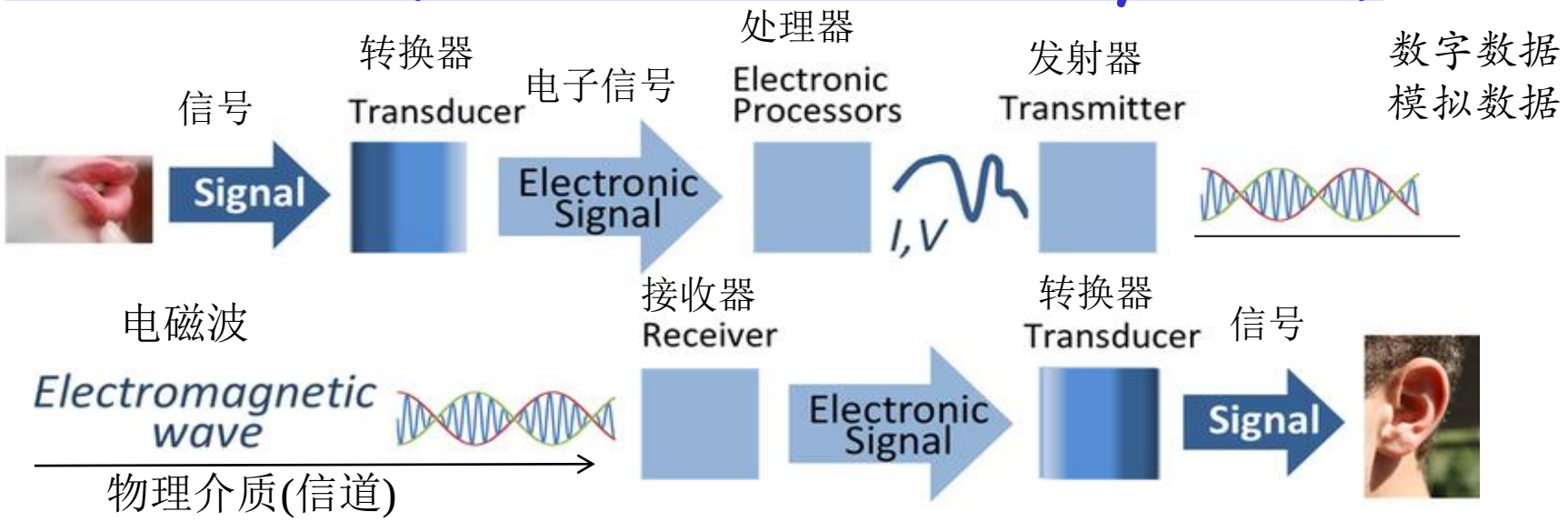
第二单元 物理层

- 通信系统
- 正弦波信号
- 频移键控
- 曼彻斯特编码
- 物理介质
- 多路复用和电路交换

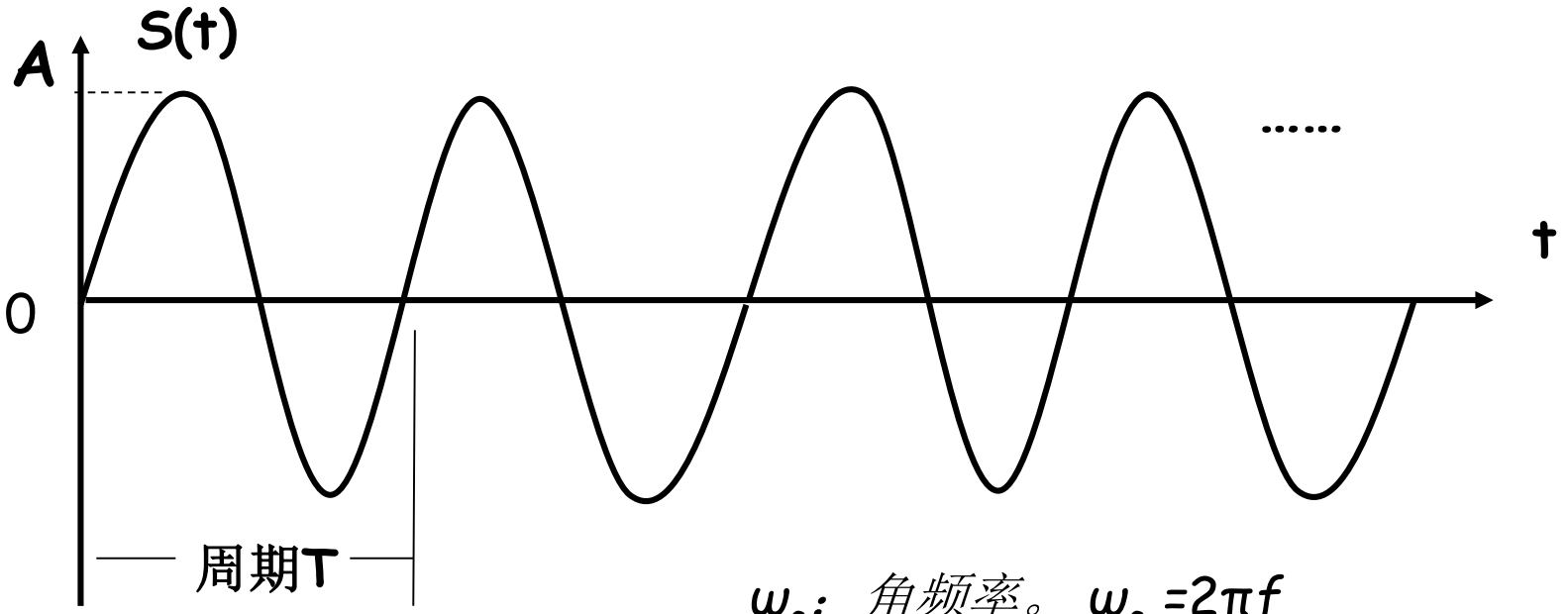
通信系统(Communication System)



Information(信息) can be interpreted as a message(data), recorded as signs(符号), transmitted as signals(信号), measured as the entropy(熵)。

- 信号(signal) : optical signal, electronic signal, radio signal
- 模拟信号(analog signal)：连续取值的信号
- 数字信号(digitial signal)：用离散值表示的信号（跳变信号）
- 模拟传输(analog transmission): 模拟信号(analog signal), 放大器(amplifier)
- 数字传输(digital transmission): 数字信号(digital signal), 中继器(repeater)

正弦波信号(Sinusoidal signal)



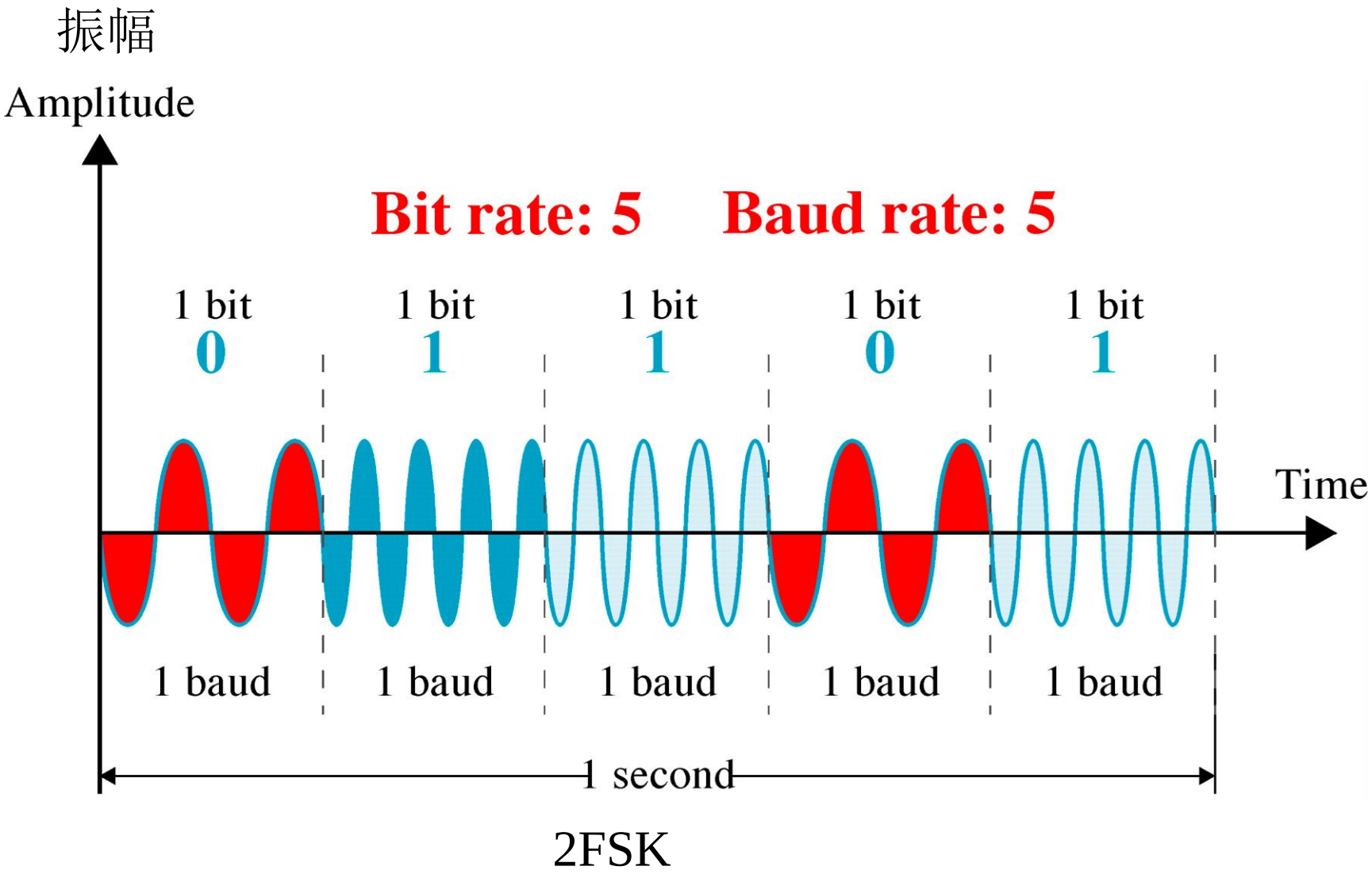
$S(t)=A\sin(\omega_c t+\varphi)$

ω_c: 角频率。 $\omega_c = 2\pi f$
f: 频率(frequency) $=1/T$
T: 周期(period)
A: 振幅(amplitude)
φ: 相位(phase)(初相)。本例为0。

