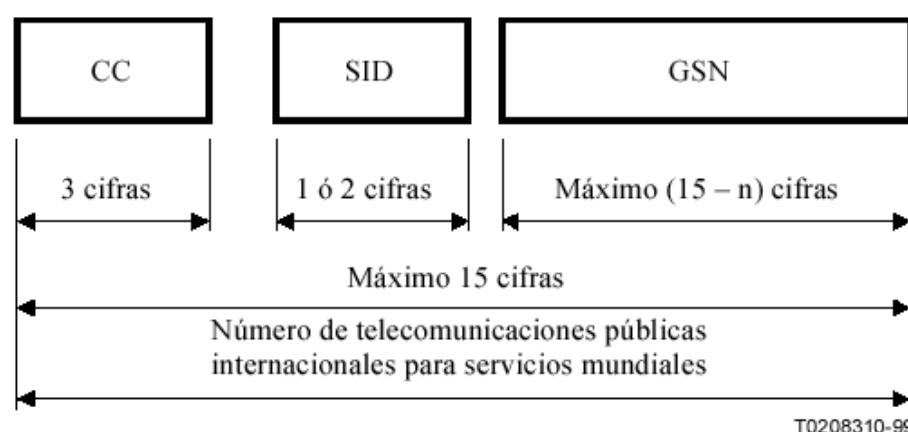
"tonos"...





