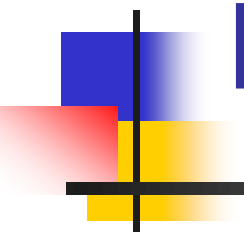

Encoding and Modulating

รศ.ดร. อนันต์ ผลเพิ่ม

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Computer Engineering Department

Kasetsart University, Bangkok, Thailand

Outline

- Digital-to-digital conversion
  - Encode digital data into a digital signal
  - Sending computer data

- Analog-to-Digital conversion
  - Digitizing an analog
  - Sending voice in telephone (Decrease effect of noise)

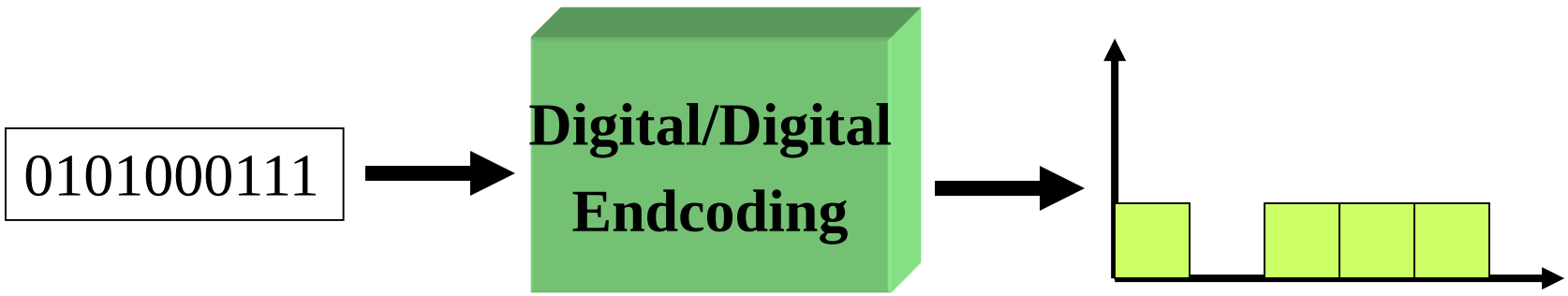
- Digital-to-Analog conversion
  - Modulating a digital signal
  - Sending computer data through public telephone line

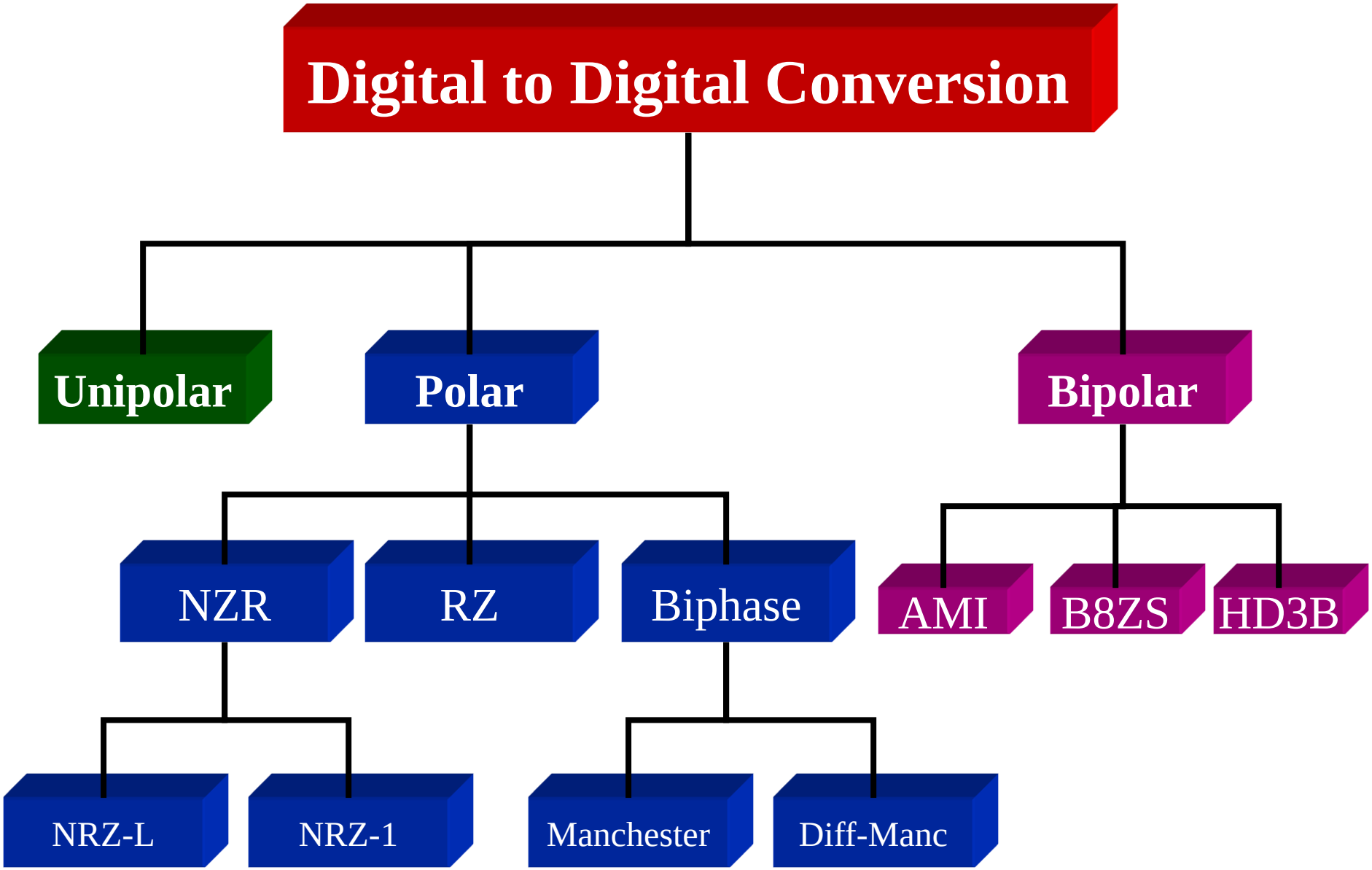
Modem

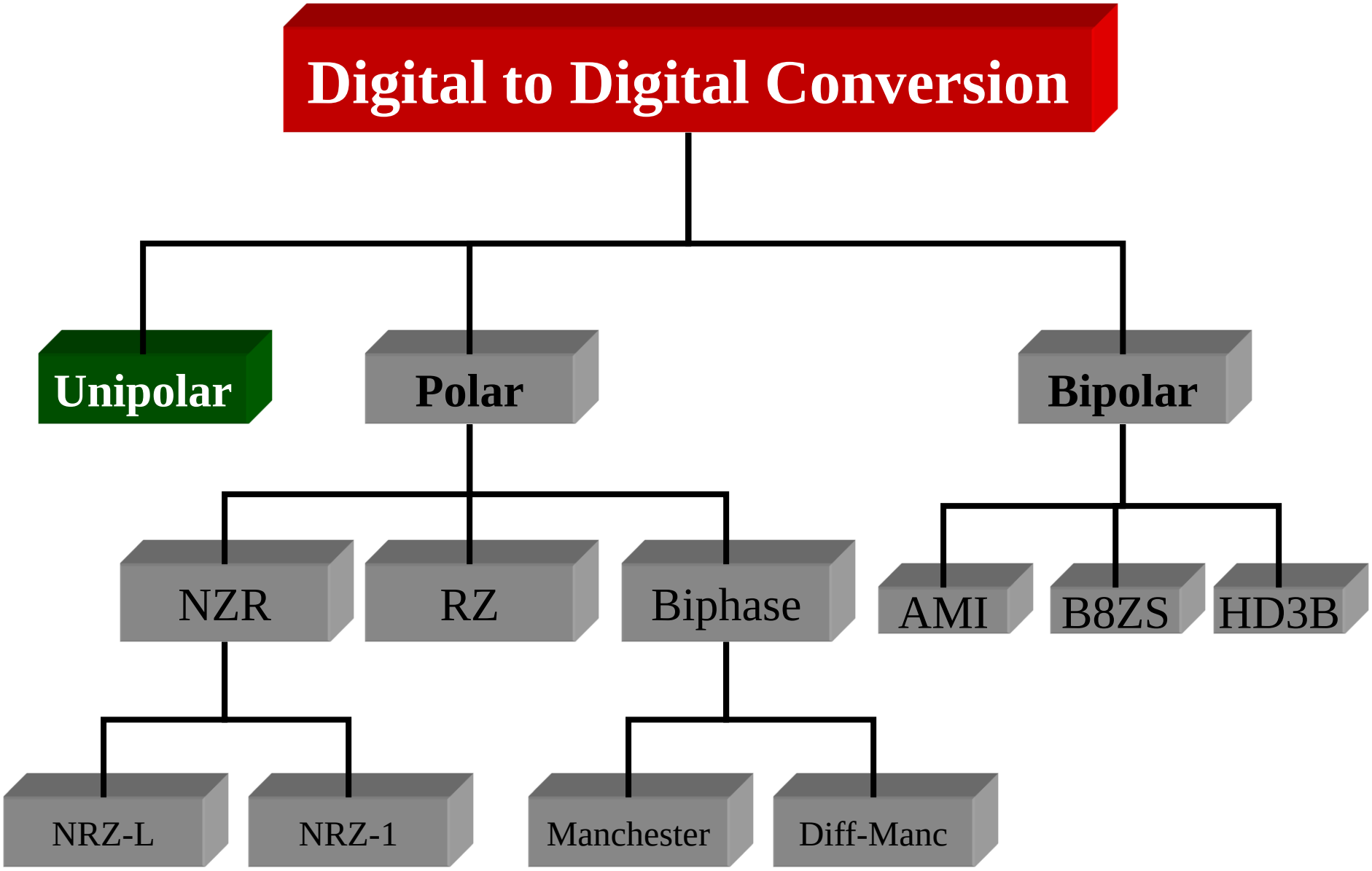
- Analog-to-Analog conversion
  - Modulating an analog signal
  - Sending music from radio station

Digital-to-digital conversion

- Encoding data into a digital signal




Digital to Digital Conversion
Unipolar
Polar
Bipolar
NZR
RZ
Biphase
AMI
B8ZS
HD3B
NRZ-L
NRZ-1
Manchester
Diff-Manc


Digital to Digital Conversion
Unipolar
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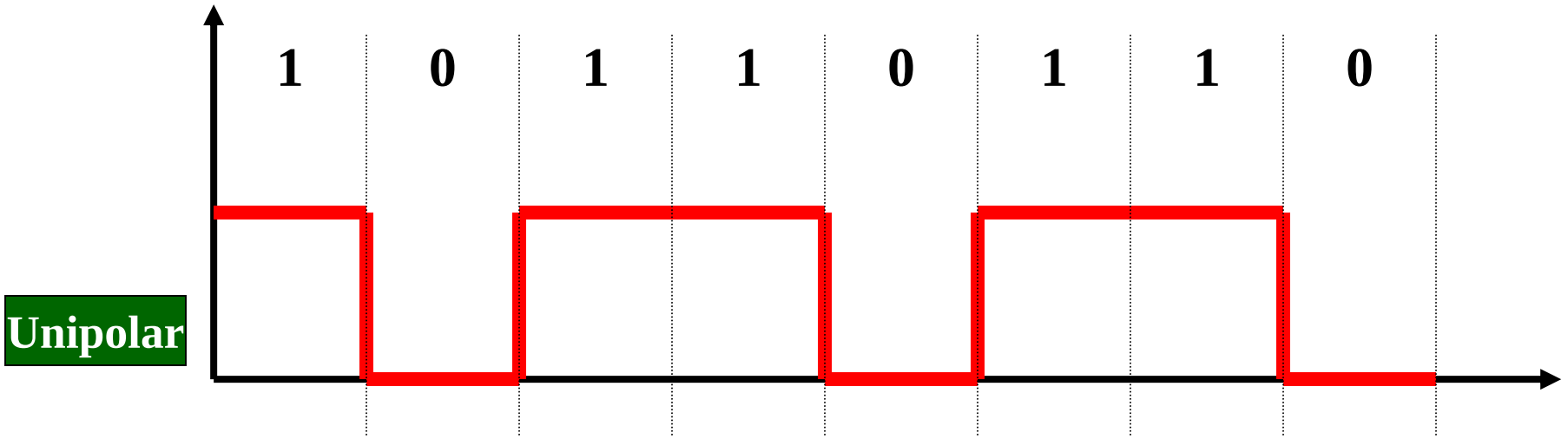
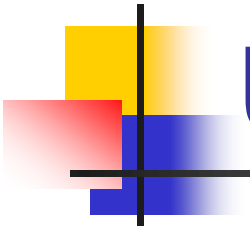
NZR
RZ
Biphase
AMI
B8ZS
HD3B
NRZ-L
NRZ-1
Manchester
Diff-Manc