载波信号(Carrier)一般采用正弦波信号

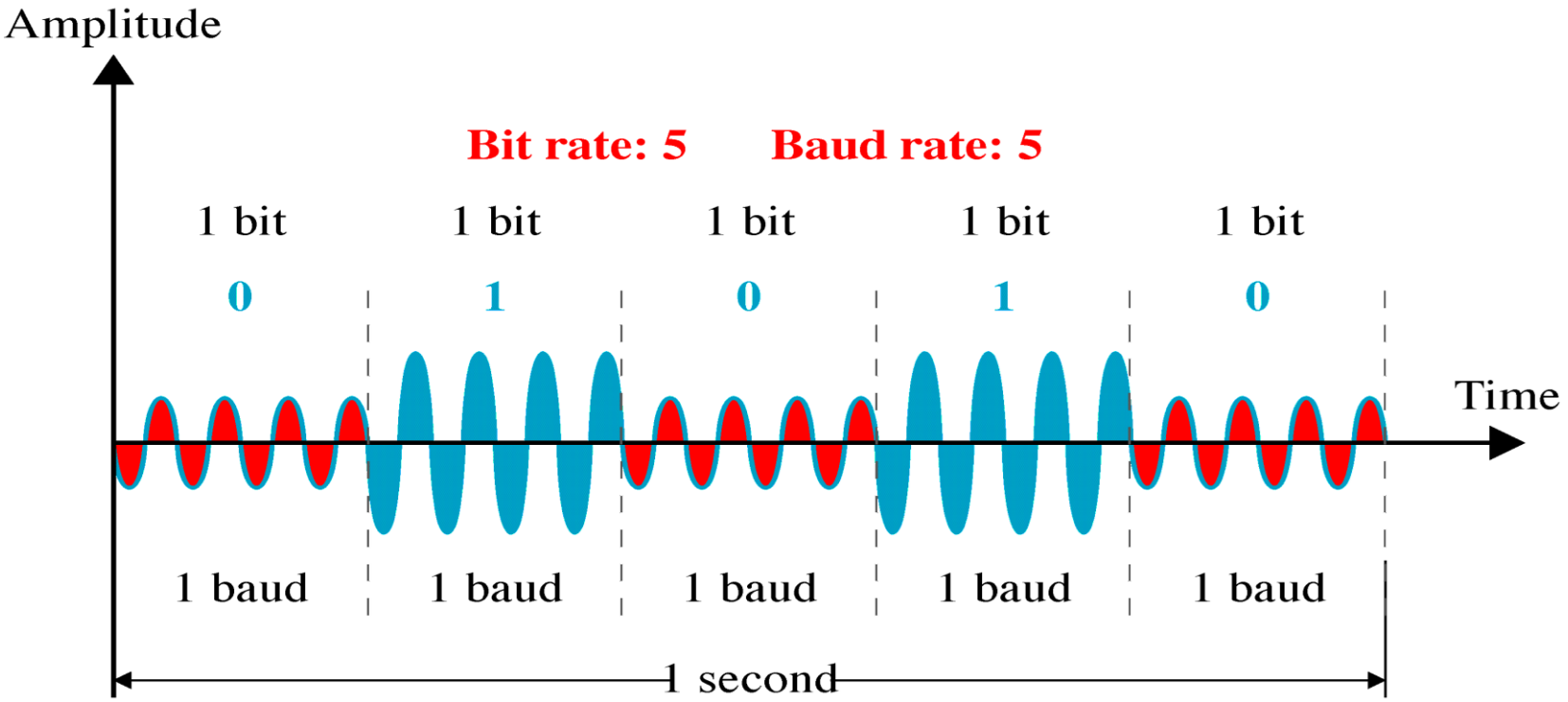
频移键控

(Frequency-Shift Keying, FSK)



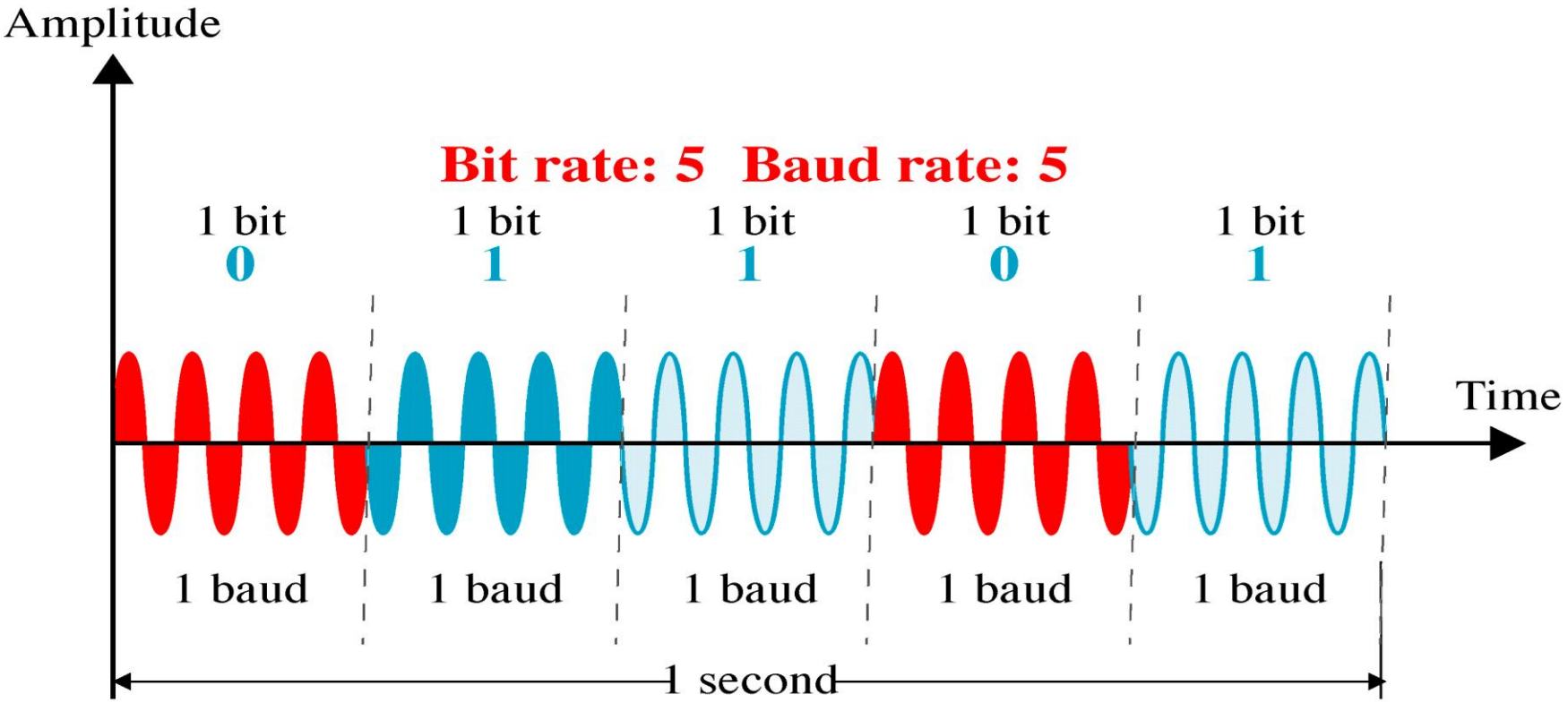
2FSK

幅移键控
(Amplitude-Shift Keying, ASK)