## NUMERACION TELEFONICA

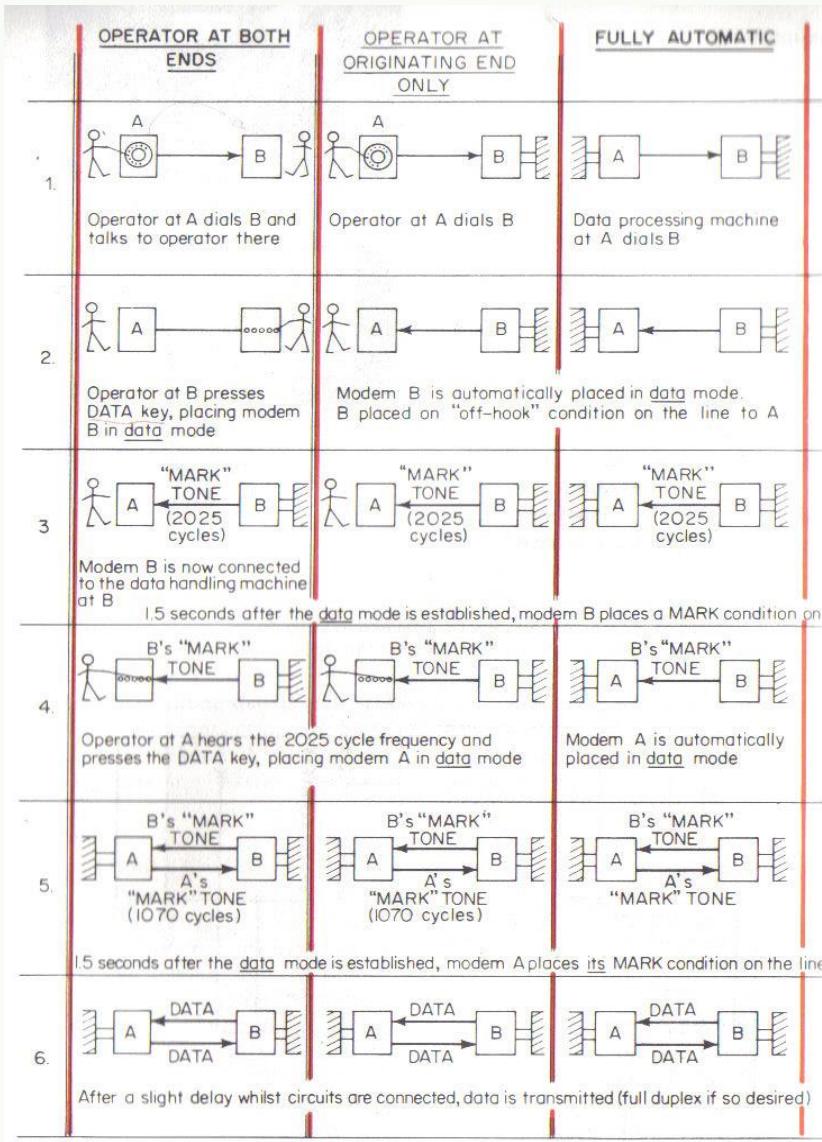
Señalización



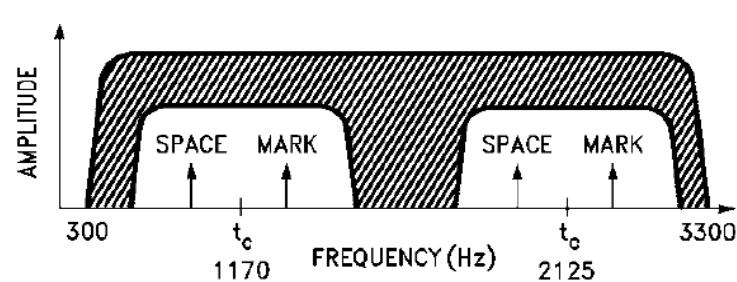
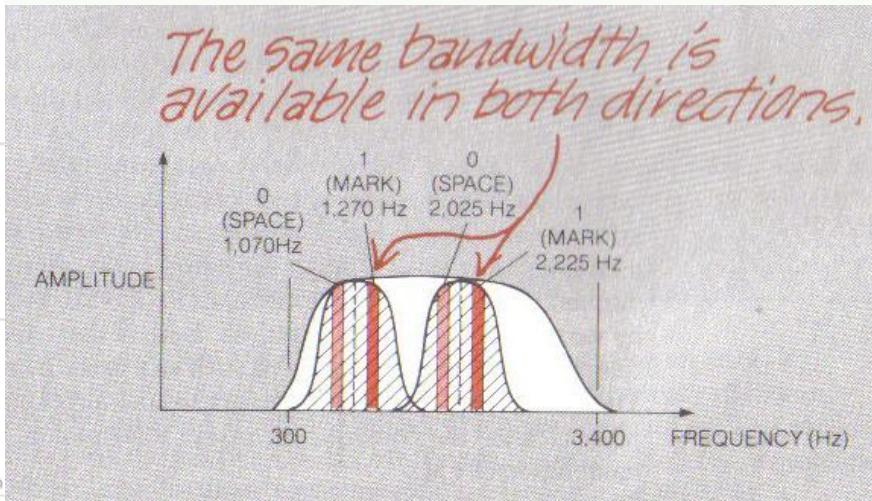
- CC Indicativo de país para servicios mundiales  
SID Identificación del servicio  
GSN Número de abonado mundial  
n Número de cifras del indicativo de país más identificación del servicio (SID)

**Figura 3/E.193 – Estructura de número de telecomunicaciones públicas internacionales para servicios mundiales**

## MODEM TELEFONICO (BANDA VOCAL )



## MODEM DE BANDA VOCAL



TL/F/8691-2

**FIGURE 2. The HC942 modem chip converts incoming ones and zeros to mark and space frequencies when digital data enters the chip's TXD input**



## MODEM V.90

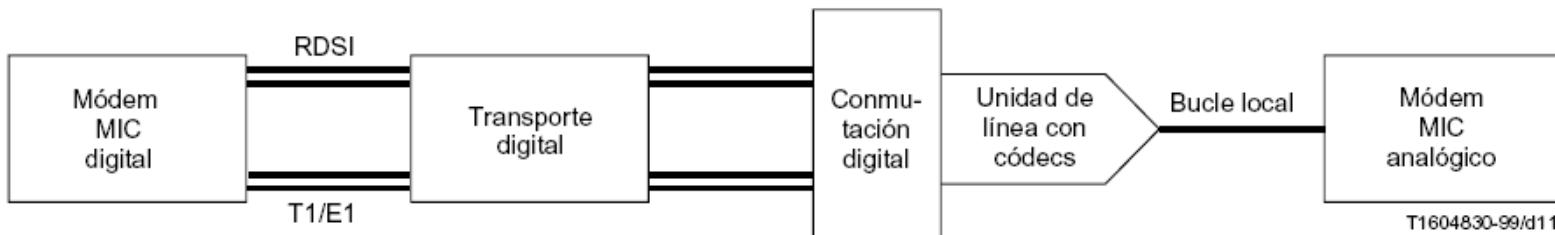


Figura I.1/V.90 – Ejemplo de configuración de red

### Resumen

Se contemplan módems digitales y analógicos para su utilización en la red telefónica pública conmutada (RTPC) a velocidades de señalización de datos de hasta 56 000 bit/s en sentido descendente y hasta 48 000 bit/s en sentido ascendente, con un tiempo de inicialización reducido en las conexiones reconocidas y procedimientos para soportar el módem en espera como respuesta a los eventos de indicación de llamada en espera o de petición de llamada saliente.



# Resumen ..

Capacidad de un canal de comunicación..	<i>C. E. Shannon ... Teoría de la información</i>
Ancho de banda de un medio físico.....	<i>Propiedades físicas ...</i>
Ancho de banda de una señal .....	<i>Serie de Fourier ...</i>
Ruido ...	<i>Depende del tipo de medio ,...</i>
Baudios .....	<i>Ancho de banda ...</i>
Modulación digital .....	<i>Modulamos una señal analógica ... de forma digital</i>
Codificación digital..	<i>Porque codificamos los 0 y 1?</i>
Ancho de banda de un canal.....	<i>Se especifica que canal es; Ej .telefónico</i>
Servicio de telecomunicación....	<i>Es la prestación de un o mas canales de comunicación de Comunicación, mas servicios ....</i>



## NS16C2552/NS16C2752

Dual UART with 16-byte/64-byte FIFO's and up to 5 Mbit/s

### Data Rate

#### 1.0 General Description

The NS16C2552 and NS16C2752 are dual channel Universal Asynchronous Receiver/Transmitter (DUART). The footprint and the functions are compatible to the PC16552D, while new features are added to the UART device. These features include low voltage support, 5V tolerant inputs, enhanced features, enhanced register set, and higher data rate.