Unipolar Encoding

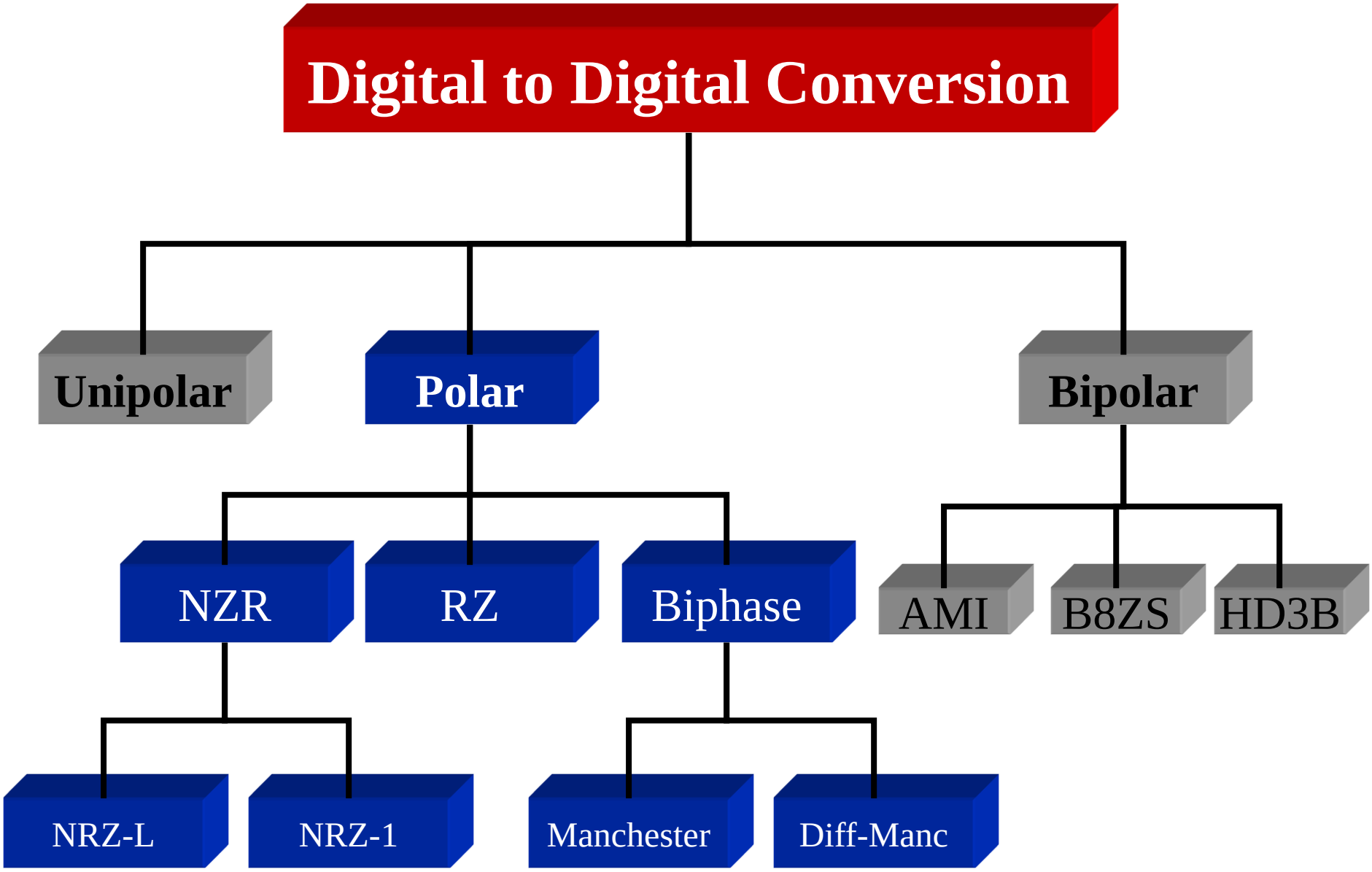
- One level of value





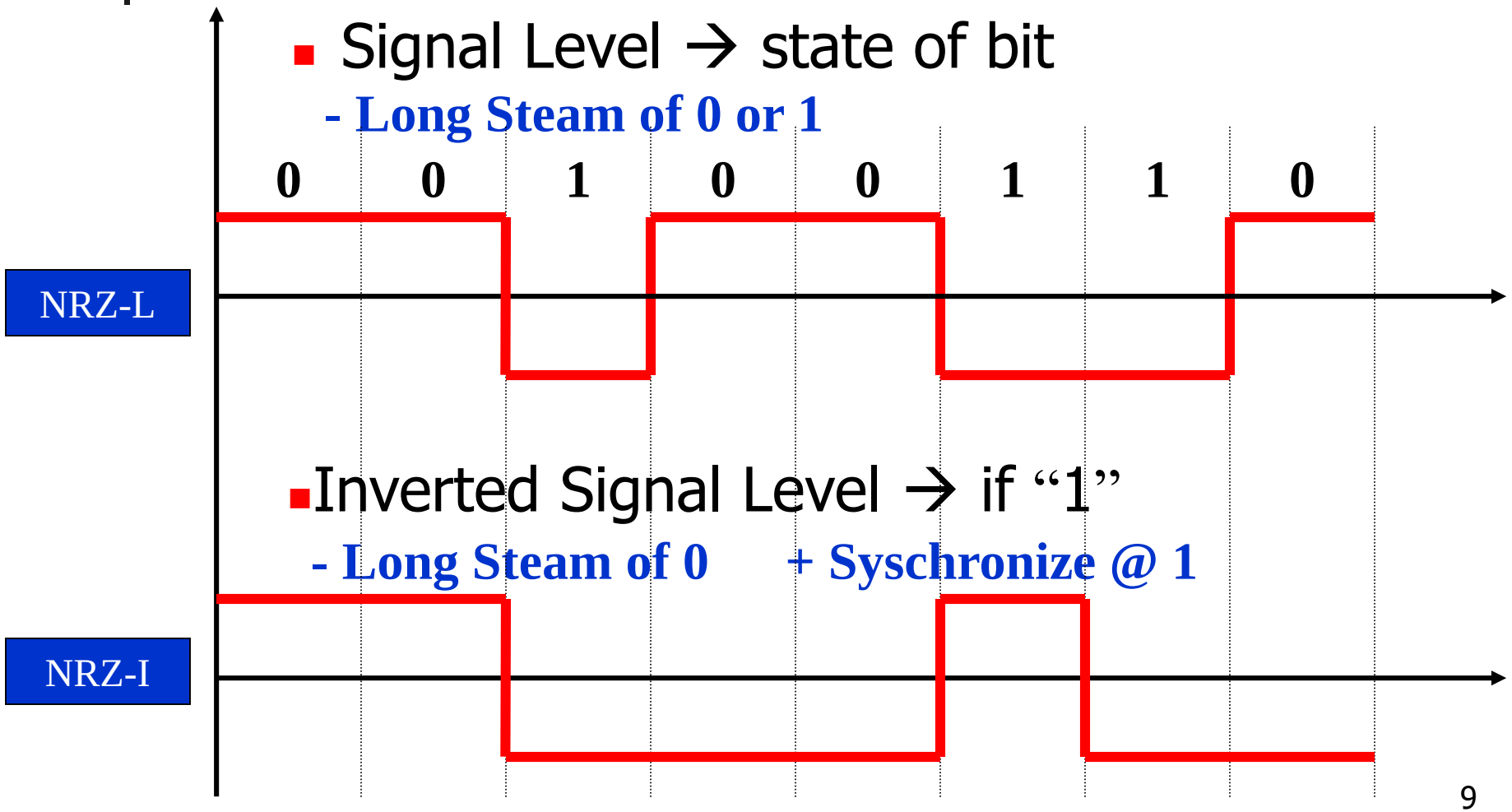
Unipolar Encoding

- Problems
  - DC components
    - Cannot pass through some media
  - Synchronization
    - Beginning/ending problem (1111111111)
    - Distortion (four 1111 → five 11111)
    - Solved by separate line


Digital to Digital Conversion
Unipolar
Polar
Bipolar
NZR
RZ
Biphase
AMI
B8ZS
HD3B
NRZ-L
NRZ-1
Manchester
Diff-Manc

Polar Encoding Two levels (+ and -)
NRZ (Nonreturn to Zero)

- Signal Level → state of bit
  - **Long Steam of 0 or 1**



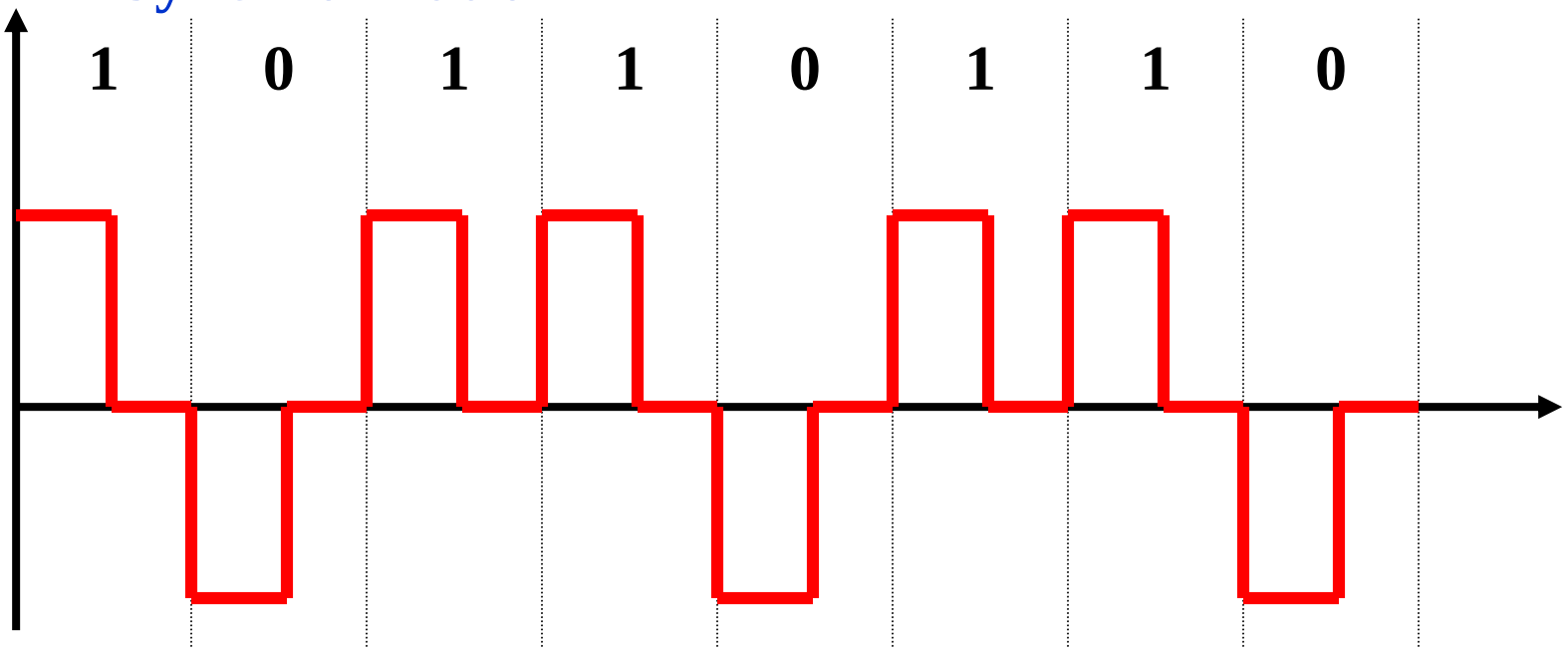
- Inverted Signal Level → if "1"
  - **Long Steam of 0** **+ Syschronize @ 1**

Polar Encoding
RZ (Return to Zero)

- Three levels (+ - 0)

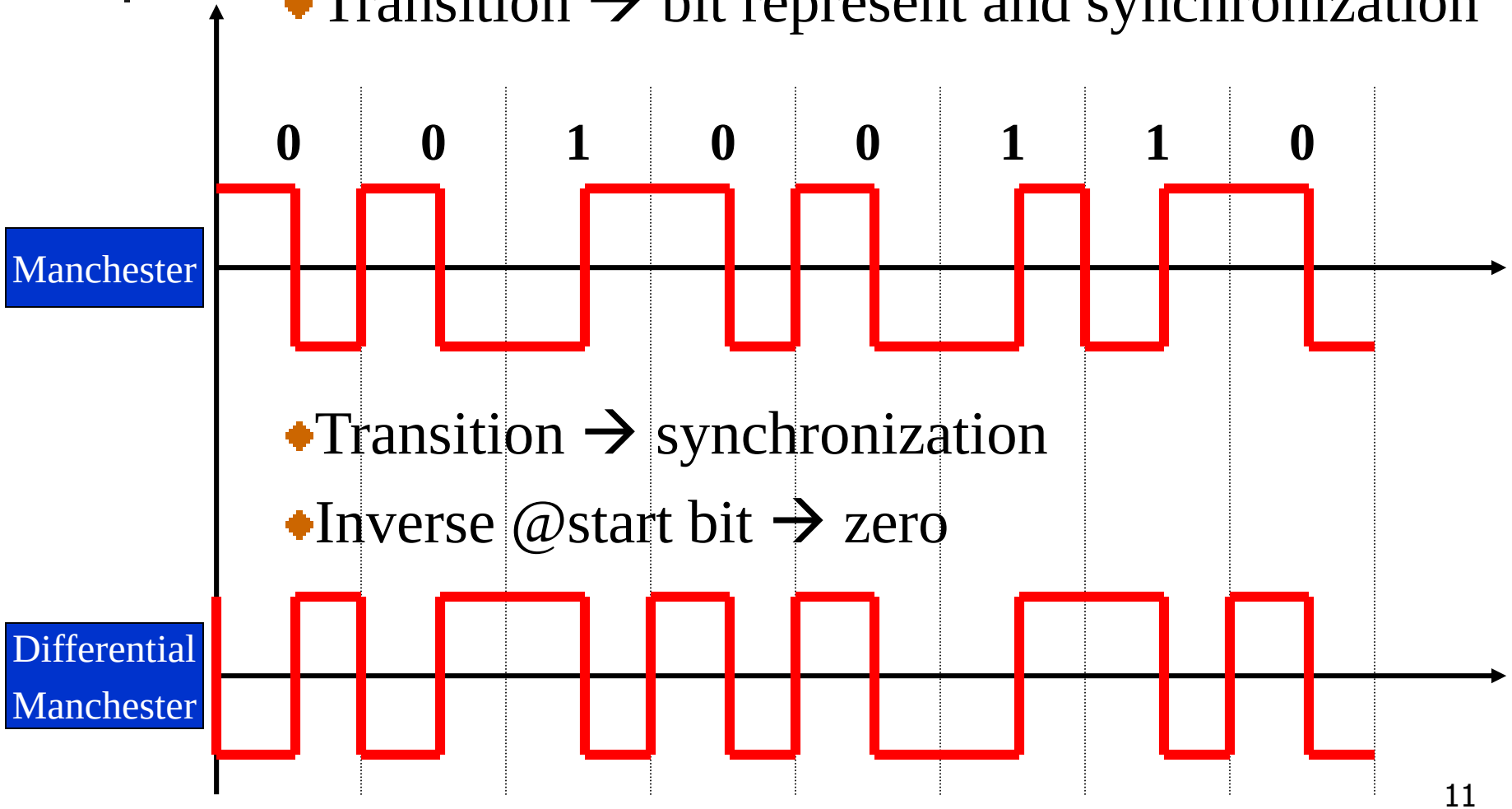
  - 2 signal changes per bit → more BW

  + Synchronization

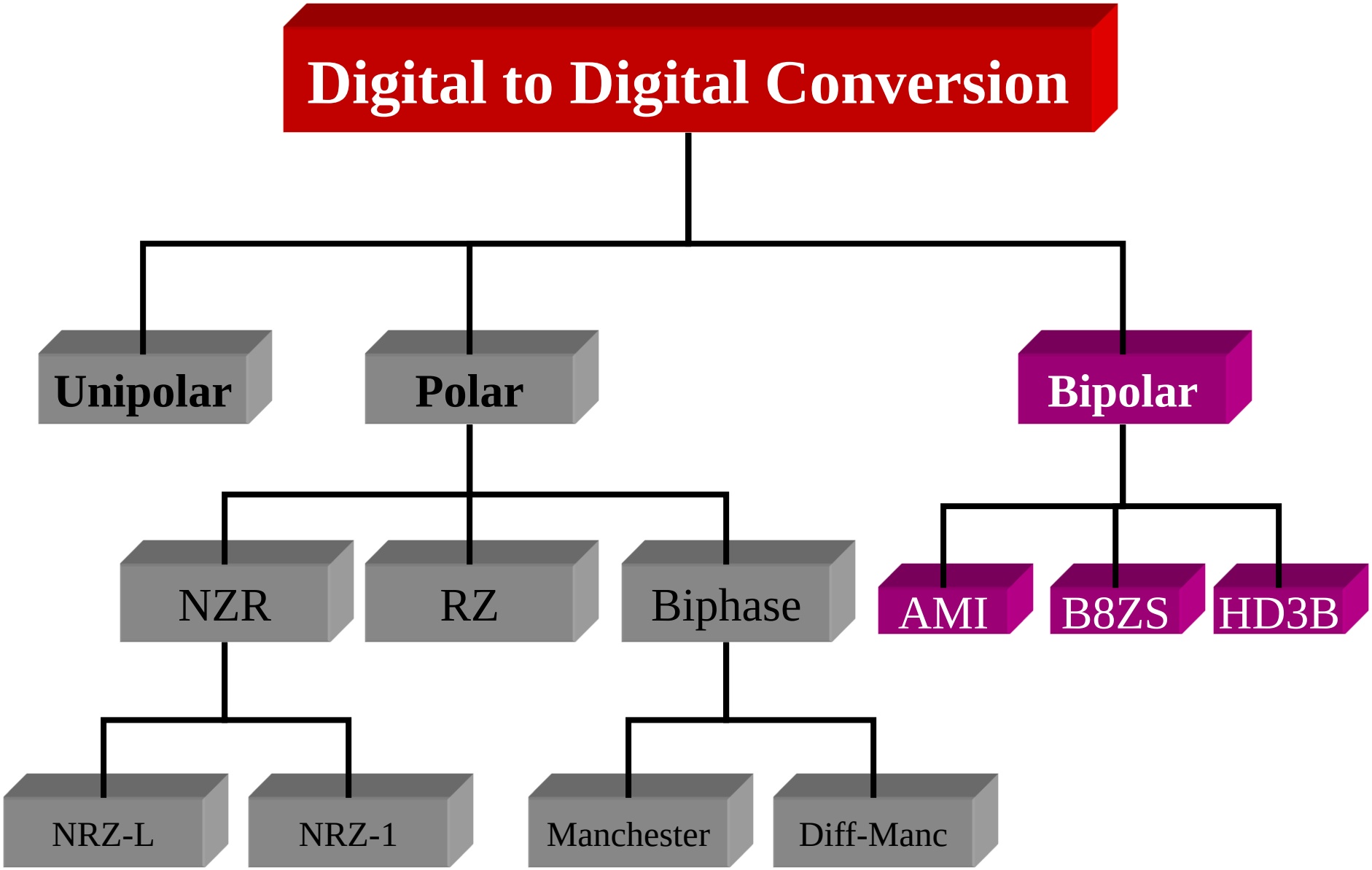


Polar Encoding
Biphase

- Transition → bit represent and synchronization



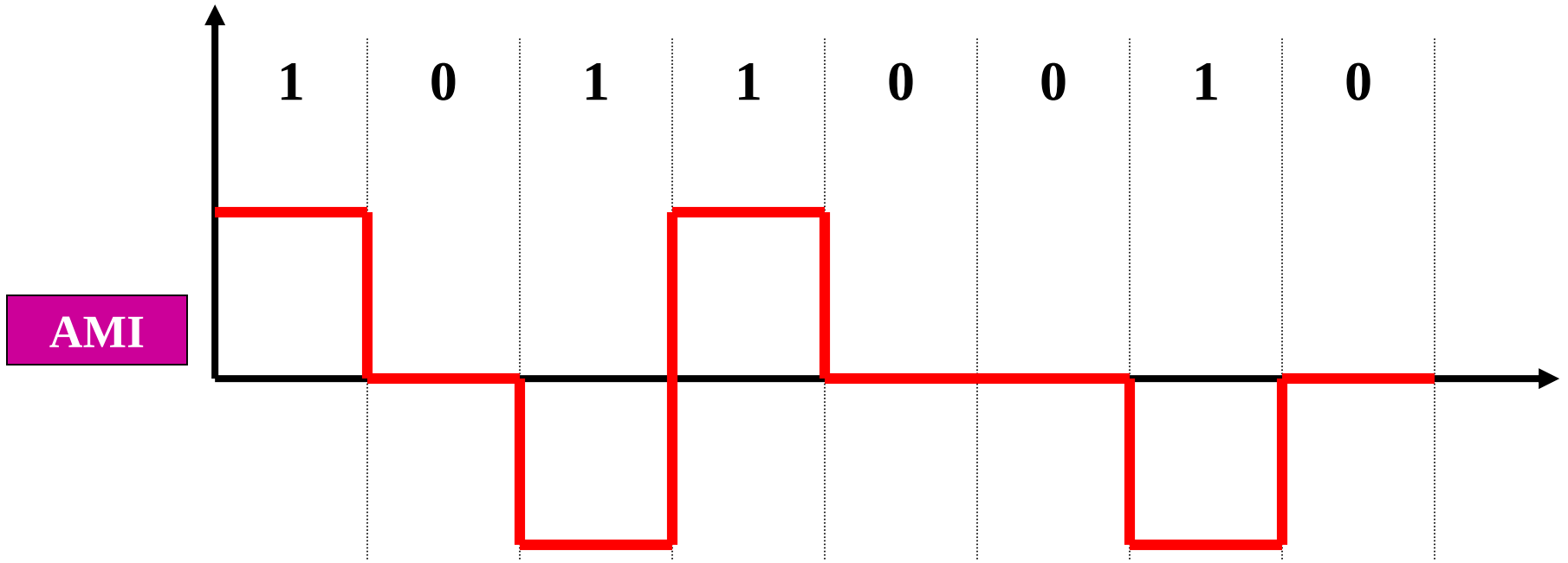
- Transition → synchronization
- Inverse @start bit → zero