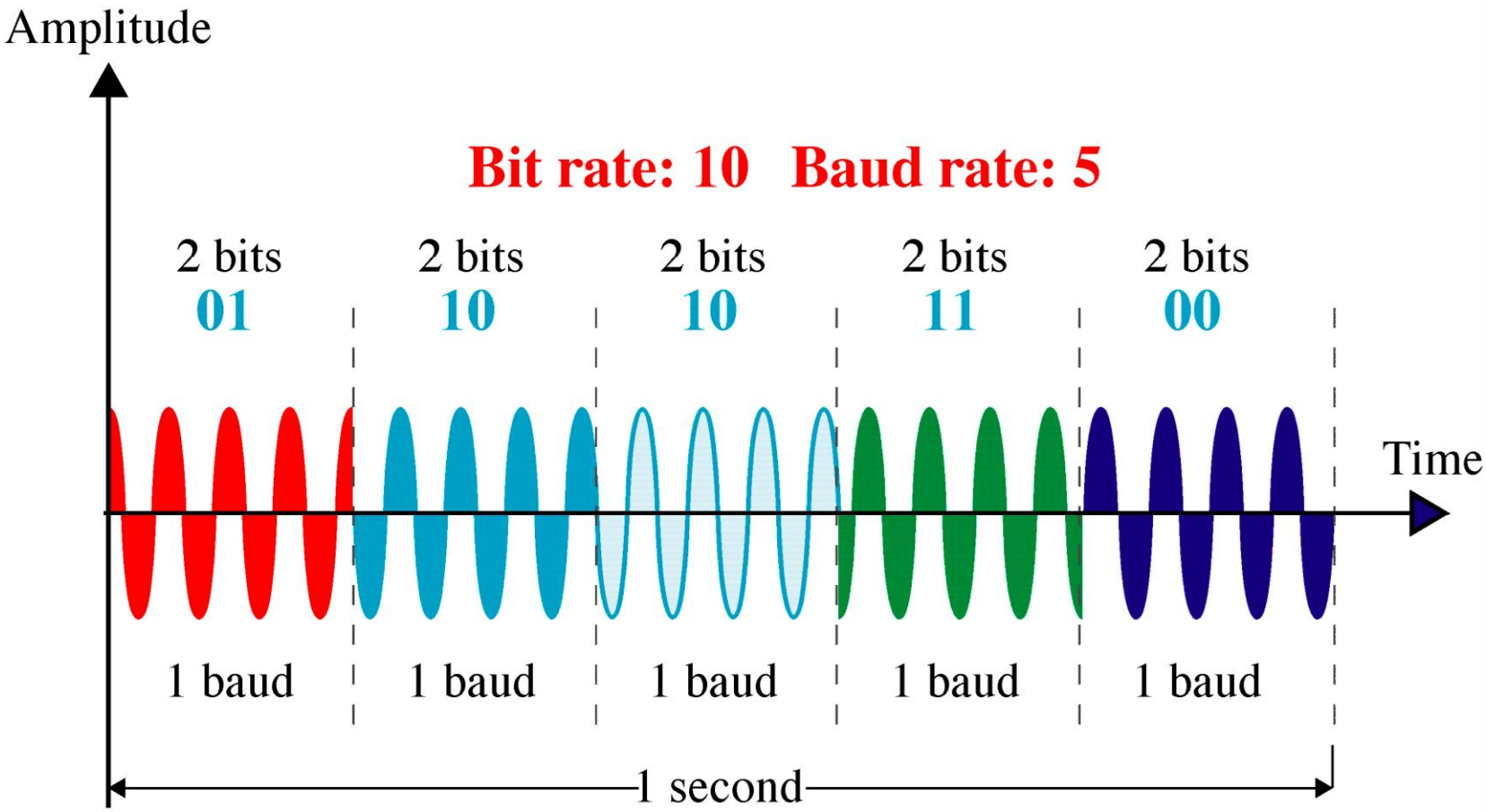


2ASK

相移键控
(Phase-Shift Keying, PSK)



2PSK或BPSK

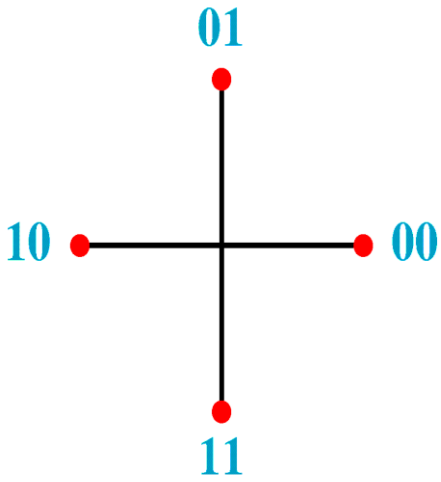

Amplitude
Bit rate: 10 Baud rate: 5
2 bits
01
2 bits
10
2 bits
10
2 bits
11
2 bits
00
Time
1 baud
1 baud
1 baud
1 baud
1 baud
1 second

4-PSK

4-PSK（QPSK）
Characteristics

Dibit	Phase
00	0
01	90
10	180
11	270

Dibit
(2 bits)

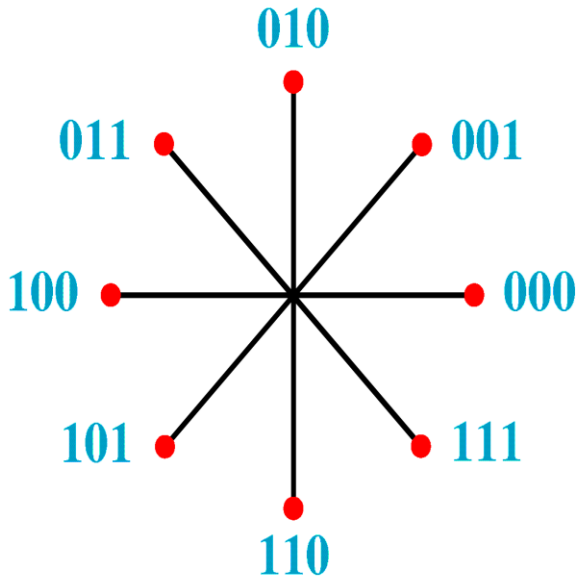


Constellation diagram

Tribit	Phase
000	0
001	45
010	90
011	135
100	180
101	225
110	270
111	315

Tribits
(3 bits)

8-PSK
Characteristics

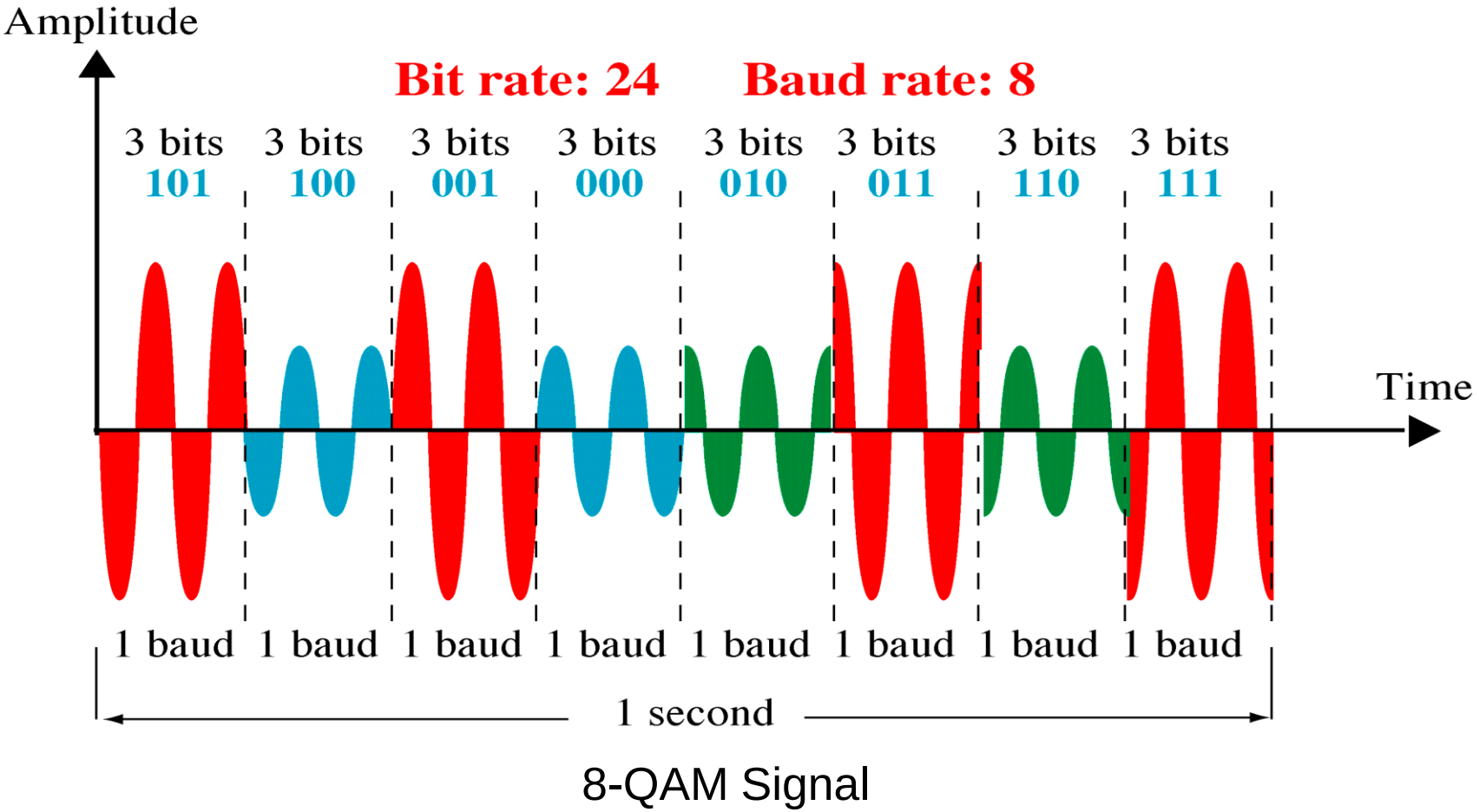


Constellation diagram

- DPSK方式是利用前后相邻码元的载波相位差值去表示数字信息的一种方式，2DPSK采用两种相位偏移 (例如，0， π)。 4DPSK(或者QDPSK)采用四种相位偏移(0，π/2，π，3π/2)编码2比特。