The two serial channels are completely independent of each other, except for a common CPU interface and crystal input. On power-up both channels are functionally identical to the PC16552D. Each channel can operate with on-chip transmitter and receiver FIFO's (in FIFO mode).

In the FIFO mode each channel is capable of buffering 16 bytes (for NS16C2552) or 64 bytes (for NS16C2752) of data in both the transmitter and receiver. The receiver FIFO also has additional 3 bits of error data per location. All FIFO control logic is on-chip to minimize system software overhead and maximize system efficiency.

To improve the CPU processing bandwidth, the data transfers between the DUART and the CPU can be done using DMA controller. Signaling for DMA transfers is done through two pins per channel (TXRDY and RXRDY). The RXRDY function is multiplexed on one pin with the OUT2 and BAUDOUT functions. The configuration is through Alternate Function Register.

PRELIMINARY

December 2006

#### 2.0 Features

- Dual independent UART
- Up to 5 Mbits/s data transfer rate
- 2.97 V to 5.50 V operational V<sub>cc</sub>
- 5 V tolerant I/Os in the entire supply voltage range
- Industrial Temperature: -40°C to 85°C
- Default registers are identical to the PC16552D
- NS16C2552/NS16C2752 is pin-to-pin compatible to NSC PC16552D, EXAR ST16C2552, XR16C2552, XR16L2552, and Phillips SC16C2552B
- NS16C2752 is compatible to EXAR XR16L2752, and register compatible to Phillips SC16C752
- Auto Hardware Flow Control (Auto-CTS, Auto-RTS)
- Auto Software Flow Control (Xon, Xoff, and Xon-any)
- Fully programmable character length (5, 6, 7, or 8) with even, odd, or no parity, stop bit
- Adds or deletes standard asynchronous communication bits (start, stop, and parity) to or from the serial data
- Independently controlled and prioritized transmit and receive interrupts
- Complete line status reporting capabilities
- Line break generation and detection
- Internal diagnostic capabilities



## 8251A PROGRAMMABLE COMMUNICATION INTERFACE

- Synchronous and Asynchronous Operation
- Synchronous 5-8 Bit Characters; Internal or External Character Synchronization; Automatic Sync Insertion
- Asynchronous 5-8 Bit Characters; Clock Rate—1, 16 or 64 Times Baud Rate; Break Character Generation; 1, 1½, or 2 Stop Bits; False Start Bit Detection; Automatic Break Detect and Handling
- Synchronous Baud Rate—DC to 64K Baud
- Asynchronous Baud Rate—DC to 19.2K Baud
- Full-Duplex, Double-Buffered Transmitter and Receiver
- Error Detection—Parity, Overrun and Framing
- Compatible with an Extended Range of Intel Microprocessors
- 28-Pin DIP Package
- All Inputs and Outputs are TTL Compatible
- Single +5V Supply
- Single TTL Clock

The Intel® 8251A is the enhanced version of the industry standard, Intel 8251 Universal Synchronous/Asynchronous Receiver/Transmitter (USART), designed for data communications with Intel's microprocessor families such as MCS-68, 80, 85, and iAPX-86, 88. The 8251A is used as a peripheral device and is programmed by the CPU to operate using virtually any serial data transmission technique presently in use (including IBM "bi-sync"). The USART accepts data characters from the CPU in parallel format and then converts them into a continuous serial data stream for transmission. Simultaneously, it can receive serial data streams and convert them into parallel data characters for the CPU. The USART will signal the CPU whenever it can accept a new character for transmission or whenever it has received a character for the CPU. The CPU can read the complete status of the USART at any time. These include data transmission errors and control signals such as SYNDET, TxEMPTY. The chip is fabricated using N-channel silicon gate technology.



## GigaLan Augmented Cat.6A F/UTP LSZH



<b>Construction</b>	RoHS Compliant Category 6A F/UTP LSZH
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<b>Description</b>	4 pairs twisted cable, using solid bare copper, 23 AWG, insulated with a special compound. External jacket using LSZH in accordance with IEC60332-3.
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<b>Installation</b>	Internal
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<b>Environment</b>	Non heavy
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<b>Compatibility</b>	FCS products
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<b>Application</b>	<ol style="list-style-type: none"><li>1. Exceeds physical and electrical requirements of ANSI/TIA-568-C.2</li><li>2. Cable according with RoHS directive (Restriction of Hazardous Substances)</li><li>3. Can be used with all of the following protocols.<ol style="list-style-type: none"><li>a) 10GIGABIT ETHERNET, IEEE 802.3an, 10 Gbps;</li><li>b) GIGABIT ETHERNET, IEEE 802.3z, 1000 Mbps;</li><li>c) 100BASE-TX, IEEE 802.3u, 100 Mbps;</li><li>d) 100BASE-T4, IEEE 802.3u ,100 Mbps;</li><li>e) 100vg-AnyLAN, IEEE802.12, 100 Mbps;</li></ol></li></ol>
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