Digital to Digital Conversion
Unipolar
Polar
Bipolar
NZR
RZ
Biphase
AMI
B8ZS
HD3B
NRZ-L
NRZ-1
Manchester
Diff-Manc

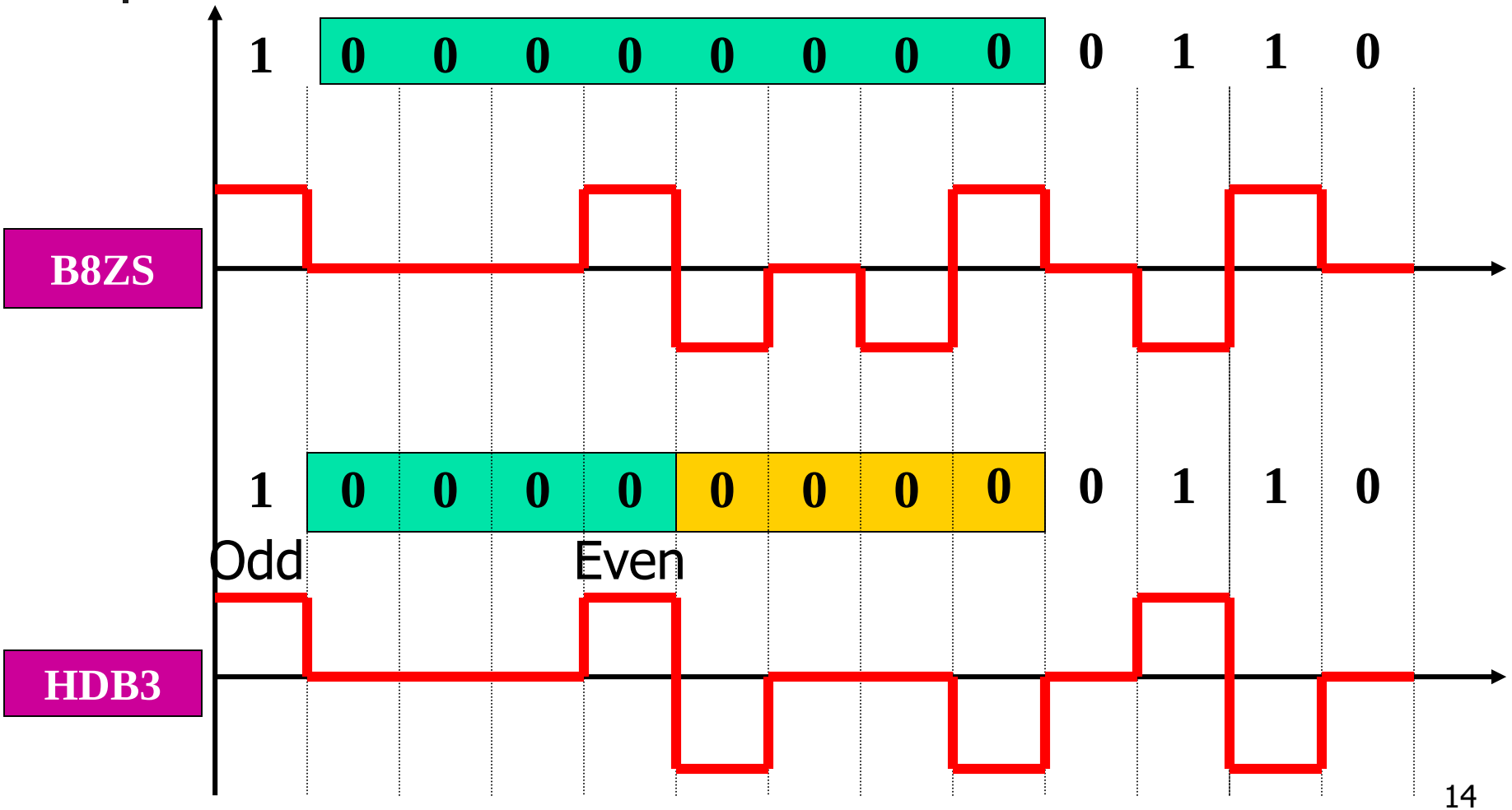
Bipolar Alternate Mark Invision (AMI)

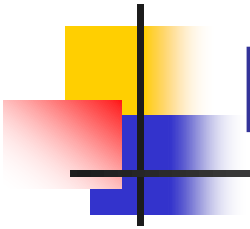
- "1" are positive and negative alternately

- Long Steam of 0 **+ DC component = 0**



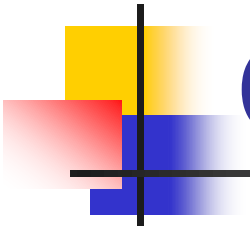
Bipolar
(solved long stream of "0" → using violation)





Problems

- DC component
- Synchronization (Long stream of 0 or 1)



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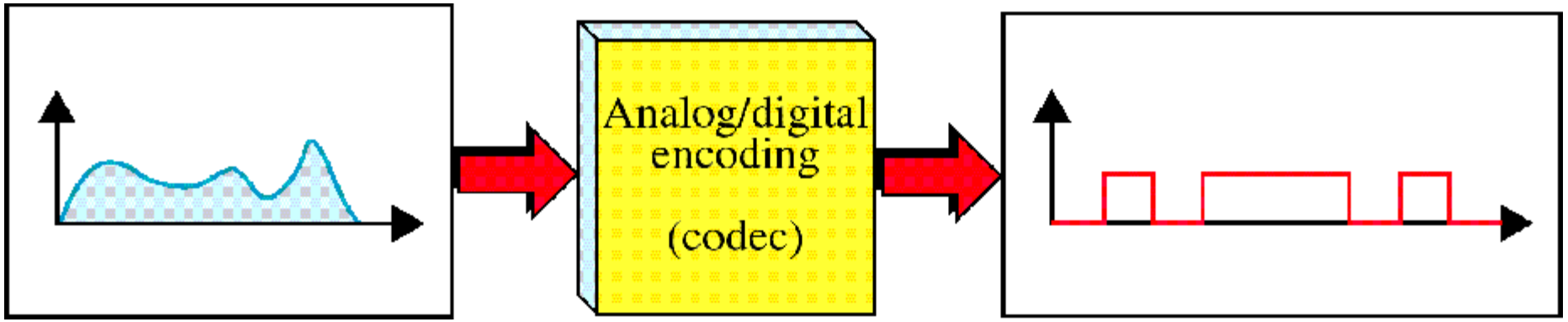
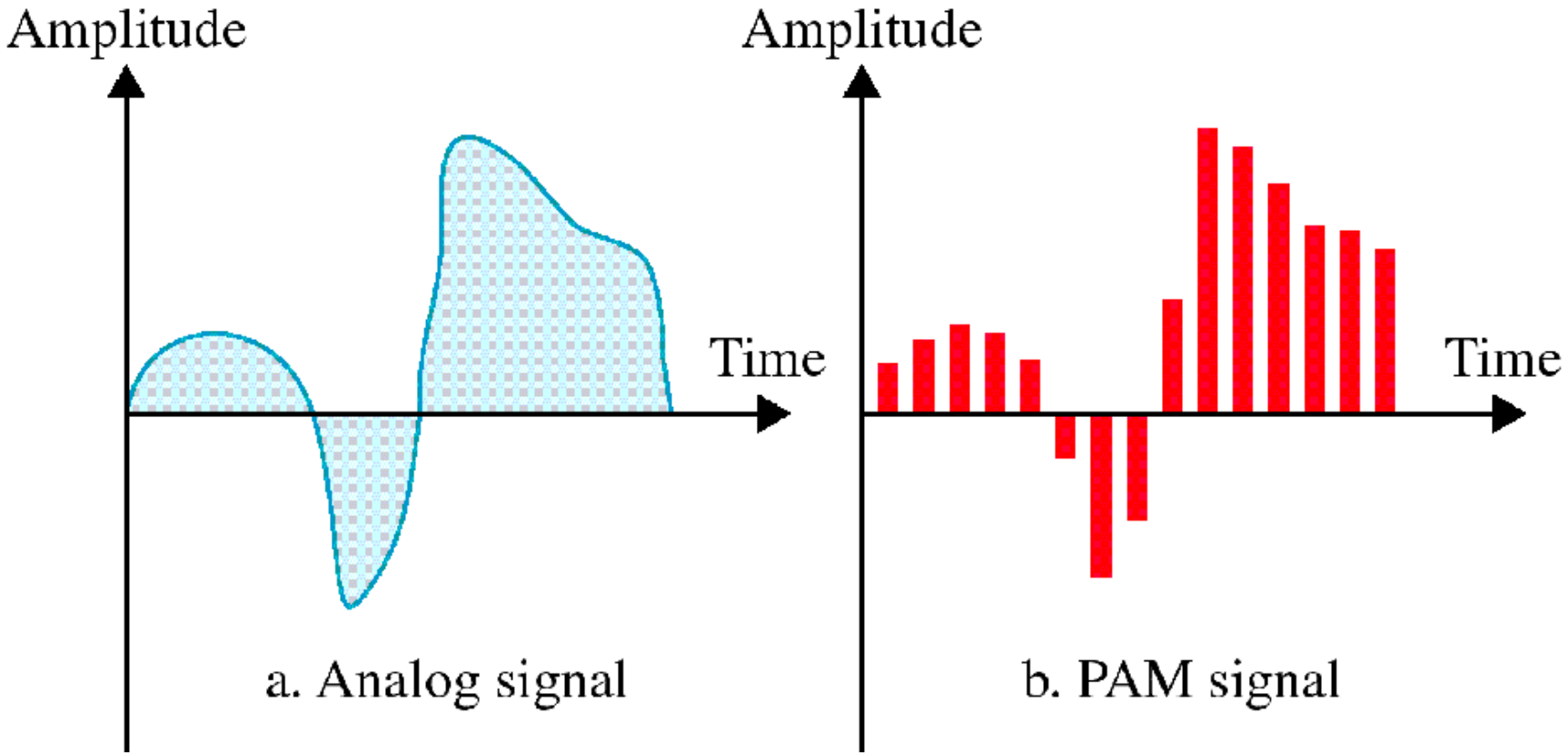
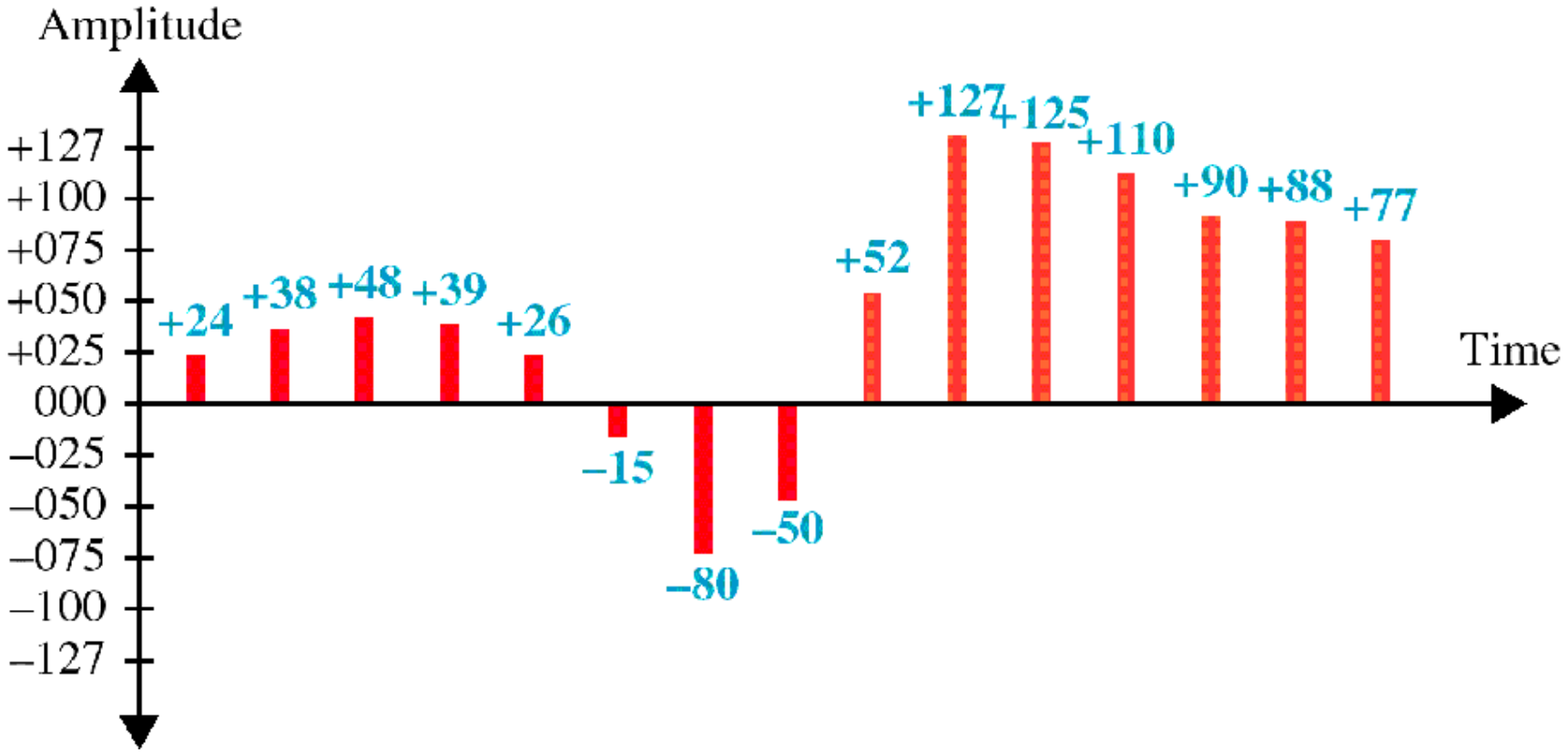
Analog to Digital Encoding



Step 1:
Pulse Amplitude Modulation(PAM)



Step 2: Quantized PAM Signal

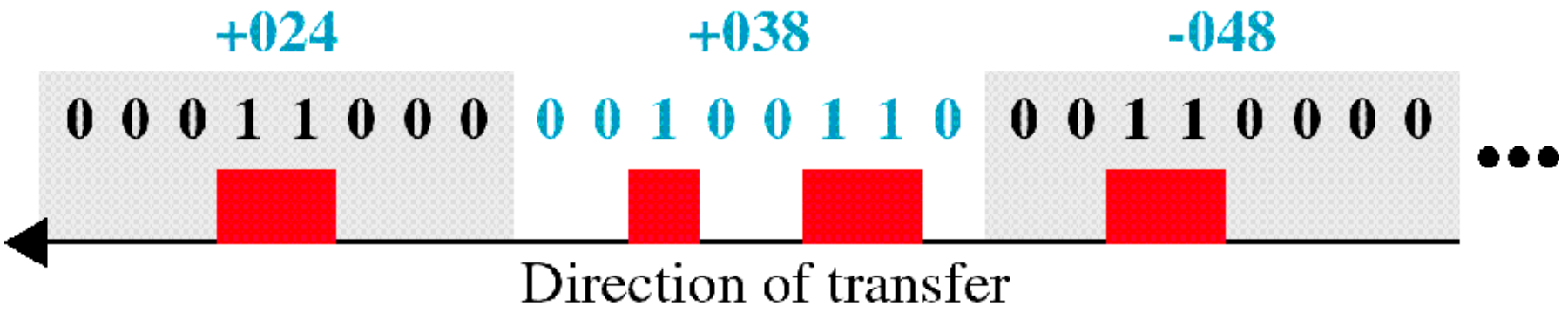


Step 3:
Quantizing Using Sign and Magnitude

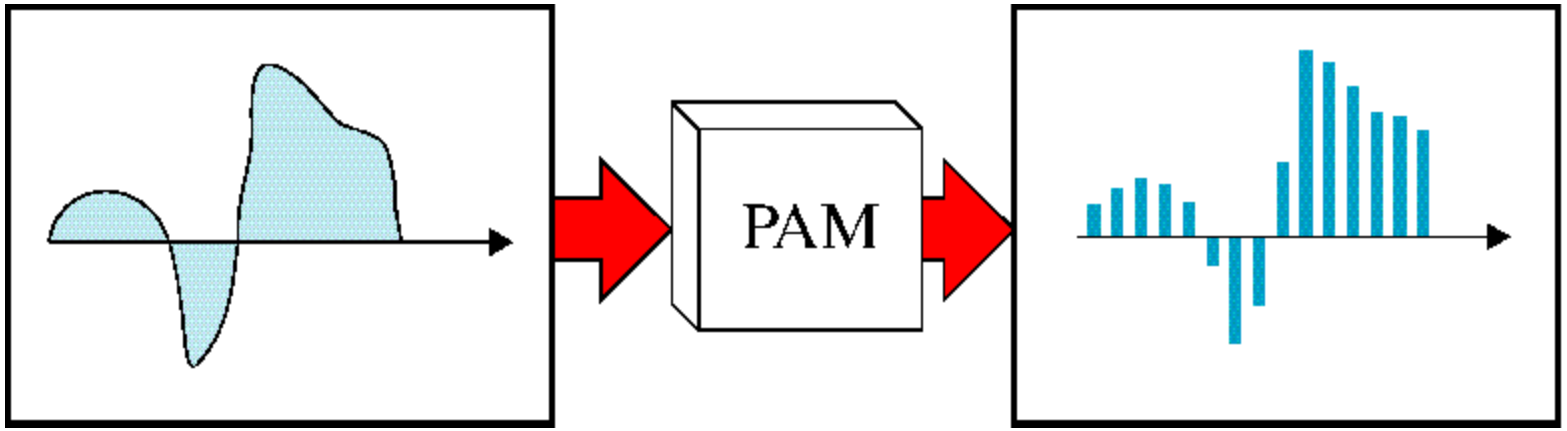
+024	00011000	–015	10001111	+125	01111101
+038	00100110	–080	11010000	+110	01101110
+048	00110000	–050	10110010	+090	01011010
+039	00100111	+052	00110110	+088	01011000
+026	00011010	+127	01111111	+077	01001101