正交调幅

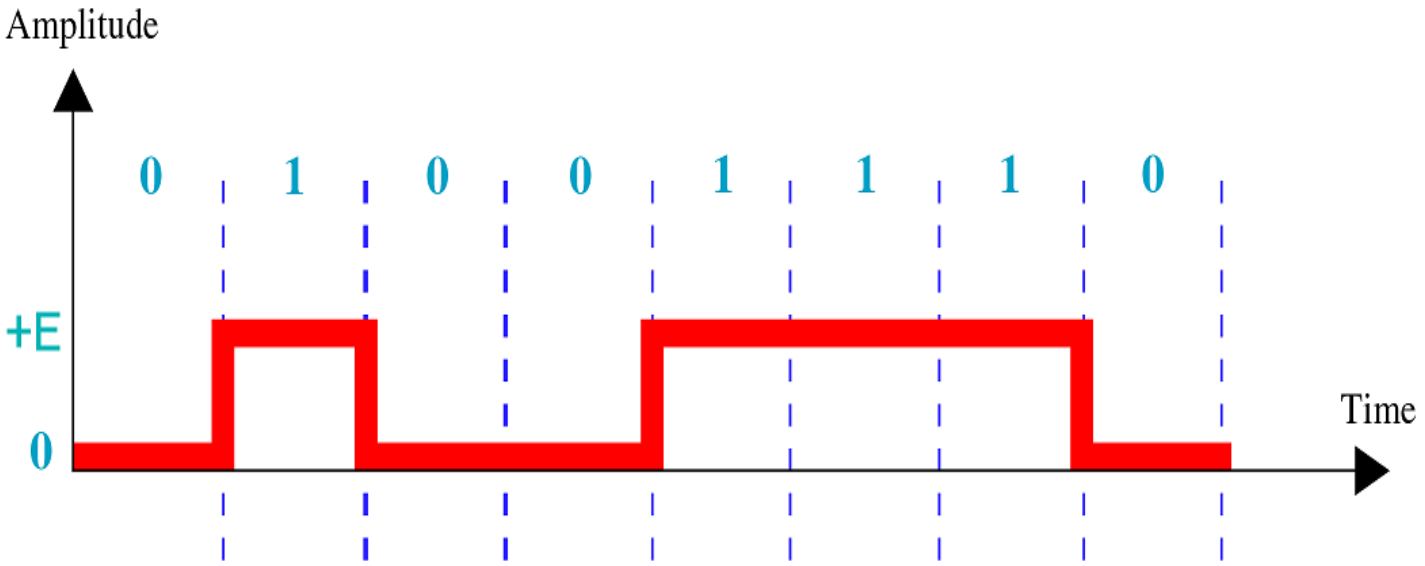
(QAM -quadrature amplitude modulation)



8-QAM Signal

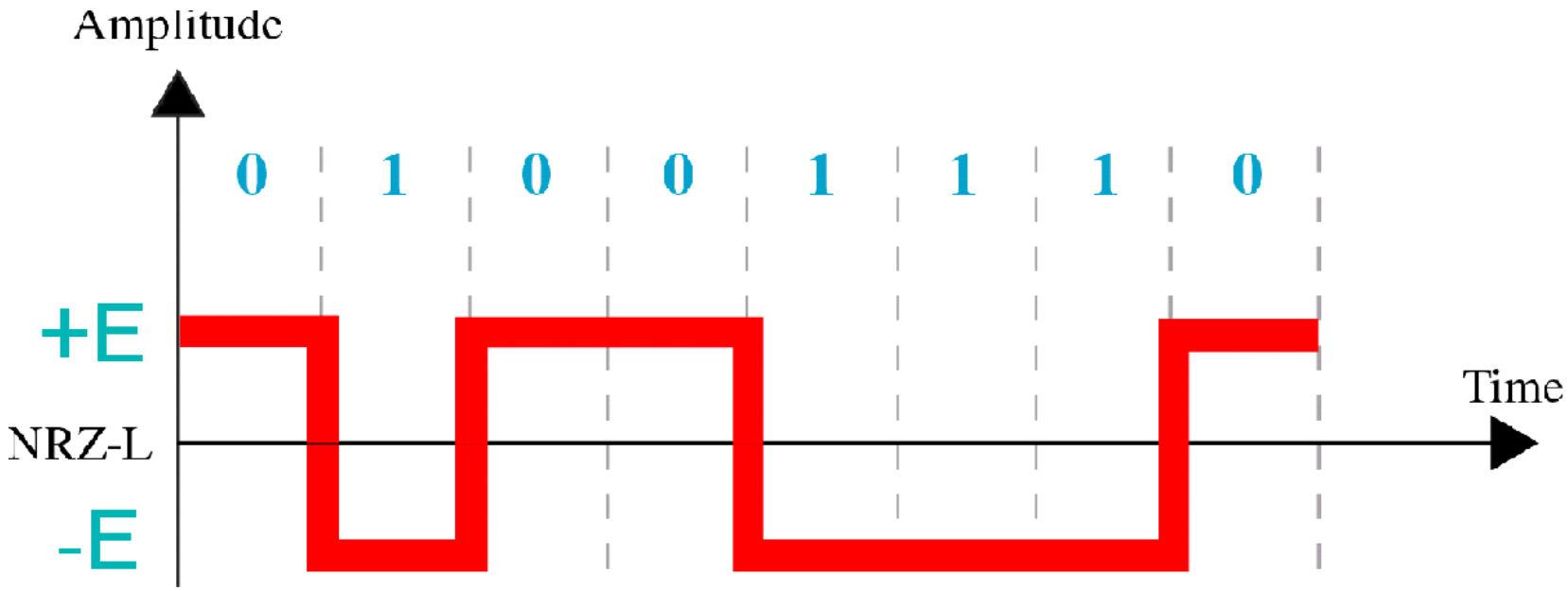
单极编码(unipolar encoding)

振幅



时钟漂移
基线漂移

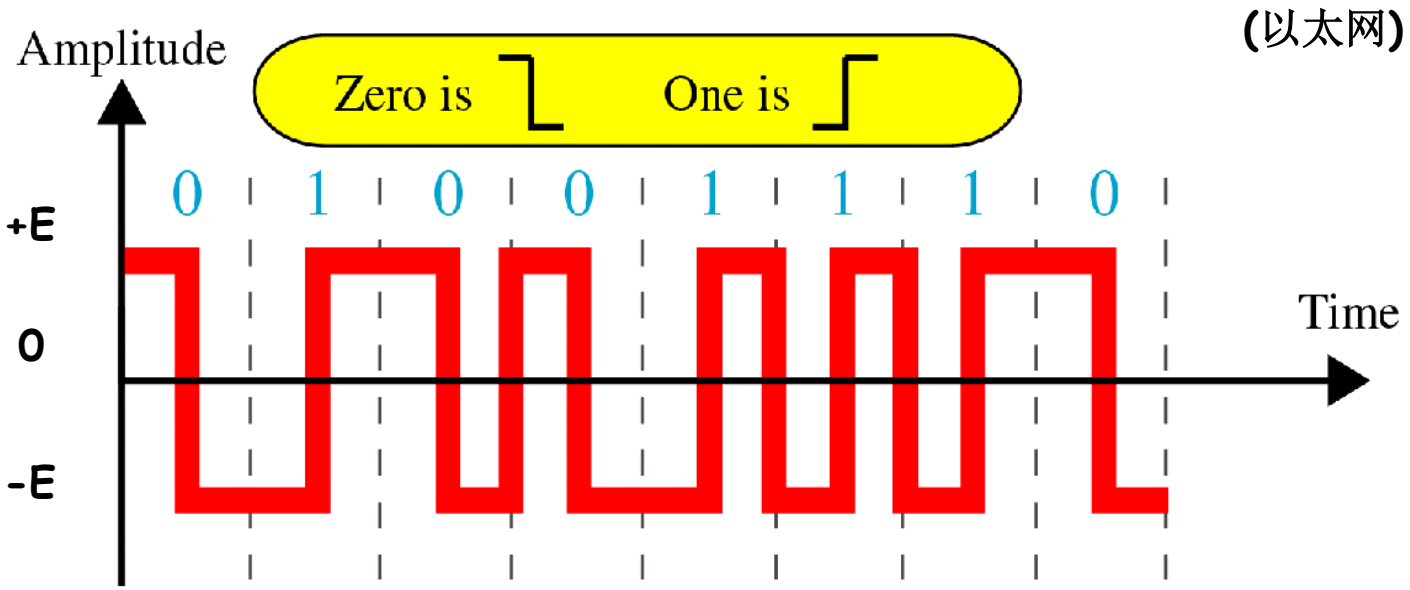
不归零编码
(Non-Return-to-Zero,NRZ或NRZ-L)



不归零编码是一种**双极编码**(bipolar encoding)。双极编码的波形就是二进制符号，0、1分别与正、负电位相对应。它的电脉冲之间也无间隔。RS-232C的接口电压就是采用双极编码。

曼彻斯特编码(Manchester Encoding)

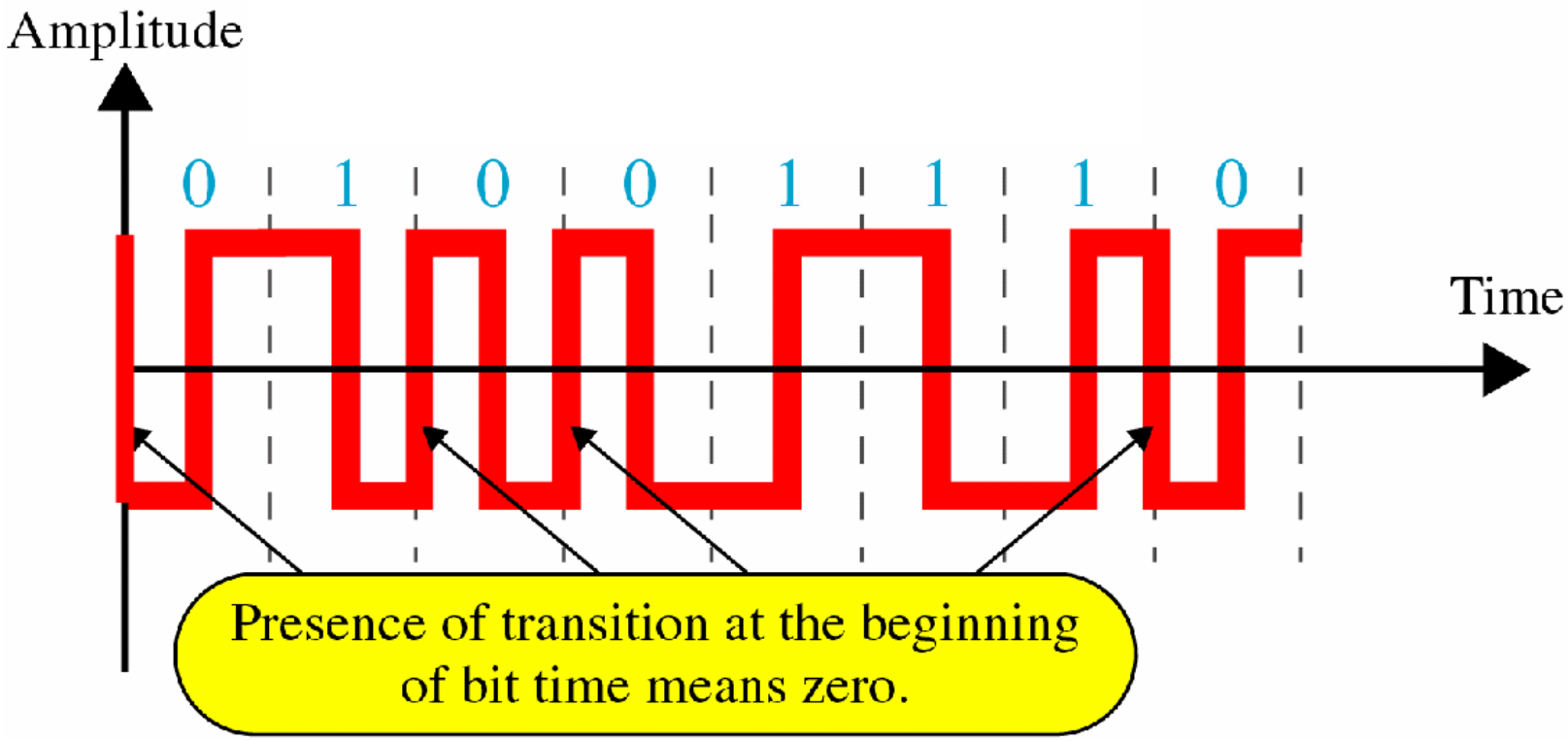
振幅



曼彻斯特码的编码规则(以太网)是：0 → 10， 1 → 01

差分曼彻斯特编码

(Differential Manchester Encoding)



差分曼彻斯特码是一种差分双相码，先把输入的NRZ波形变换成差分波形，再用绝对双相码(第一个规则)编码，即，”1”起始不跳变，”0”起始跳变，再用Manchester编码第一规则按当前电平进行编码。简单描述：起始是否跳变确定是否0或1，中间一定跳变。

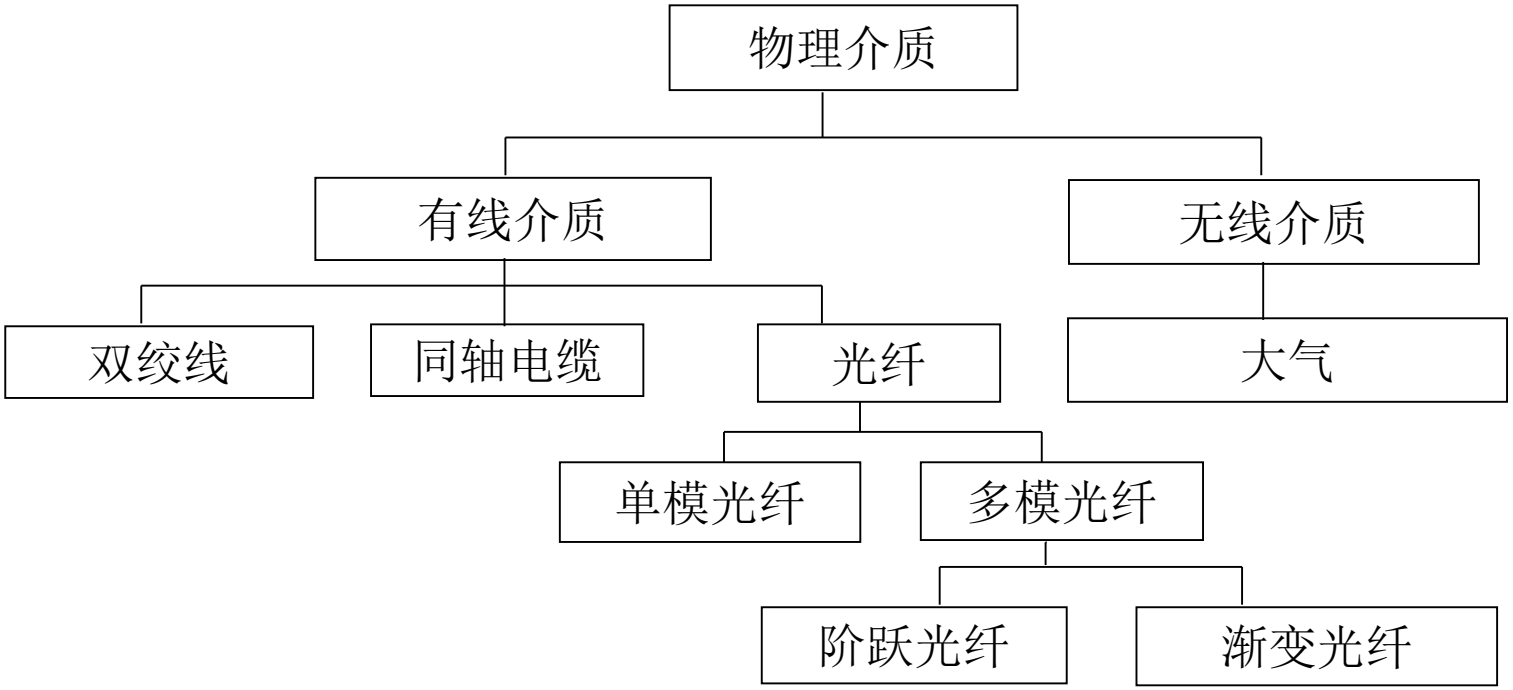
4B/5B编码

- 用5比特表示4比特。 每个编码没有多于1个的前导零和多于2个的末端零。如果结合NRZI编码，就可以既防止跳变过多，又消除基线漂移和时钟漂移。其它编码用于控制，如，11111表示空闲。

4比特数据符号	5比特编码
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110

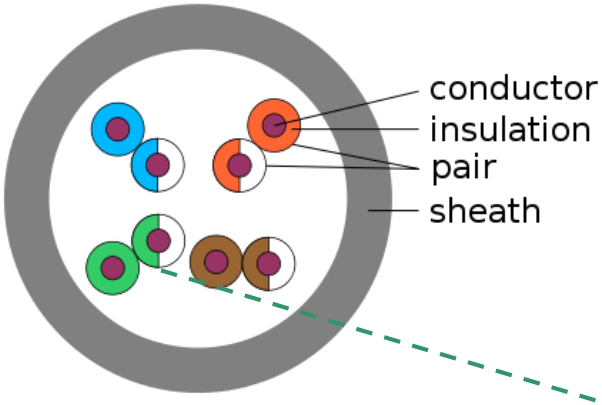
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

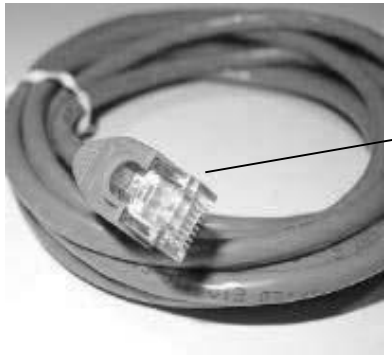
物理介质(Physical Media)

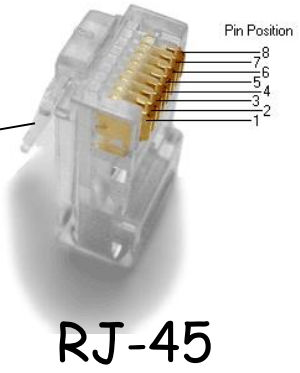


非屏蔽双绞线 (Unshielded Twisted Pair)

UTP

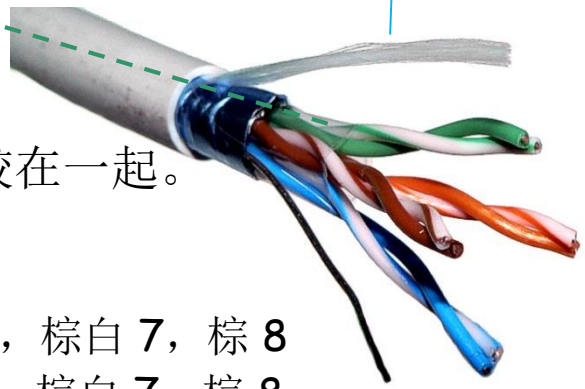






RJ-45

尼龙线



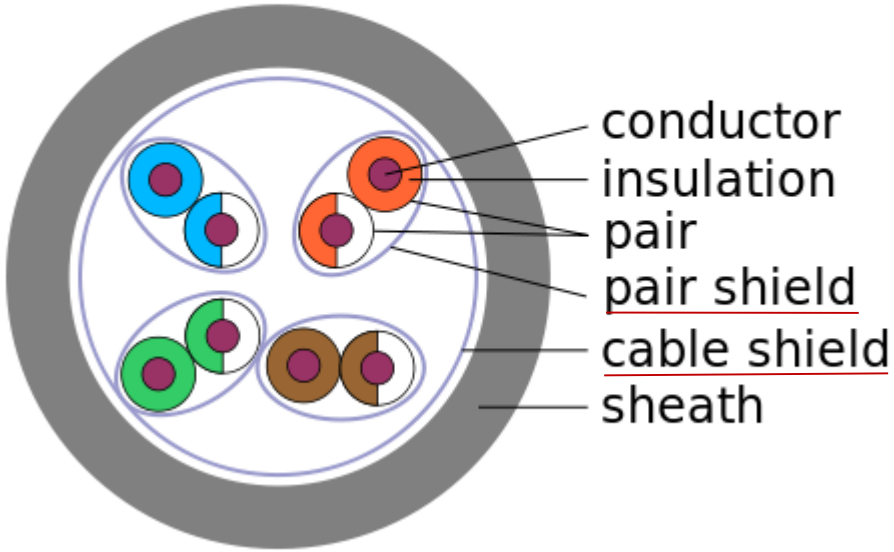
- 四对线: 绿 绿白，橙 橙白，蓝 蓝白，棕棕白
- 每对线先逆时针绞在一起，然后所有线对再逆时针绞在一起。
- 标准568A：绿白 1，绿 2，橙白 3，蓝 4，蓝白 5，橙 6，棕白 7，棕 8
- 标准568B：橙白 1，橙 2，绿白 3，蓝 4，蓝白 5，绿 6，棕白 7，棕 8