Sign bit
+ is 0 – is 1

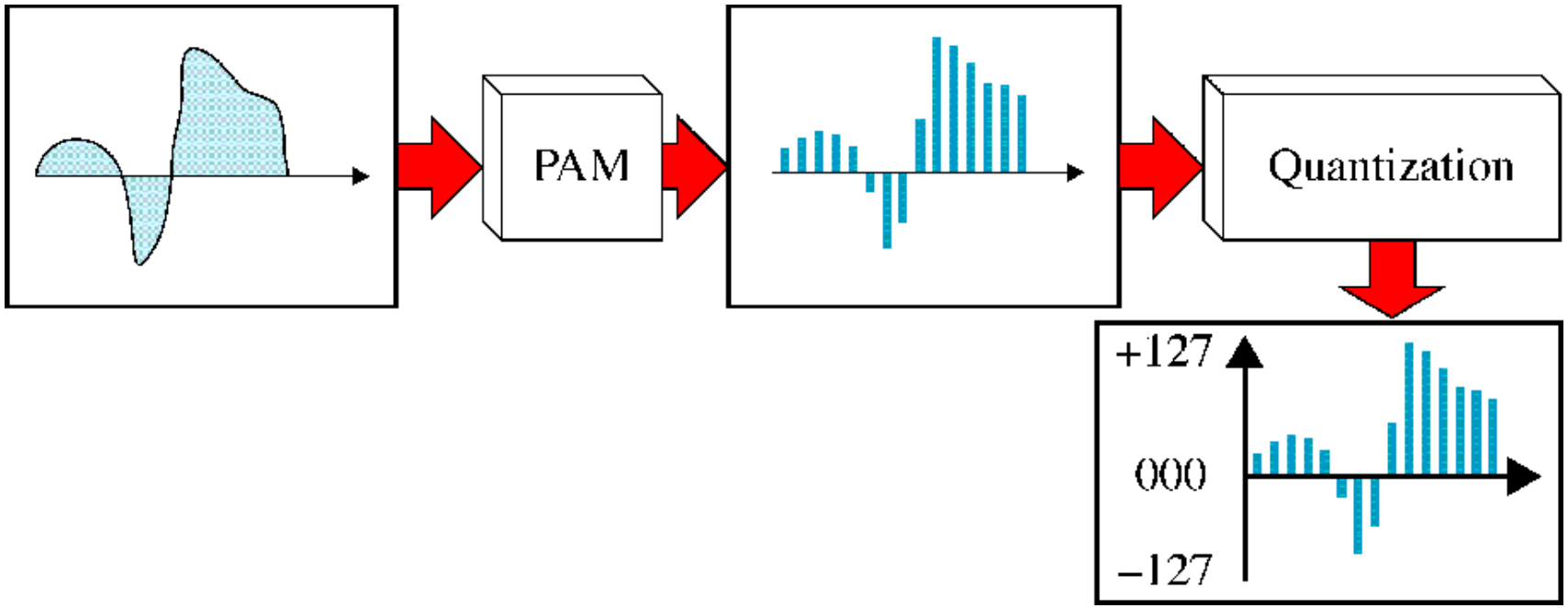
Step 4:
Pulse Code Modulation (PCM)



Summary
From Analog to PCM



From Analog to PCM



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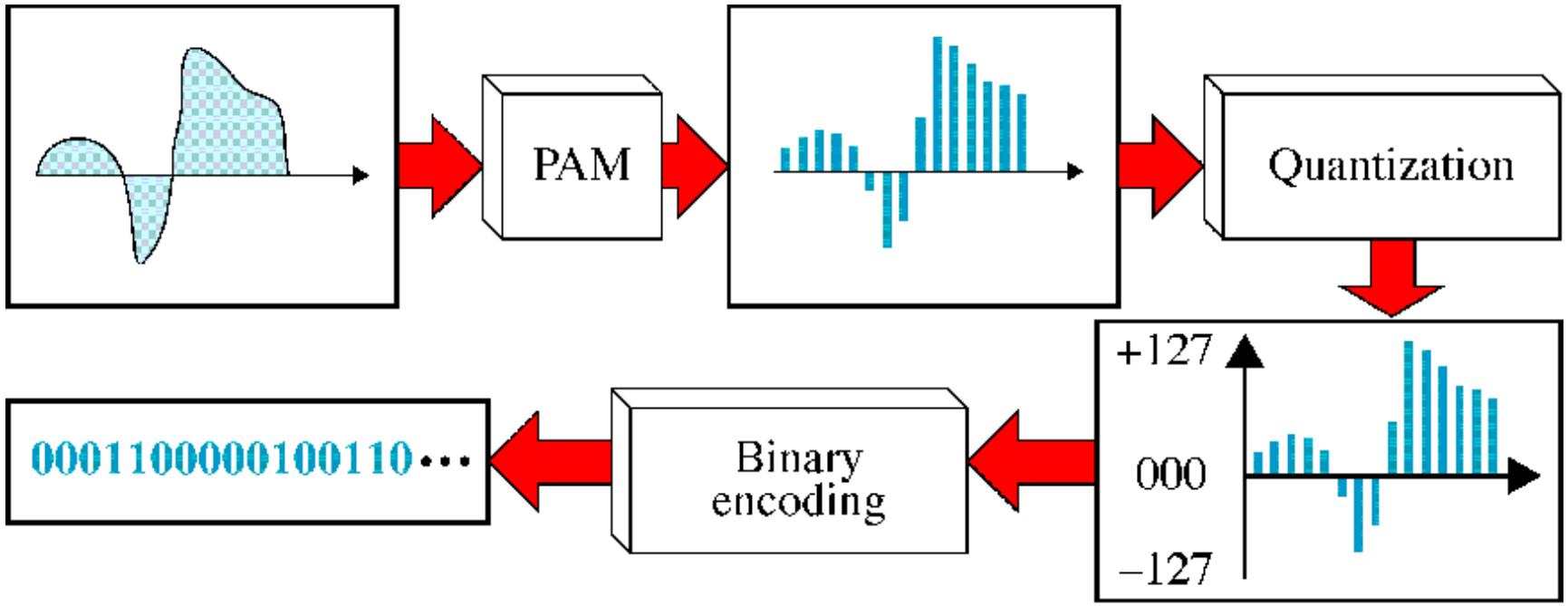
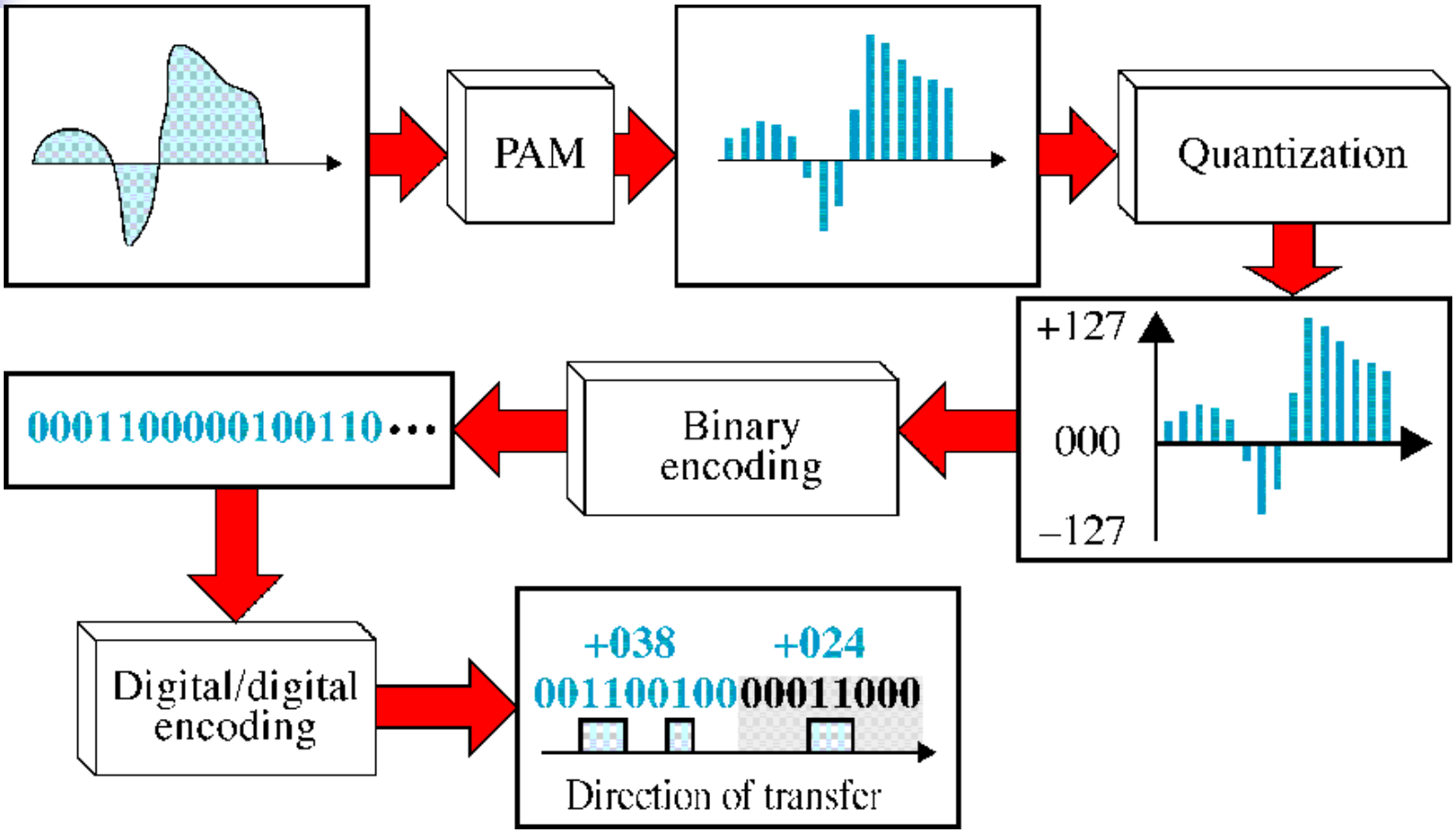
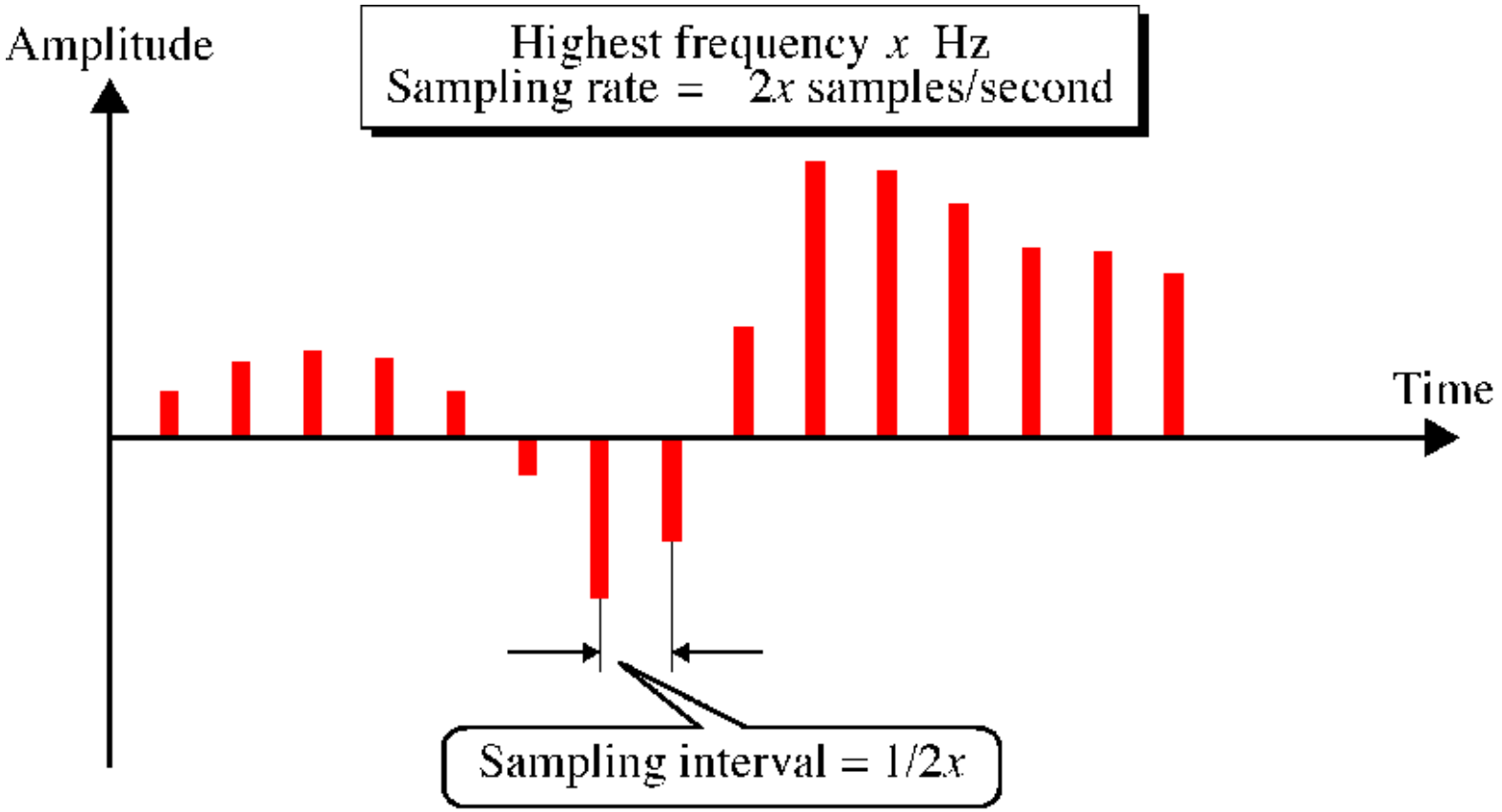
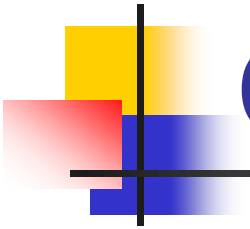


From Analog to PCM



Nyquist Theorem





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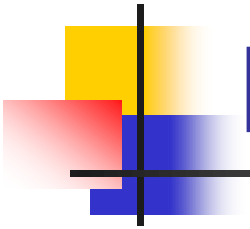
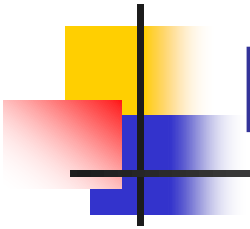