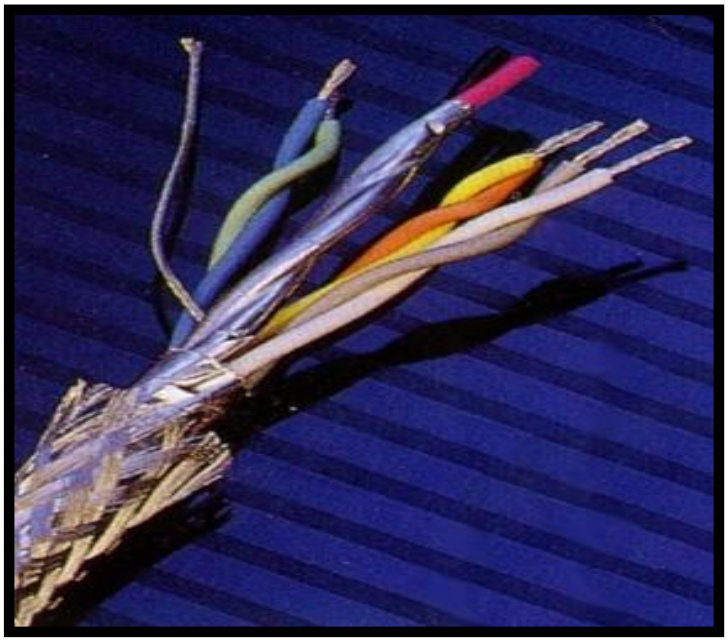
UTP Categories

UTP Category	Max Speed Rating	Description
1	—	Used for telephones, and not for data
2	4 Mbps	Originally intended to support Token Ring over UTP
3	10 Mbps	Can be used for telephones as well; popular option for Ethernet in years past, if Cat 3 cabling for phones was already in place
4	16 Mbps	Intended for the fast Token Ring speed option
5	1 Gbps	Very popular for cabling to the desktop
5e	1 Gbps	Added mainly for the support of copper cabling for Gigabit Ethernet
6	1 Gbps+	Intended as a replacement for Cat 5e, with capabilities to support multigigabit speeds

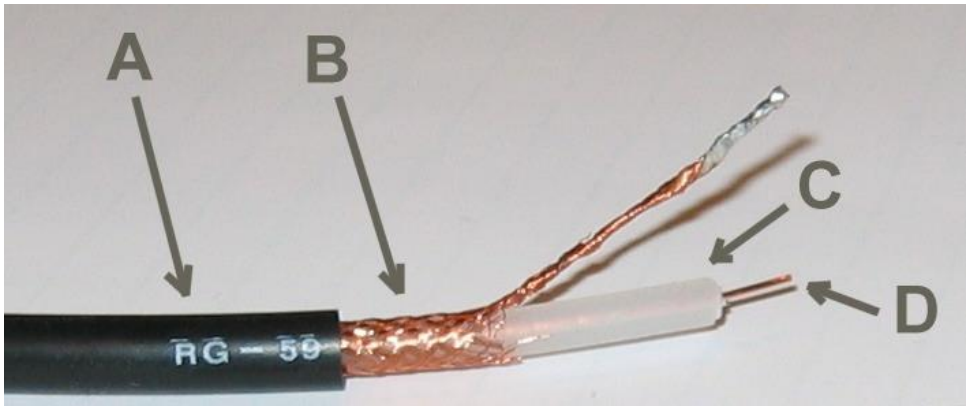
屏蔽双绞线 (Shielded Twisted Pair)

STP





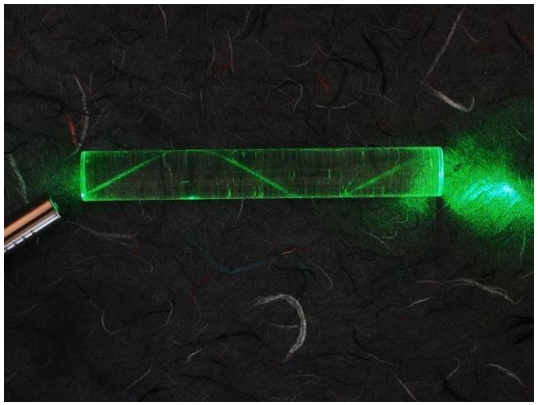
同轴电缆(Coaxial Cable)



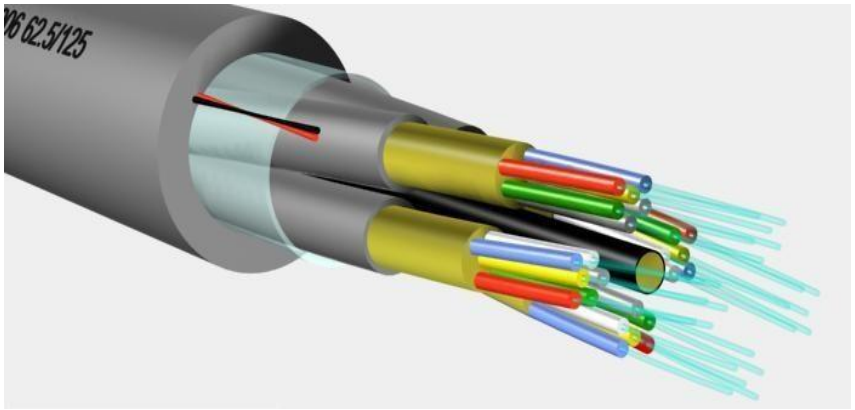
A: 外层塑料护套
B: 铜网屏蔽层(接地)
C: 内绝缘体
D: 铜芯(信号)

光导纤维 (Optical Fiber)