Basic Concepts

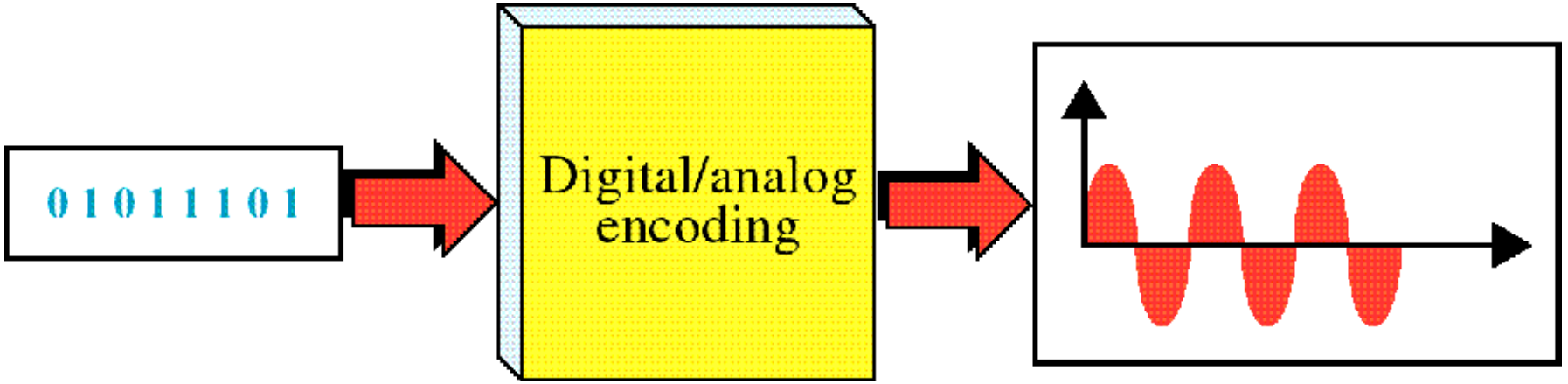
- Bit rate
  - Bits transfer in a second
  - Computer Efficiency (time to send)
- Baud rate
  - # of Signal per second
  - Data transmission (move data)
  - Few signal → efficiency
- Analogy (transportation)

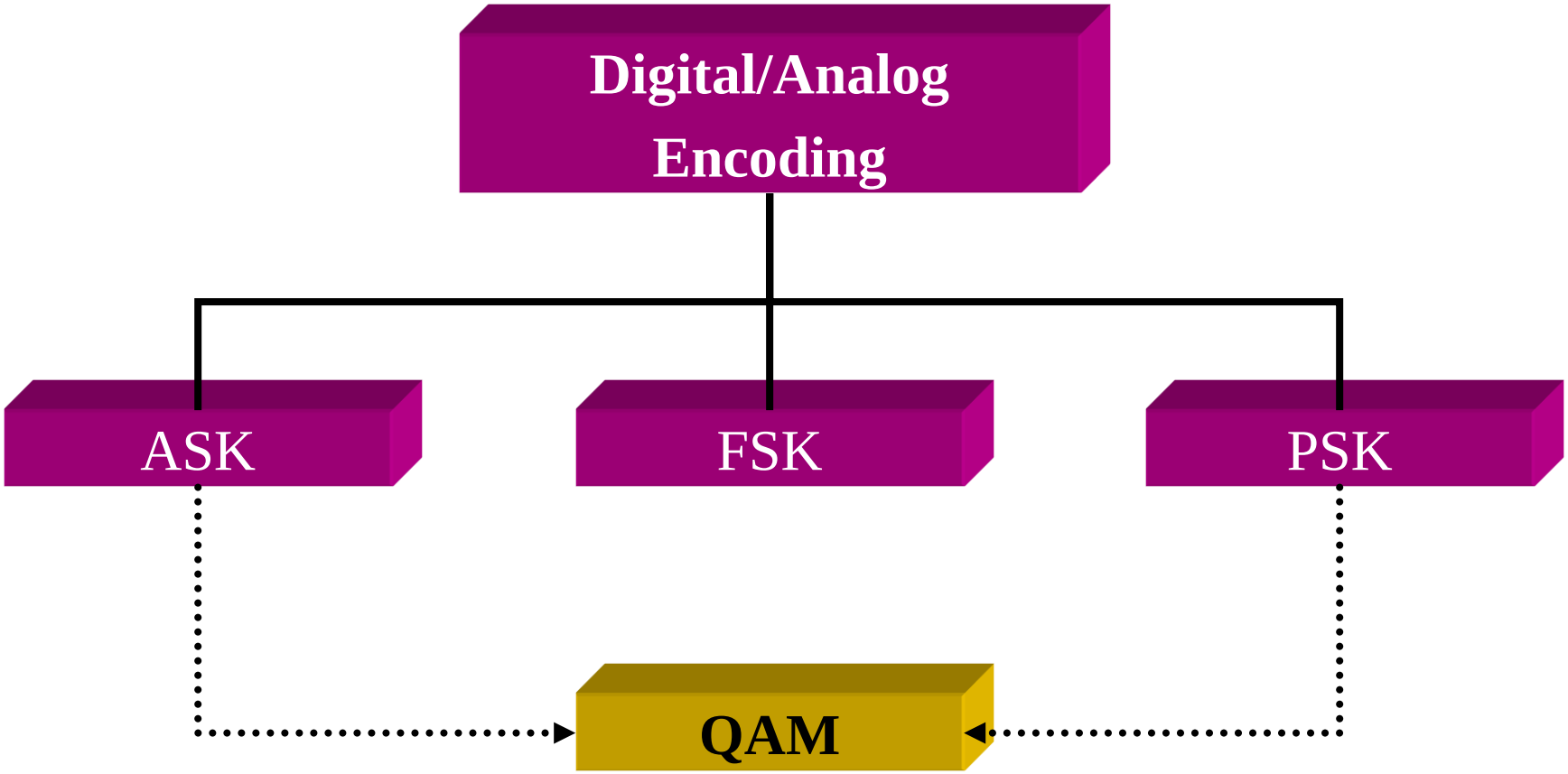


Basic concepts

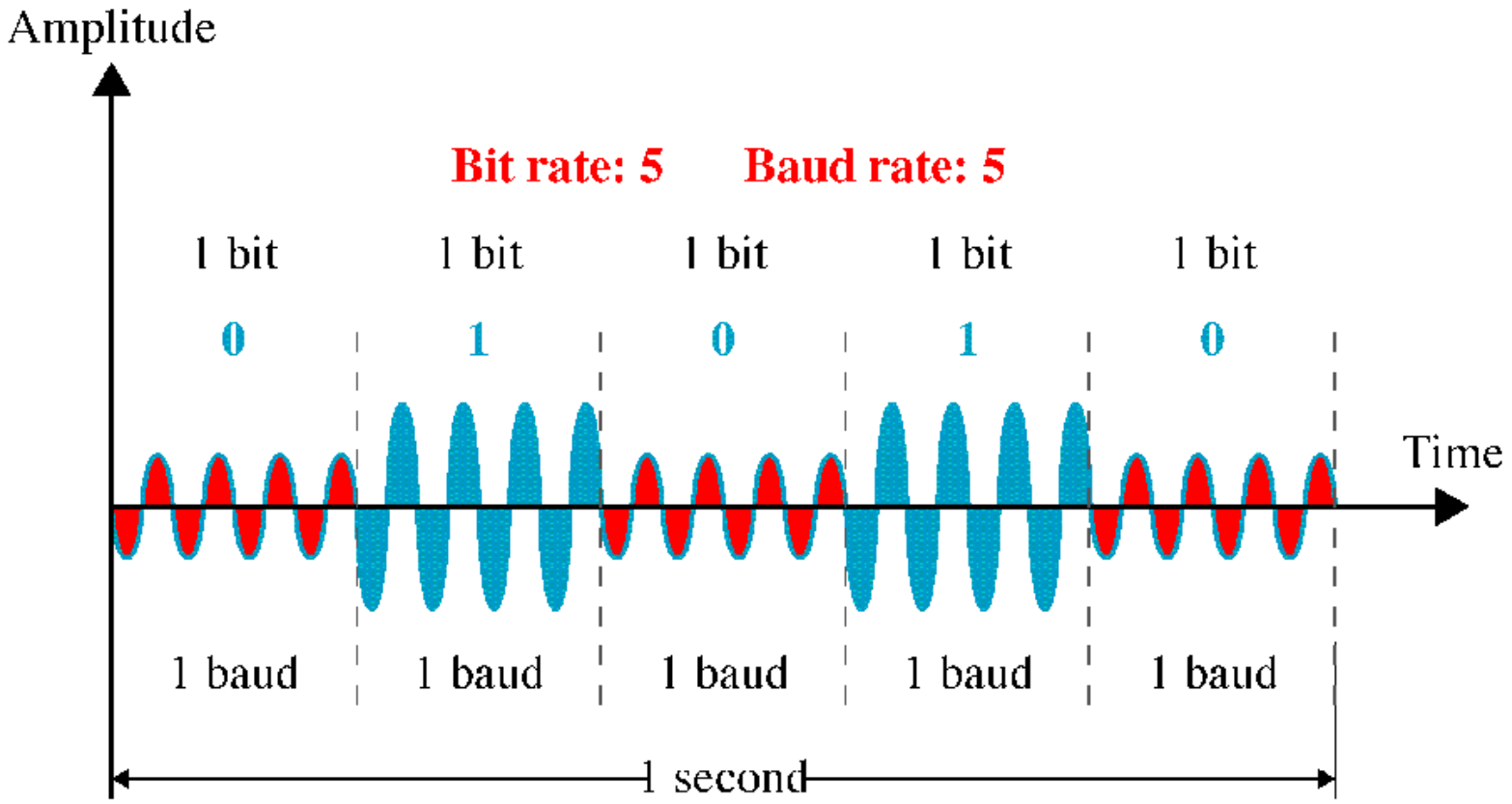
- **Carrier signal (carrier frequency)**
  - High frequency as a basis for information
  - Sender and receiver agree on the frequency
  - Digital data is modulated (shift keying) on the carrier by modifying carrier characteristics
- **3 characteristics of carrier signal**
  - Amplitude
  - Frequency
  - Phase

Digital to Analog Encoding

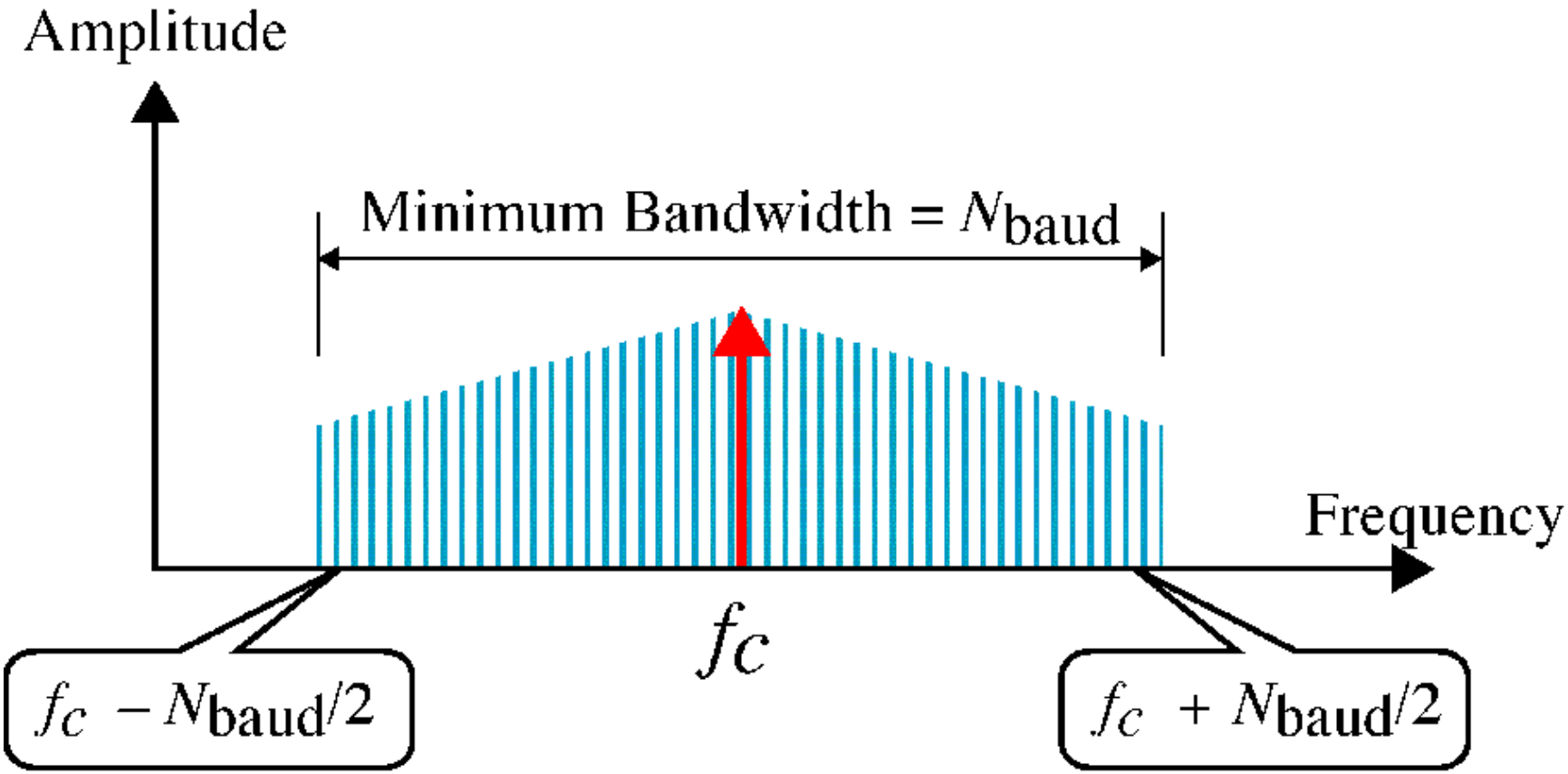



Digital/Analog
Encoding
ASK
FSK
PSK
QAM

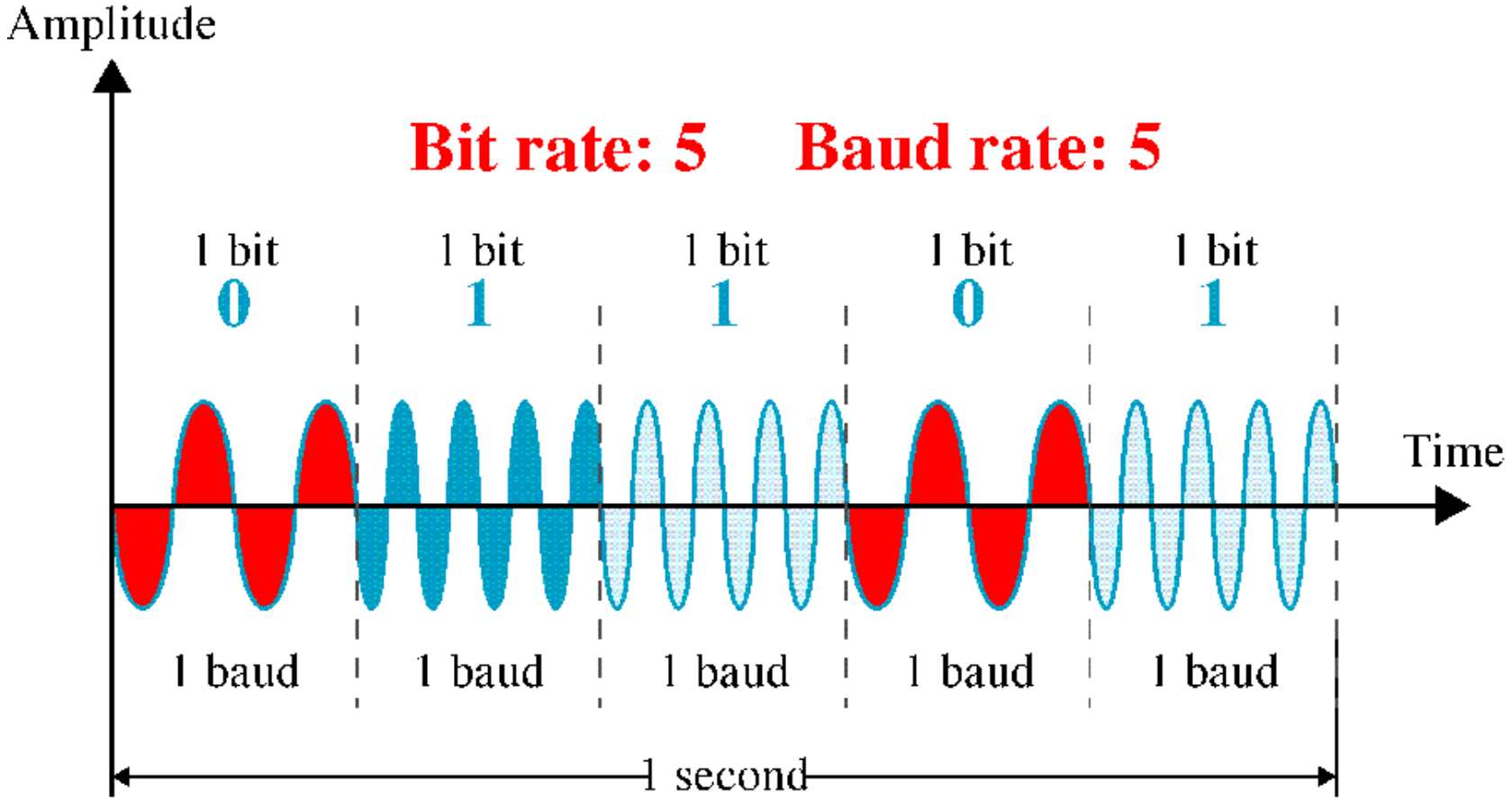
Amplitude Shift Keying (ASK)



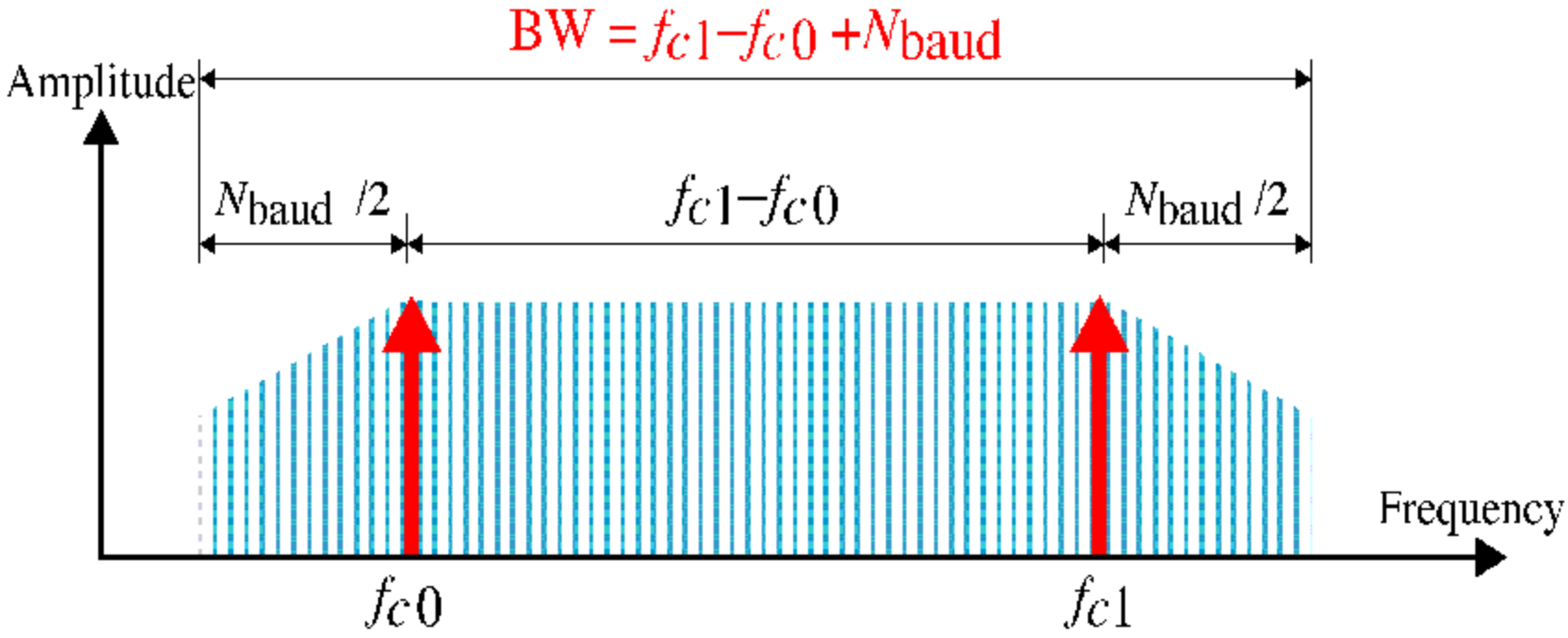
Bandwidth for ASK



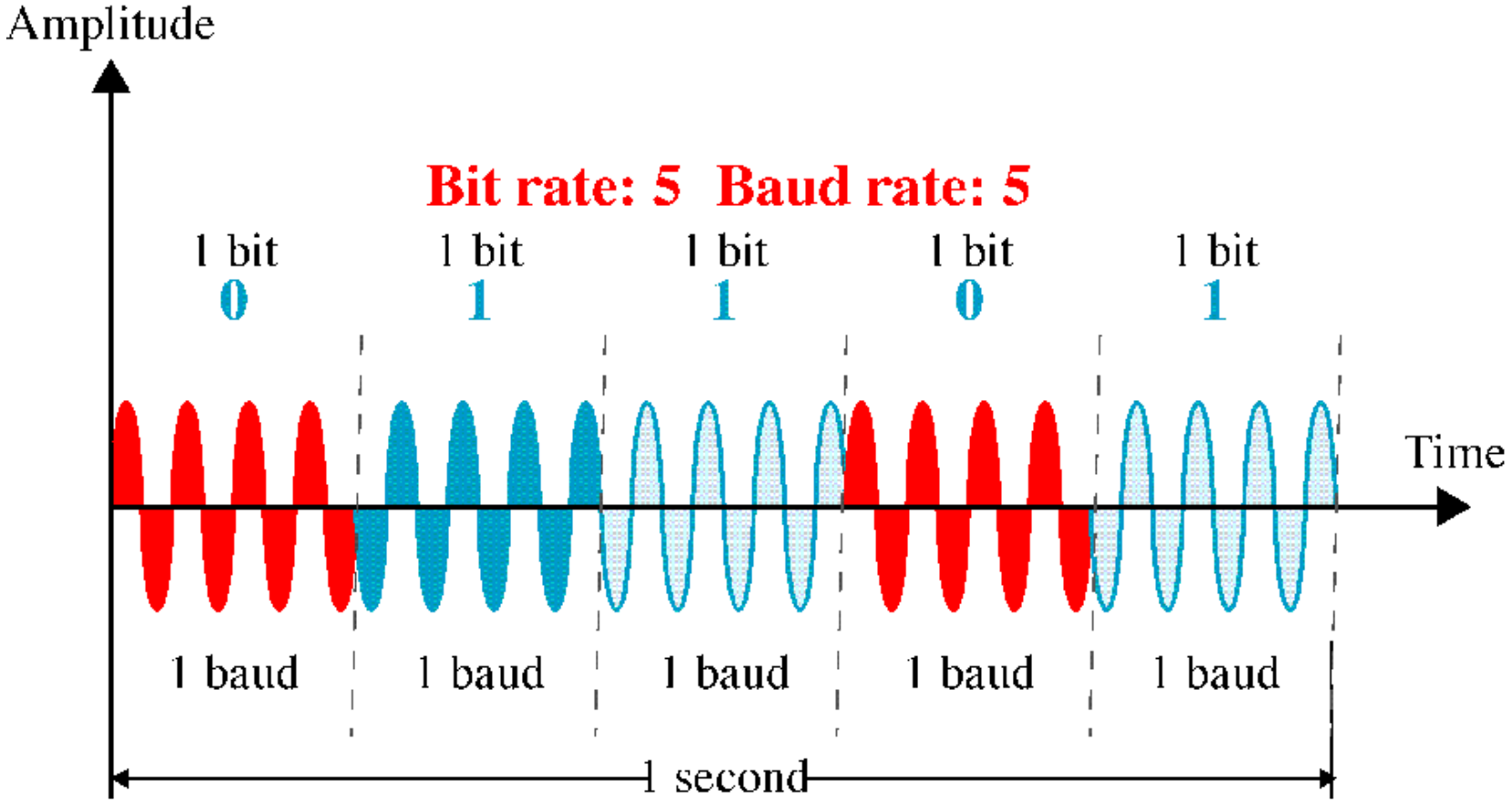
Frequency Shift Keying (FSK)



Bandwidth for FSK



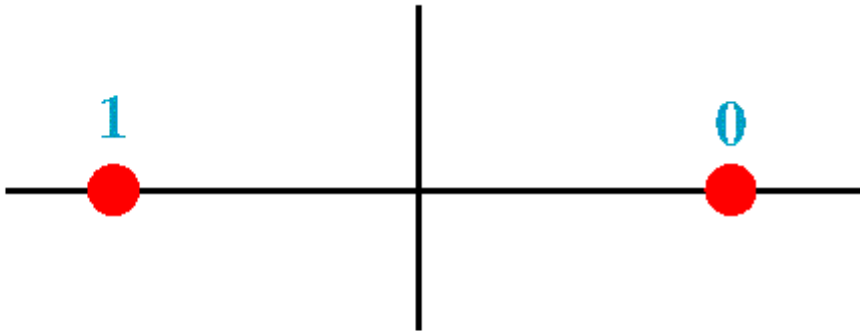
Phase Shift Keying (PSK)



PSK Constellation

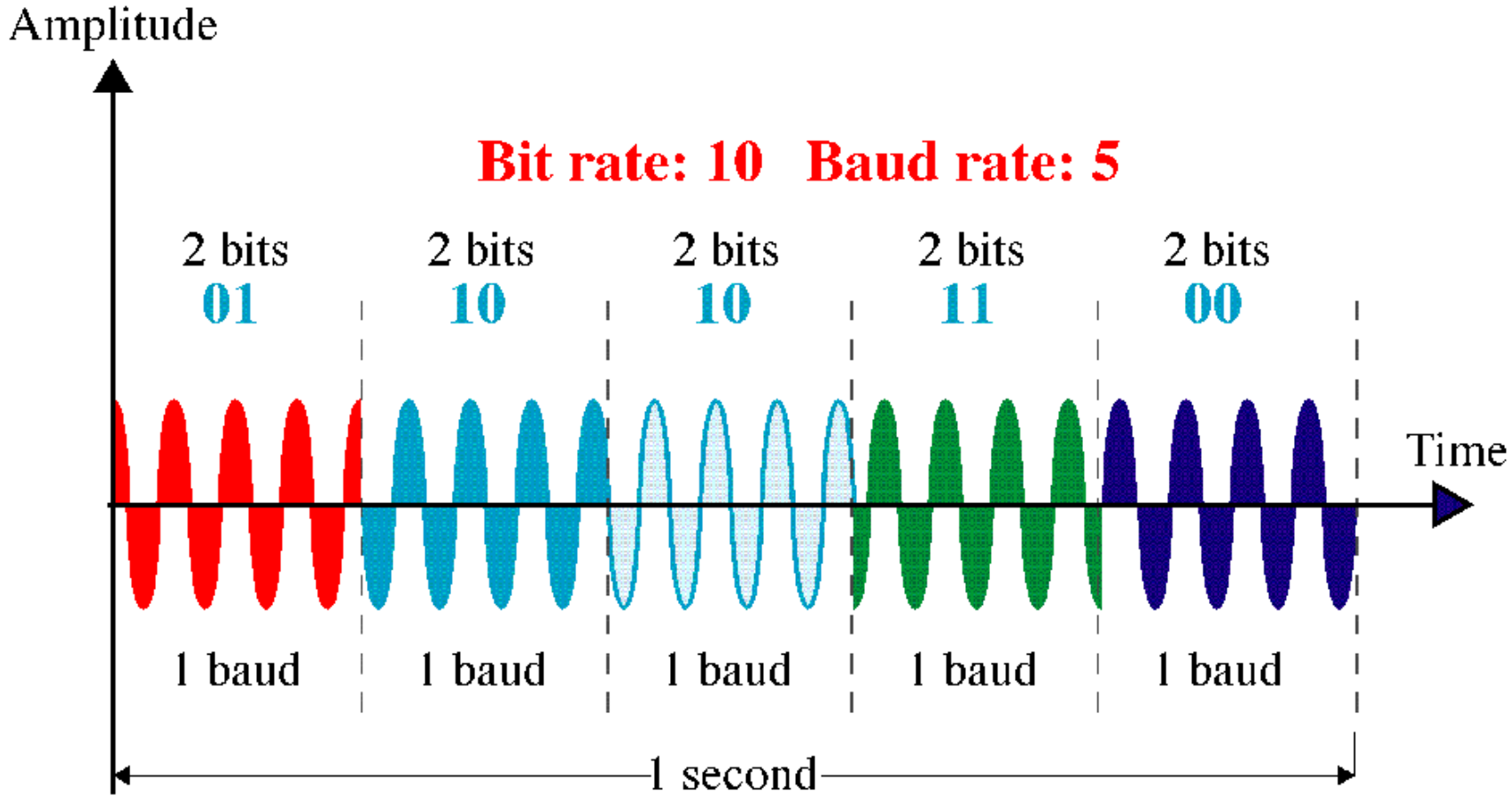
Bit	Phase
0	0
1	180

Bits



Constellation diagram

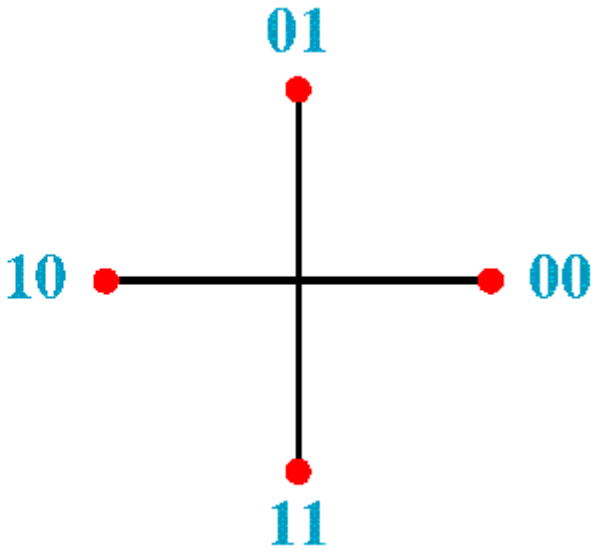
4-PSK


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 Constellation

Dibit	Phase
00	0
01	90
10	180
11	270

Dibit
(2 bits)

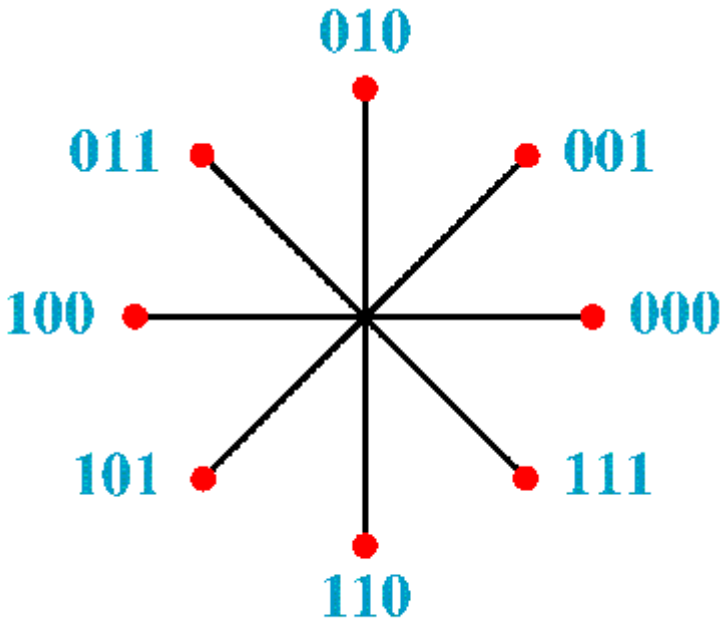


Constellation diagram

8-PSK Constellation

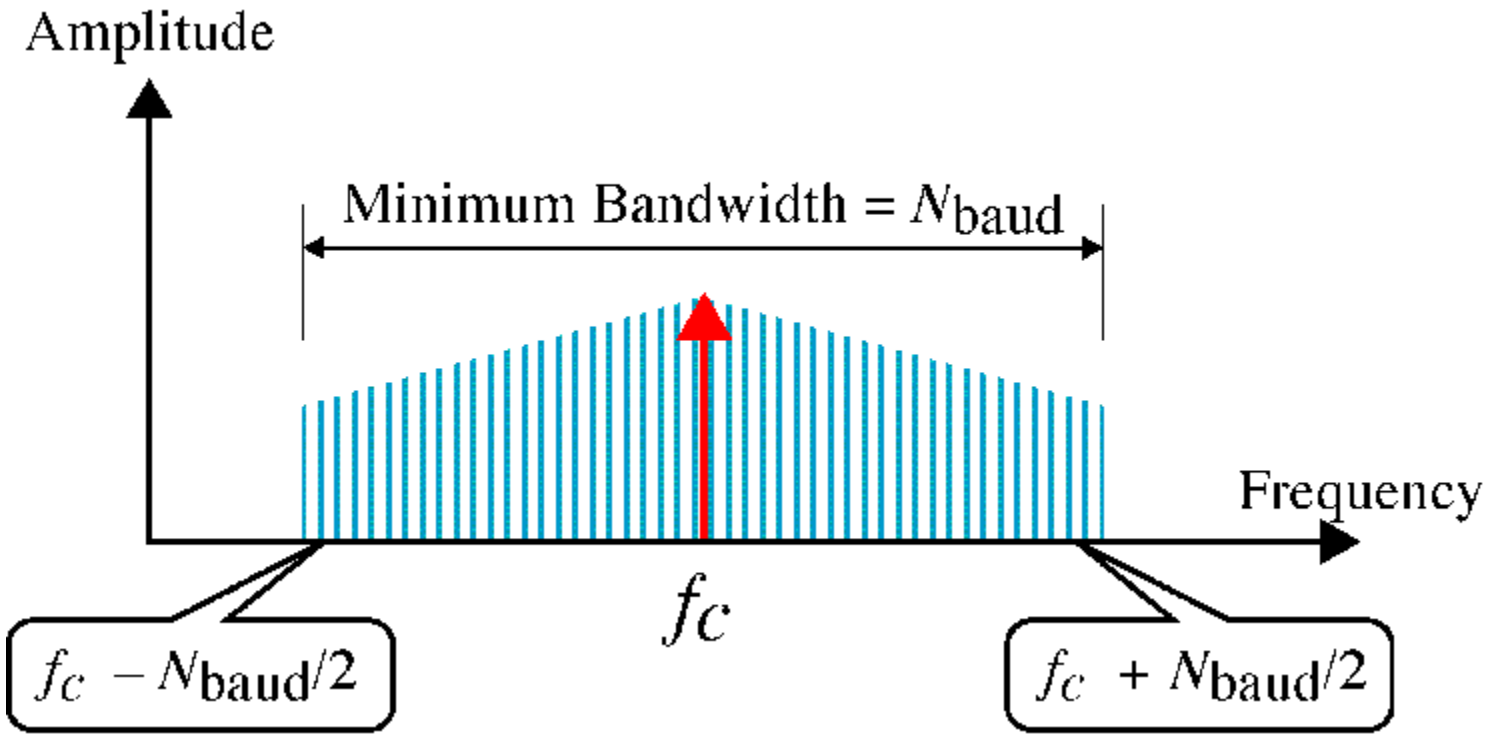
Tribit	Phase
000	0
001	45
010	90
011	135
100	180
101	225
110	270
111	315