- 在玻璃纤维传输光脉冲，每个脉冲一比特

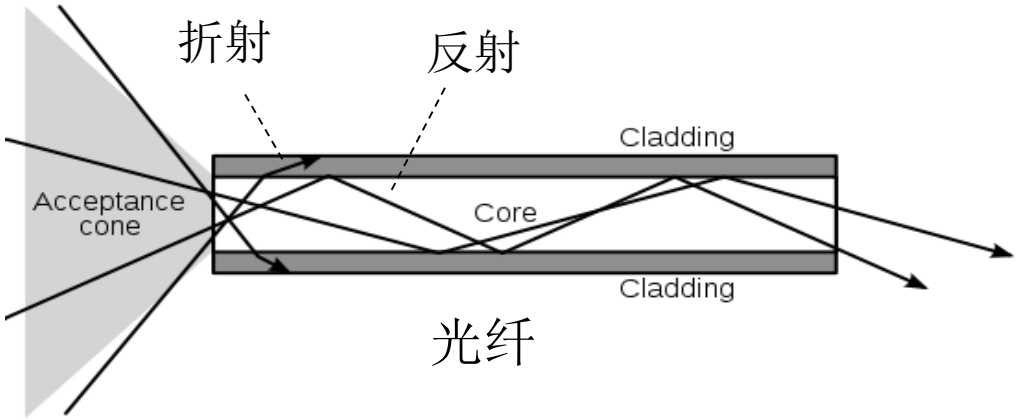


单根光纤



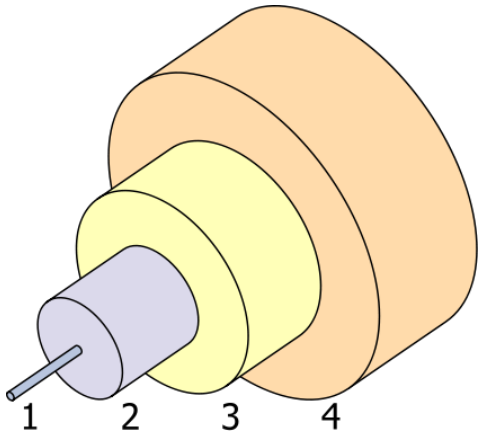
光缆

- 全反射条件: 入射角大于临界角



- 一条典型单模光纤的结构

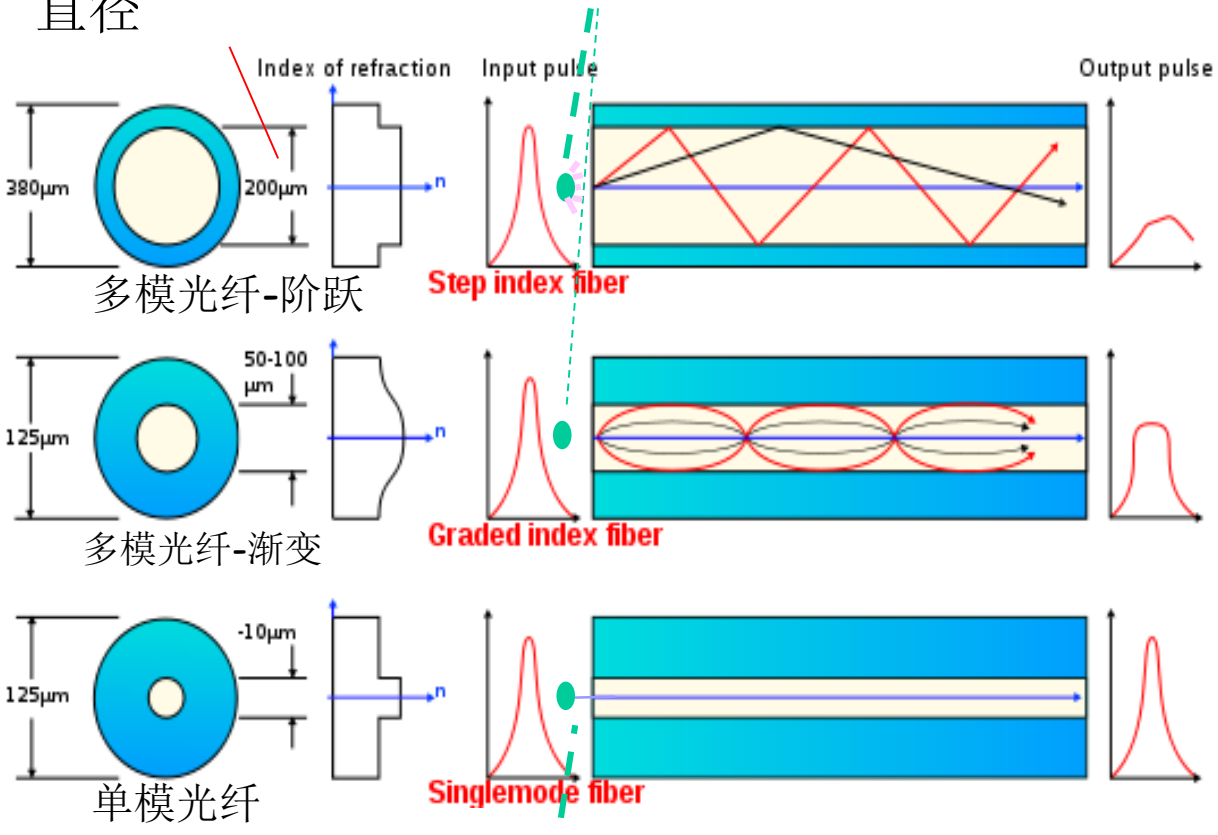
1. 纤芯: 直径8 μm
2. 覆层:直径125 μm
3. 缓冲曾:直径250 μm
4. 护套:直径400 μm



单模光纤和多模光纤

Source：发光二极管(Light Emitting Diode, LED)

直径



	DataRate	Maximum Distance
多模光纤-阶跃	low 4Gbps	5000m
多模光纤-渐变	medium	middle
单模光纤	high > 40Gbps	50km

Source：注入式激光二极管(Injection Laser Diode, ILD)

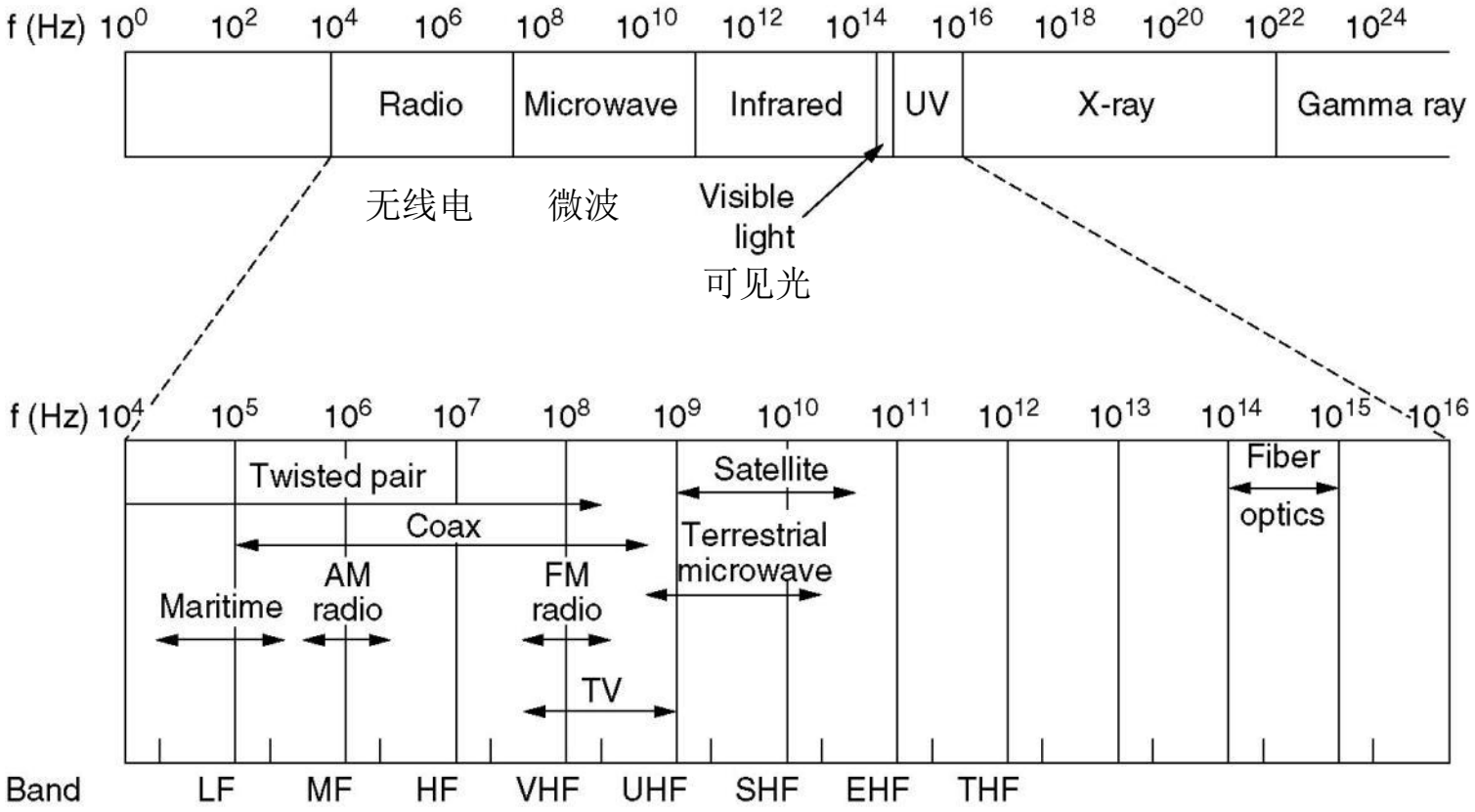
Single Mode fiber 单模光纤
Step-index fiber 阶跃光纤 graded-index 渐变光纤

无线介质

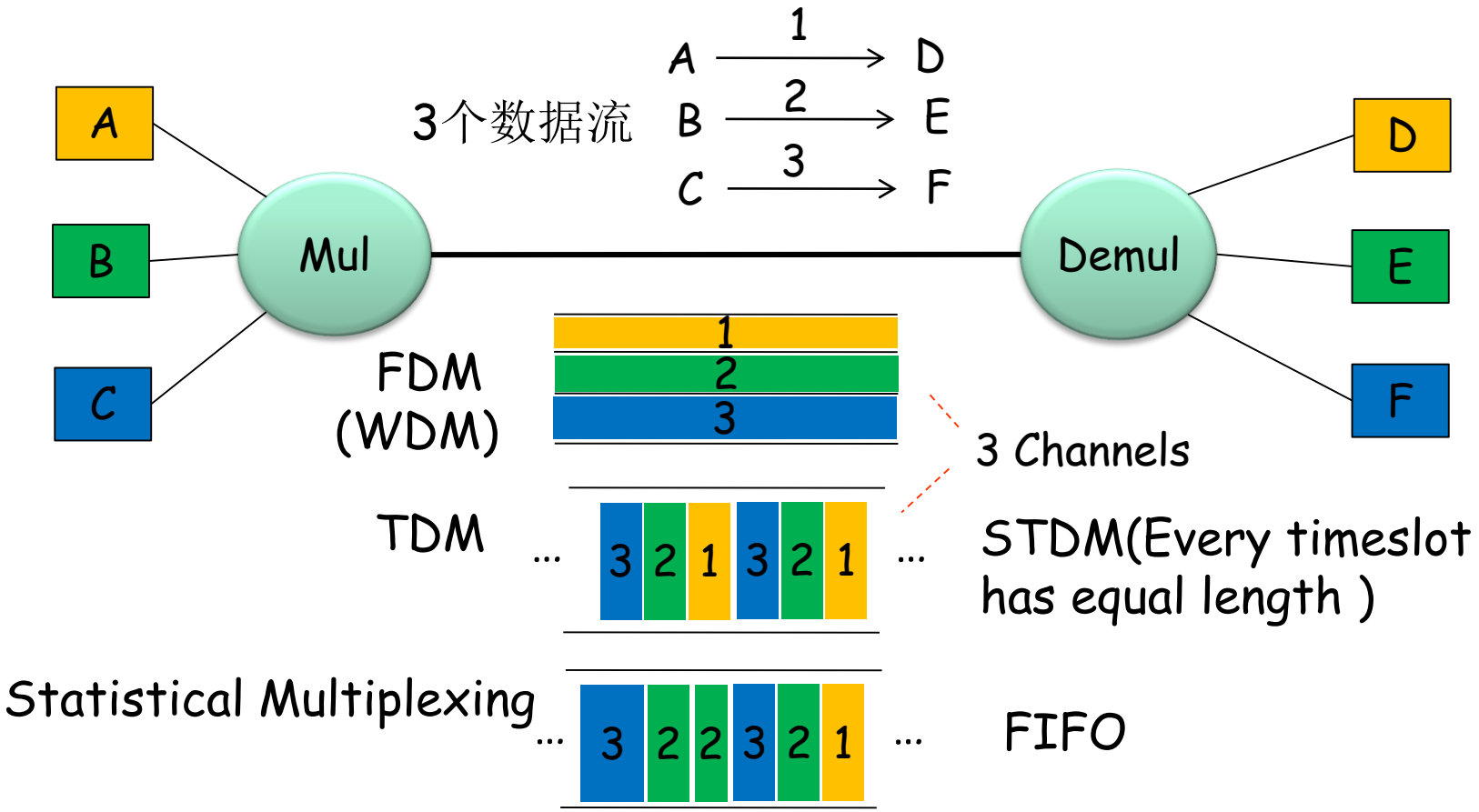
- 地面微波
  45 Mbps channels
- WiFI
  54 Mbps(802.11g),600Mbps(802.11n),
- 3G网络
  ~ 1 Mbps
- 卫星
  1 Kbps ~ 45Mbps
  270 msec 延迟