Tribits
(3 bits)

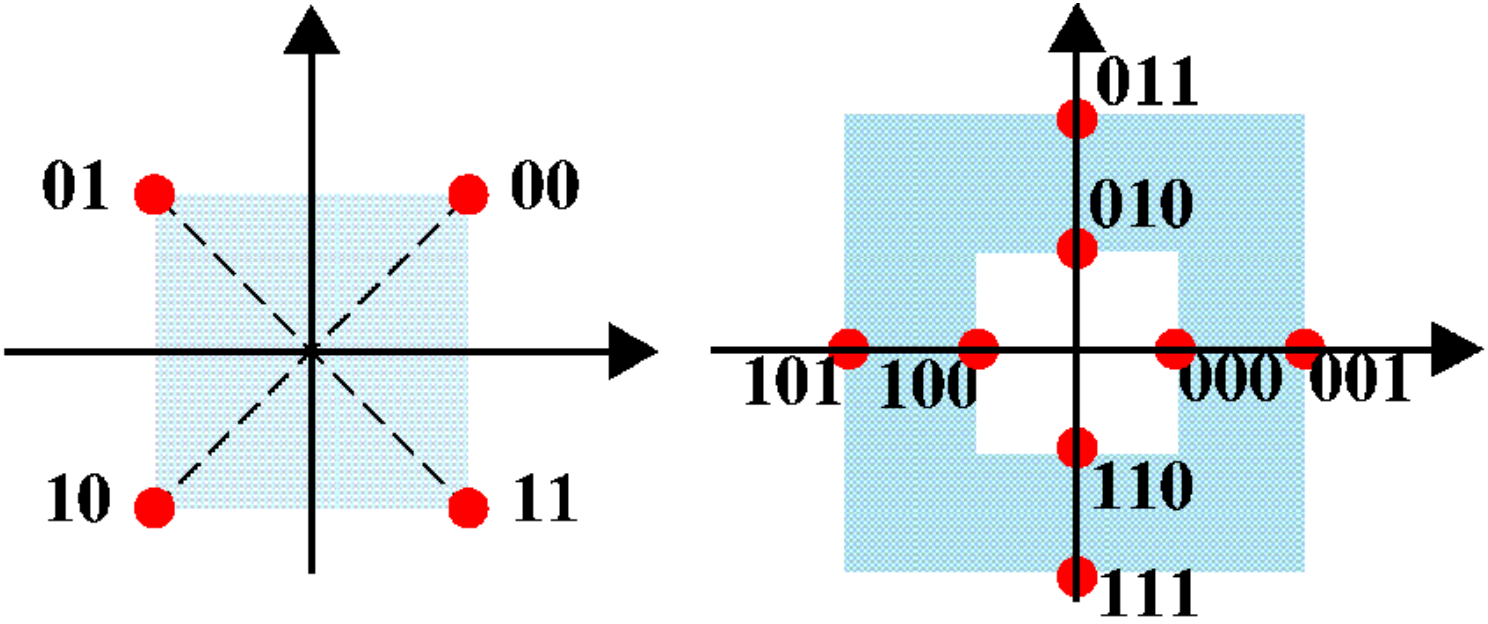


Constellation diagram

PSK Bandwidth



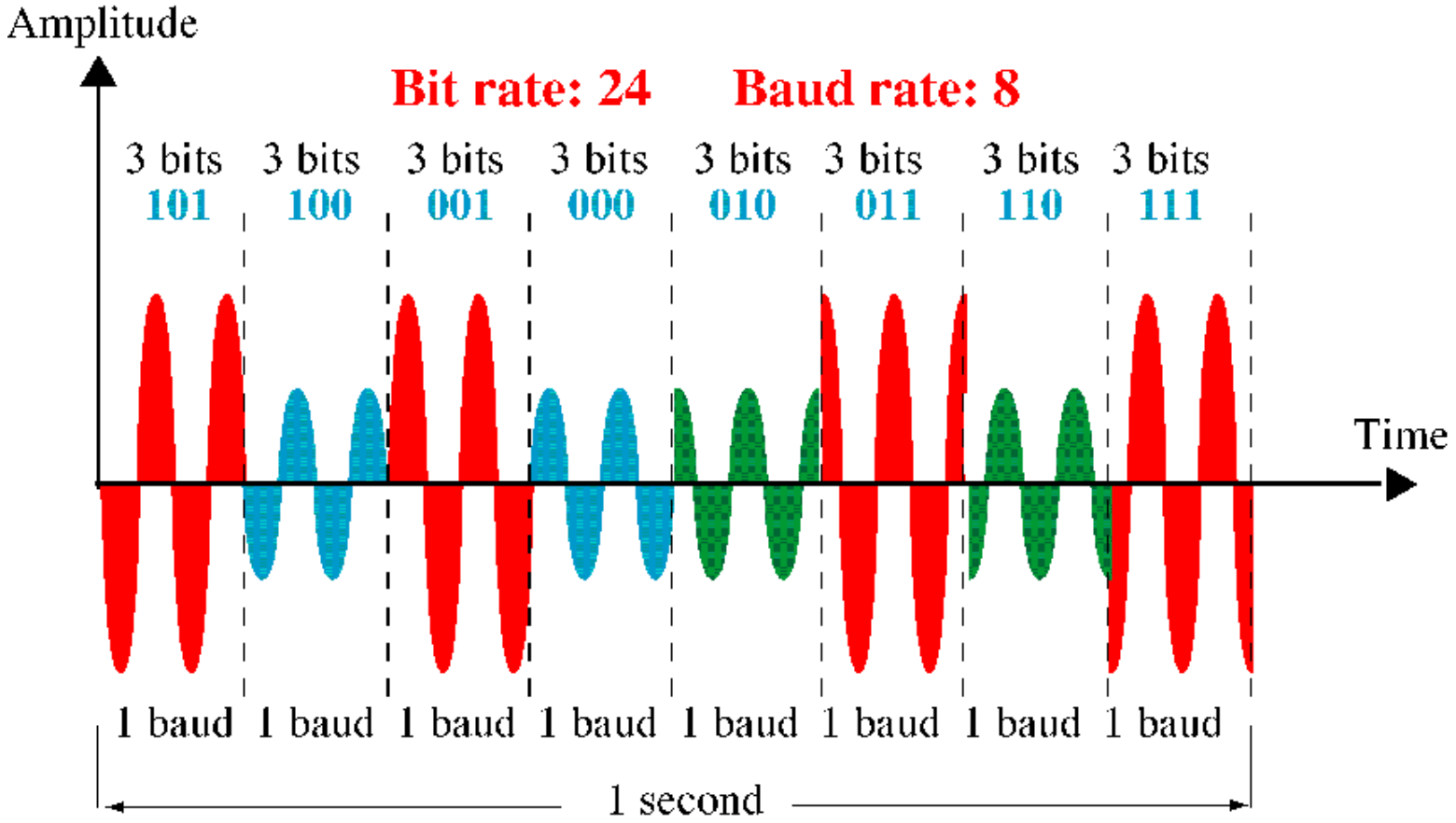
Quadrature Amplitude Modulation (QAM)



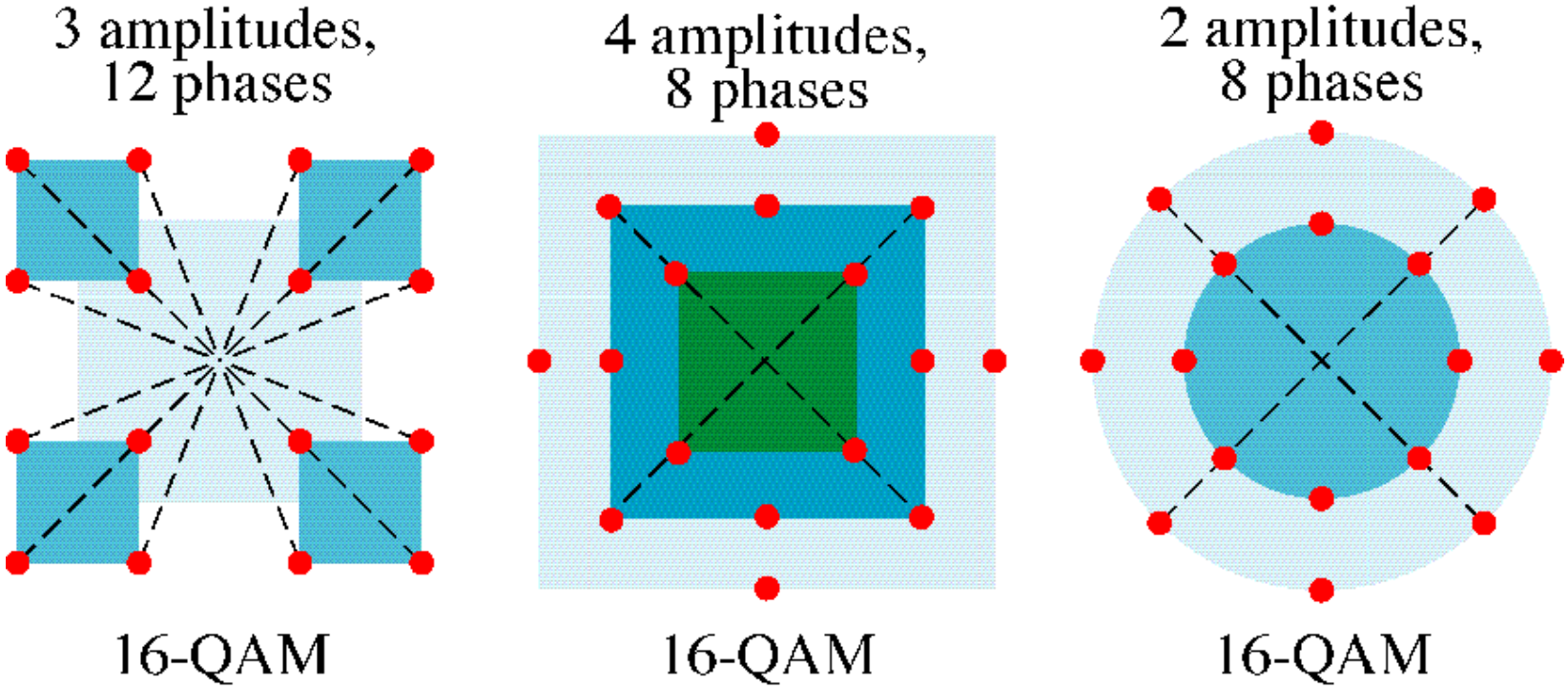
4-QAM
1 amplitude, 4 phases

8-QAM
2 amplitudes, 4 phases

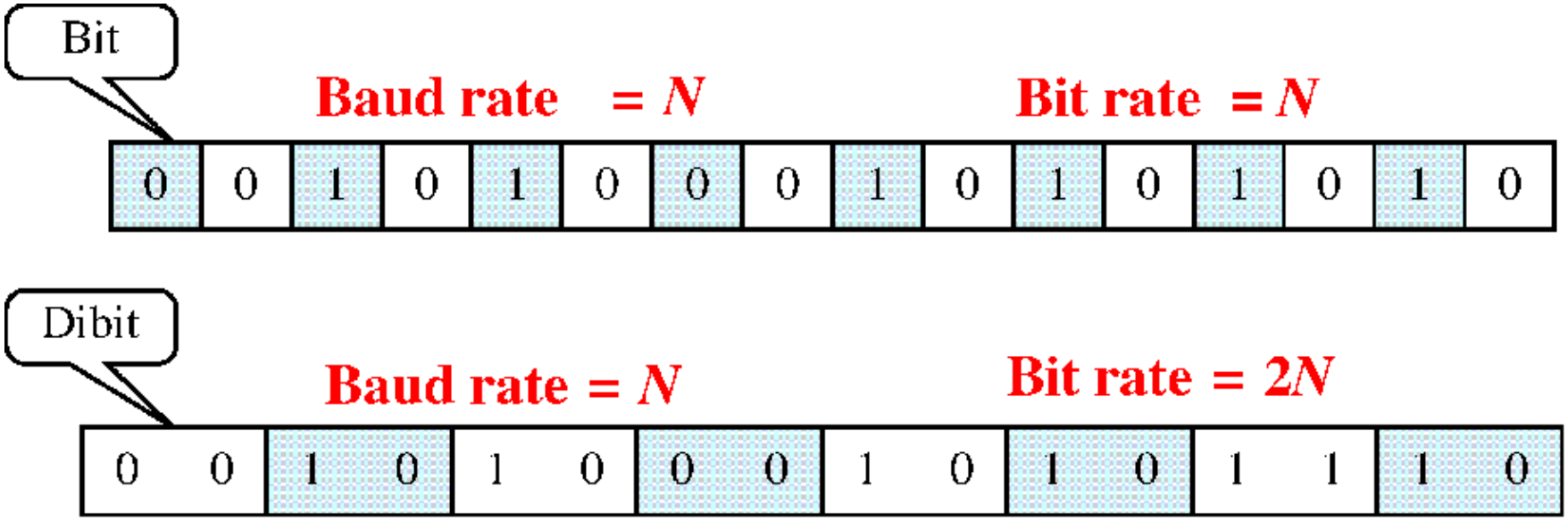
8-QAM Signal


Amplitude
Bit rate: 24
Baud rate: 8
3 bits
101
3 bits
100
3 bits
001
3 bits
000
3 bits
010
3 bits
011
3 bits
110
3 bits
111
Time
1 baud
1 baud
1 baud
1 baud
1 baud
1 baud
1 baud
1 baud
1 second