电磁谱

红外线　　紫外线　　X射线　　伽马射线



多路复用 (Multiplexing)



时分多路复用(Time Division Multiplexing) (STDM--Synchronous TDM)
频分多路复用(Frequency Division Multiplexing)
波分多路复用(Wavelength Division Multiplexing)
码分多路复用(Code Division Multiplexing)

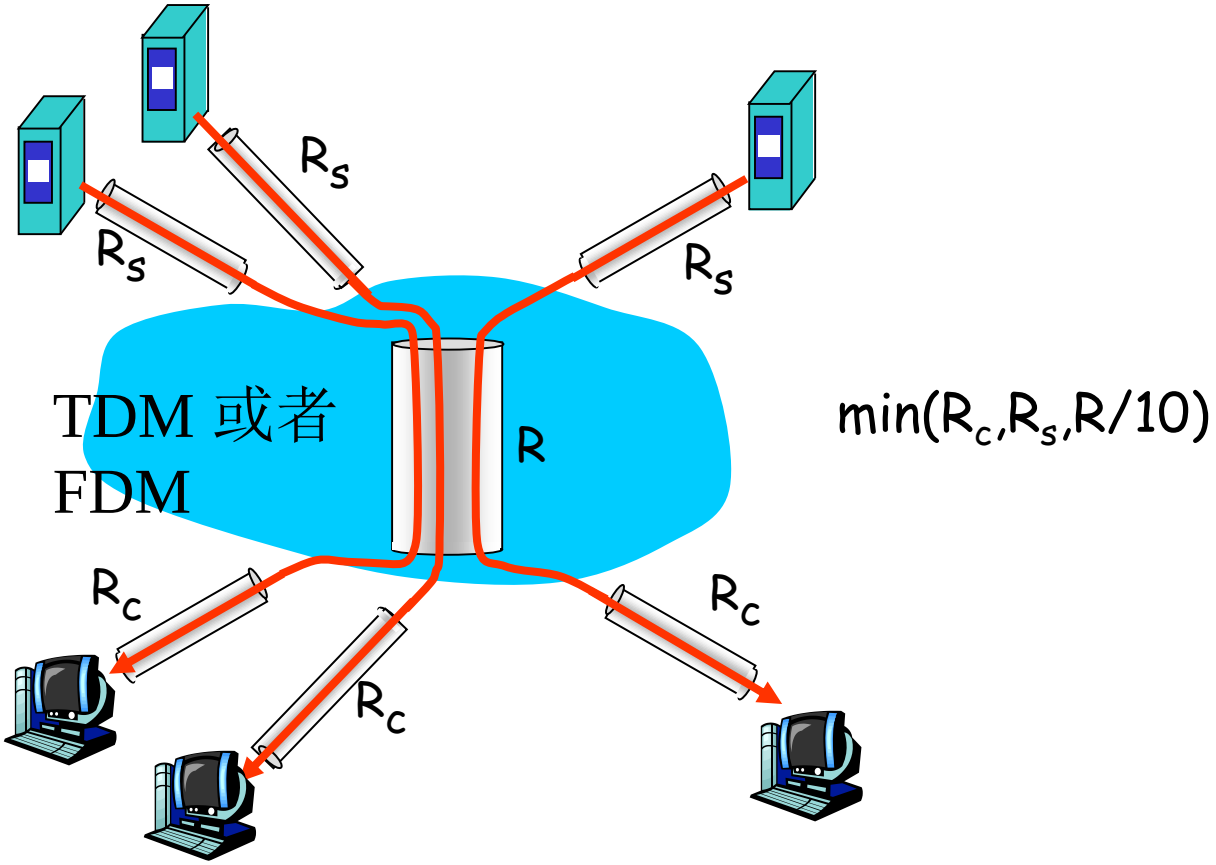
波分多路复用和统计多路复用

- 波分复用(Wavelength Division Multiplexing,WDM)是利用多个激光器在单条光纤上同时发送多束不同波长激光的技术。
- WDM的每个信号经过数据（文本、语音、视频等）调制后都在它独有的色带内传输。WDM能使电话公司和其他运营商的现有光纤基础设施容量大增。
- 制造商已推出了DWDM(Dense Wavelength Division Multiplexing)系统，也叫密集波分复用系统。DWDM可以支持150多束不同波长的光波同时传输，每束光波最高达到10Gb/s的数据传输率。这种系统能在一条比头发丝还细的光缆上提供超过1Tb/s的数据传输率。 ---维基
- 统计多路复用(Statistical Multiplexing)采用动态分配的方法共享通信链路，比如，先到先发送(FIFO)。对于多个可变速率的数据流，统计多路复用可以提高链路利用率。

电路交换技术(Circuit-Switching)采用FDM、TDM、WDM和CDM技术。

包交换技术(Packet-Switching)采用统计多路复用技术。

- 每条链路端到端的吞吐量是多少？



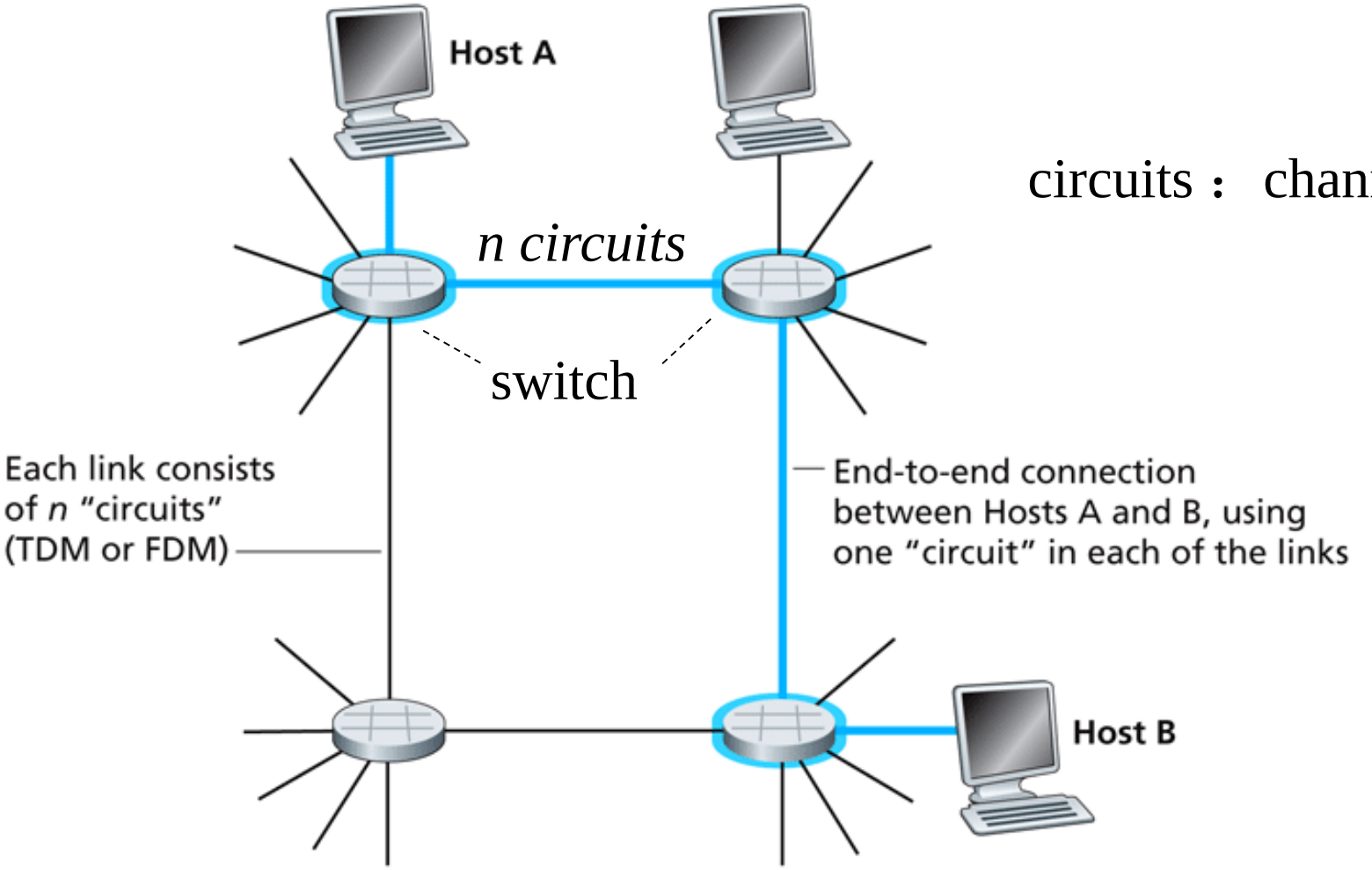
10个链接(平均)共享主干链路的带宽R(bits/sec)

- How long does it take to send a file of 640,000 bits from host A to host B over a circuit-switched network?
  - All links are 1.536 Mbps
  - Each link uses TDM with 24 slots/sec (24circuits)
  - 500 msec to establish end-to-end circuit

Let's work it out!

500ms + 640000bits/(1.536Mbps/24)
= 500ms + 640000/64000
= 500ms + 10s
= 10.5s

- What is the maximum number of simultaneous connections that can be in progress at any one time in this network?
- Suppose that all connections are between the switch in the upper-left-hand corner and the switch in the lower-right-hand corner. What is the maximum number of simultaneous connections that can be in progress?



circuits： channels

总结

- 通信系统
- 正弦波信号
- 频移键控
- 曼彻斯特编码
- 物理介质
- 多路复用和电路交换