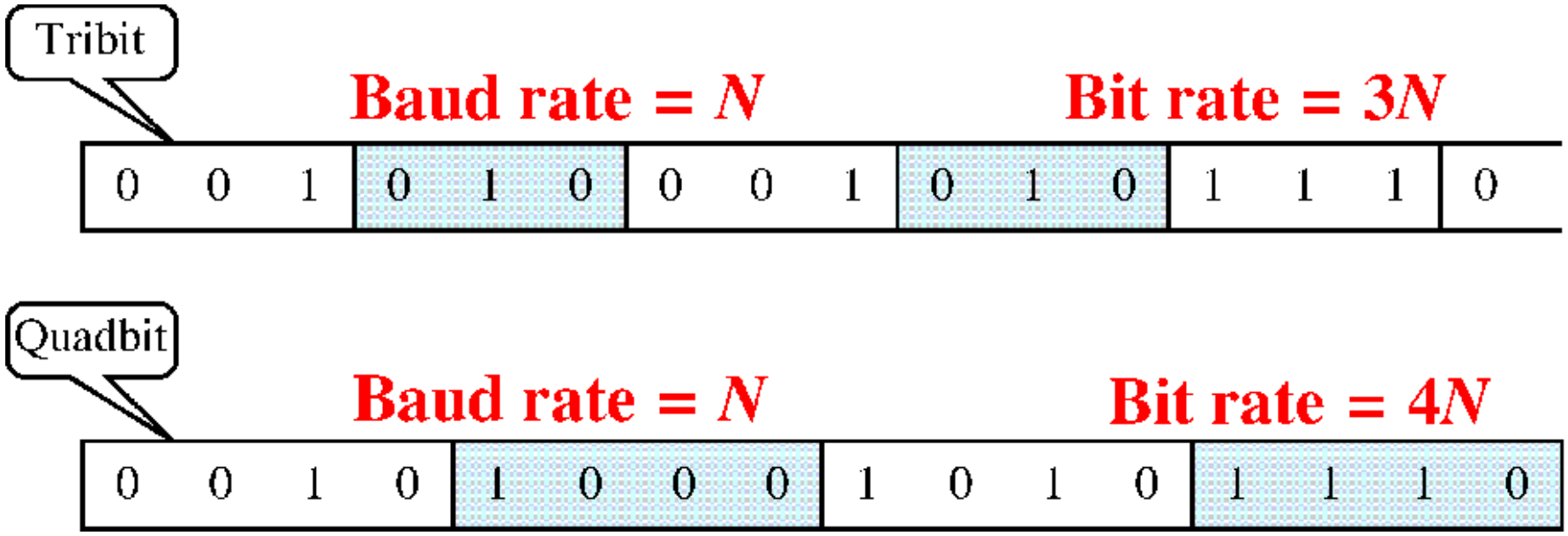
16-QAM Constellation

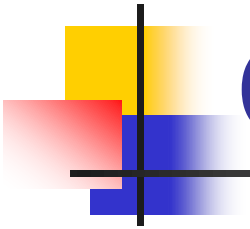


Bit Rate and Baud Rate



Bit Rate and Baud Rate





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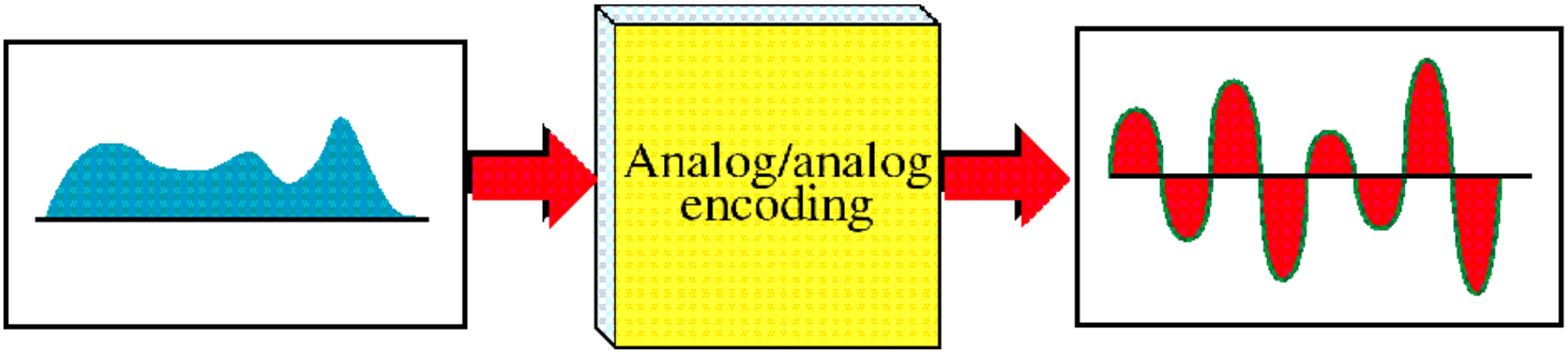
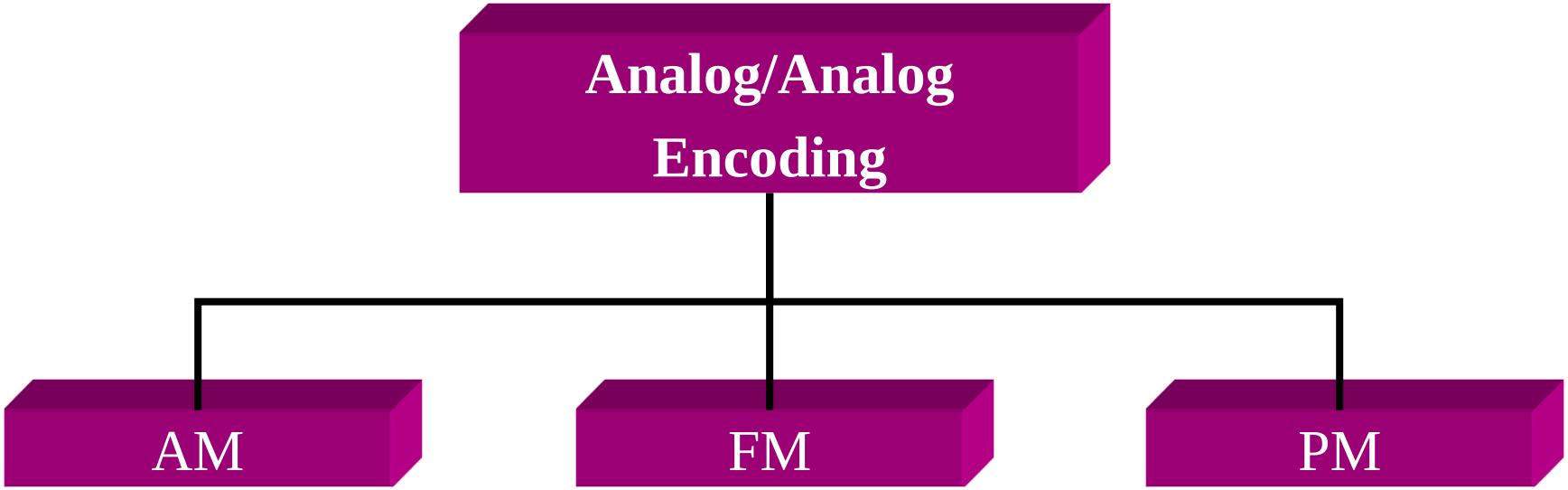
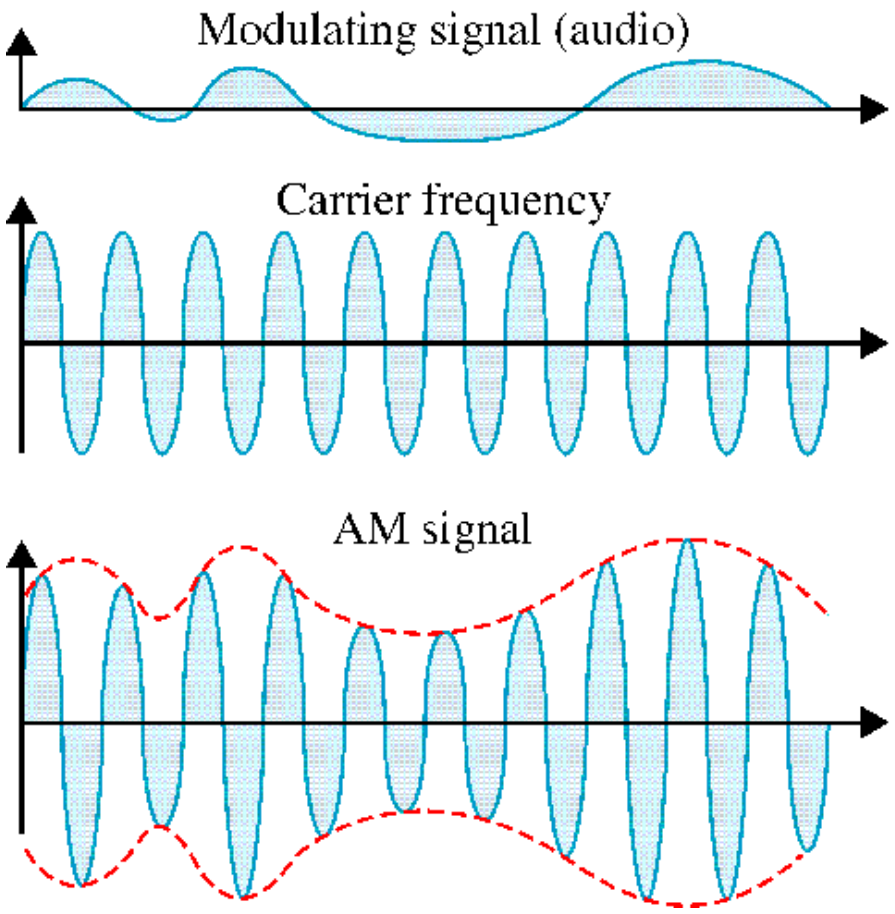
Analog to Analog Encoding



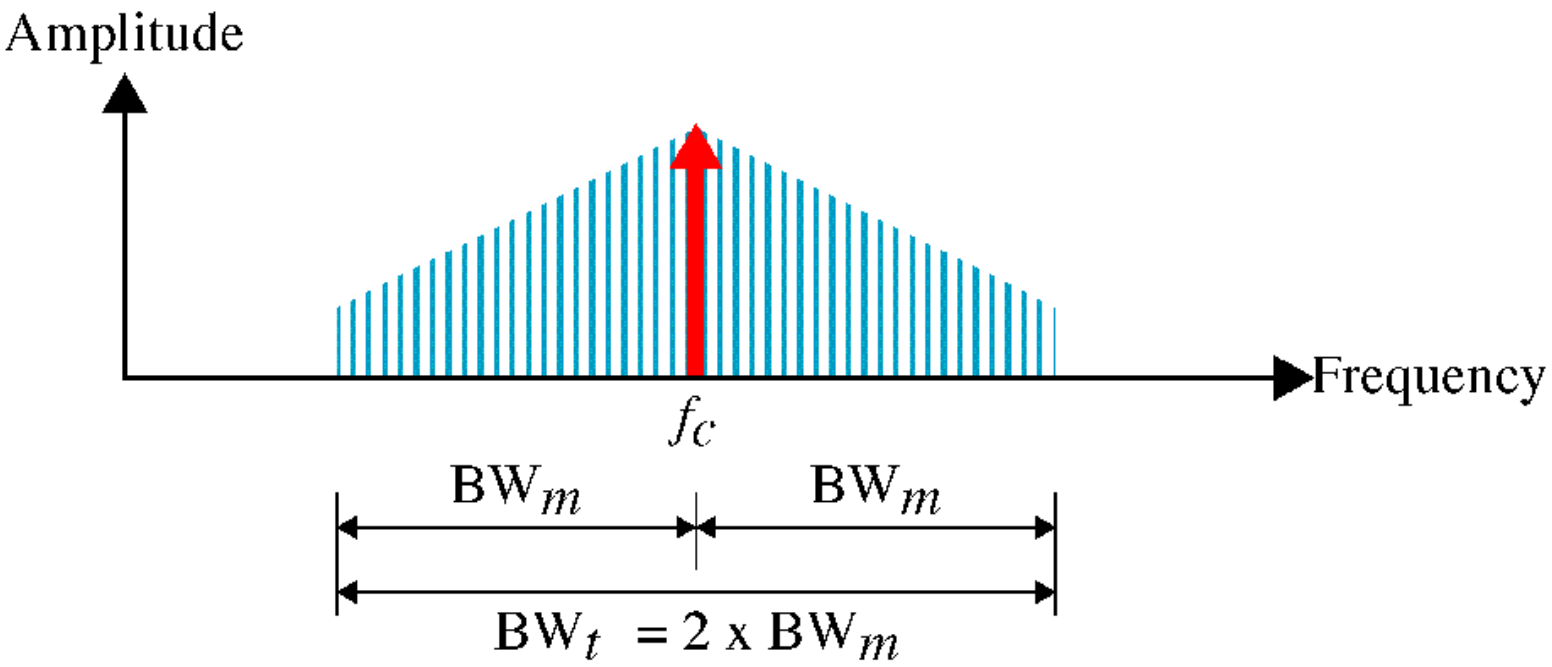

Analog/Analog
Encoding
AM
FM
PM

Amplitude Modulation



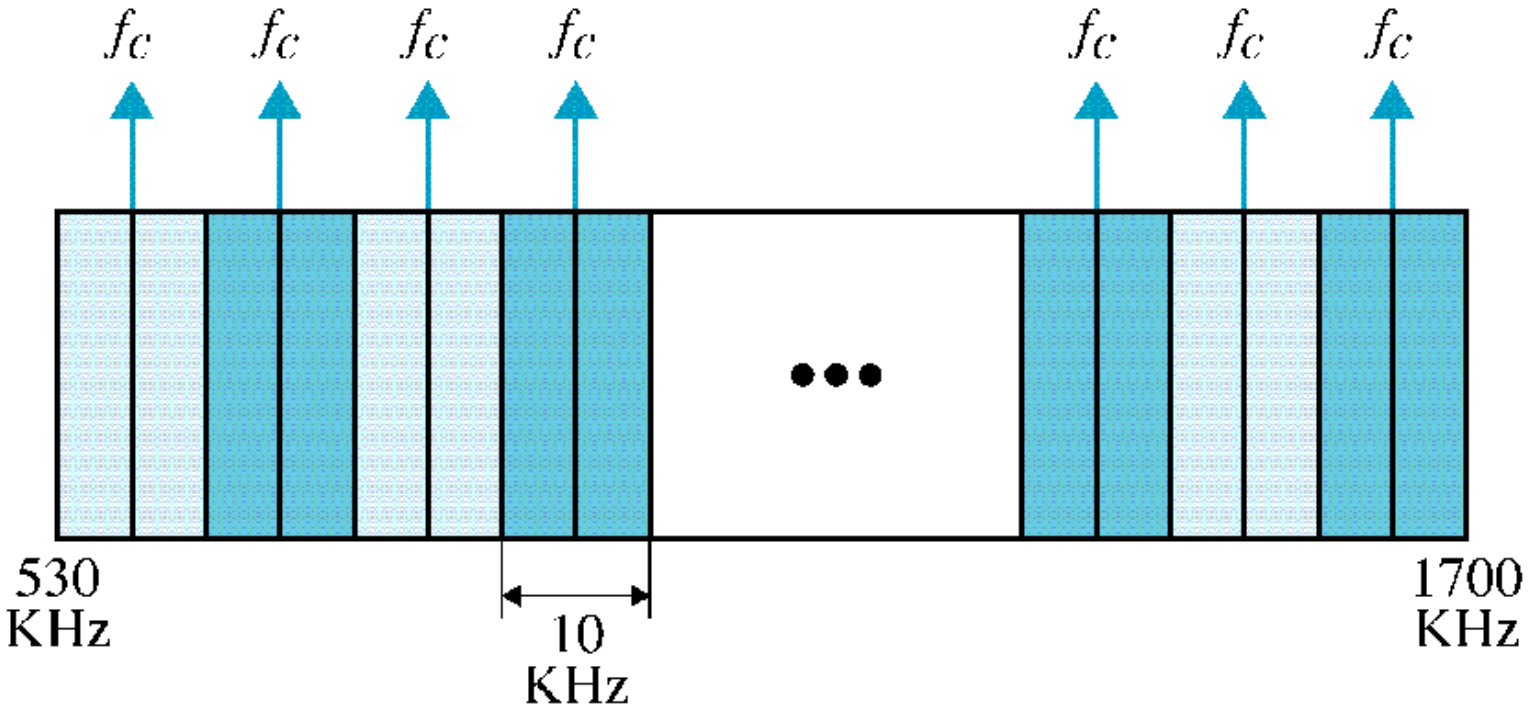
AM Bandwidth

BW_m =Bandwidth of the modulating signal (audio)
BW_t = Total bandwidth (radio)
f_c = Frequency of the carrier

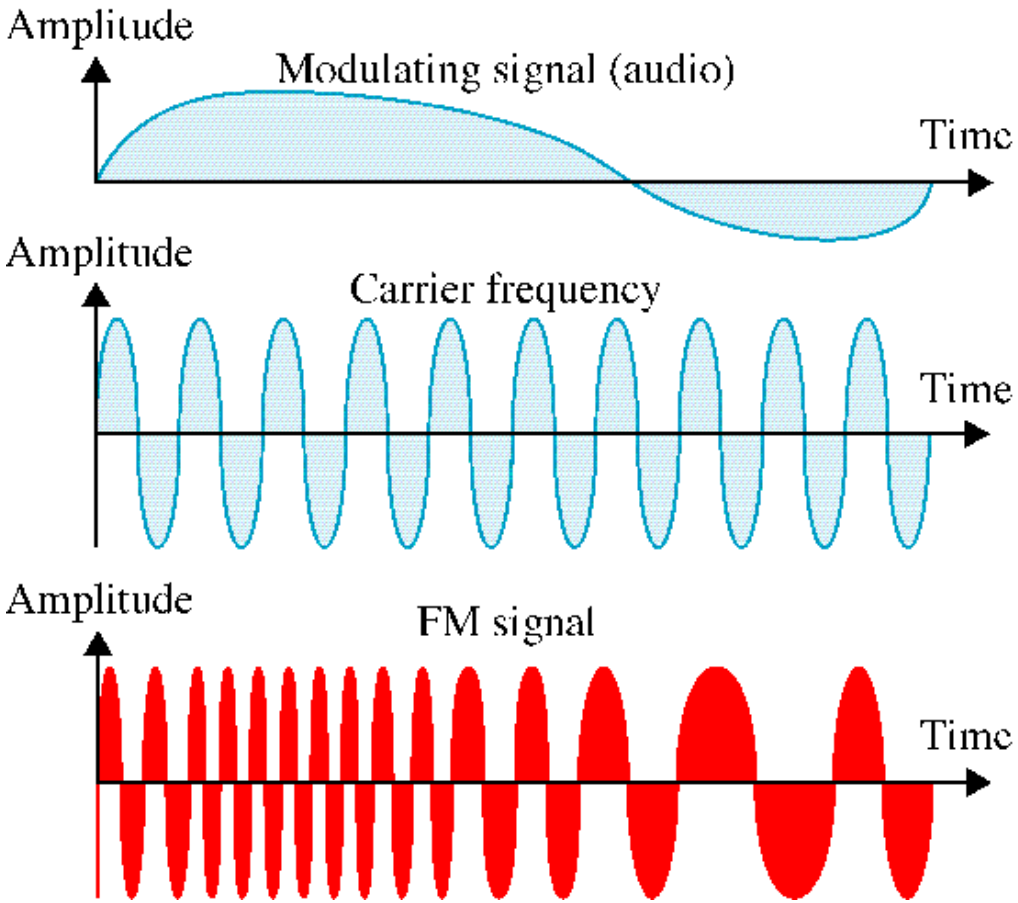


AM Band Allocation

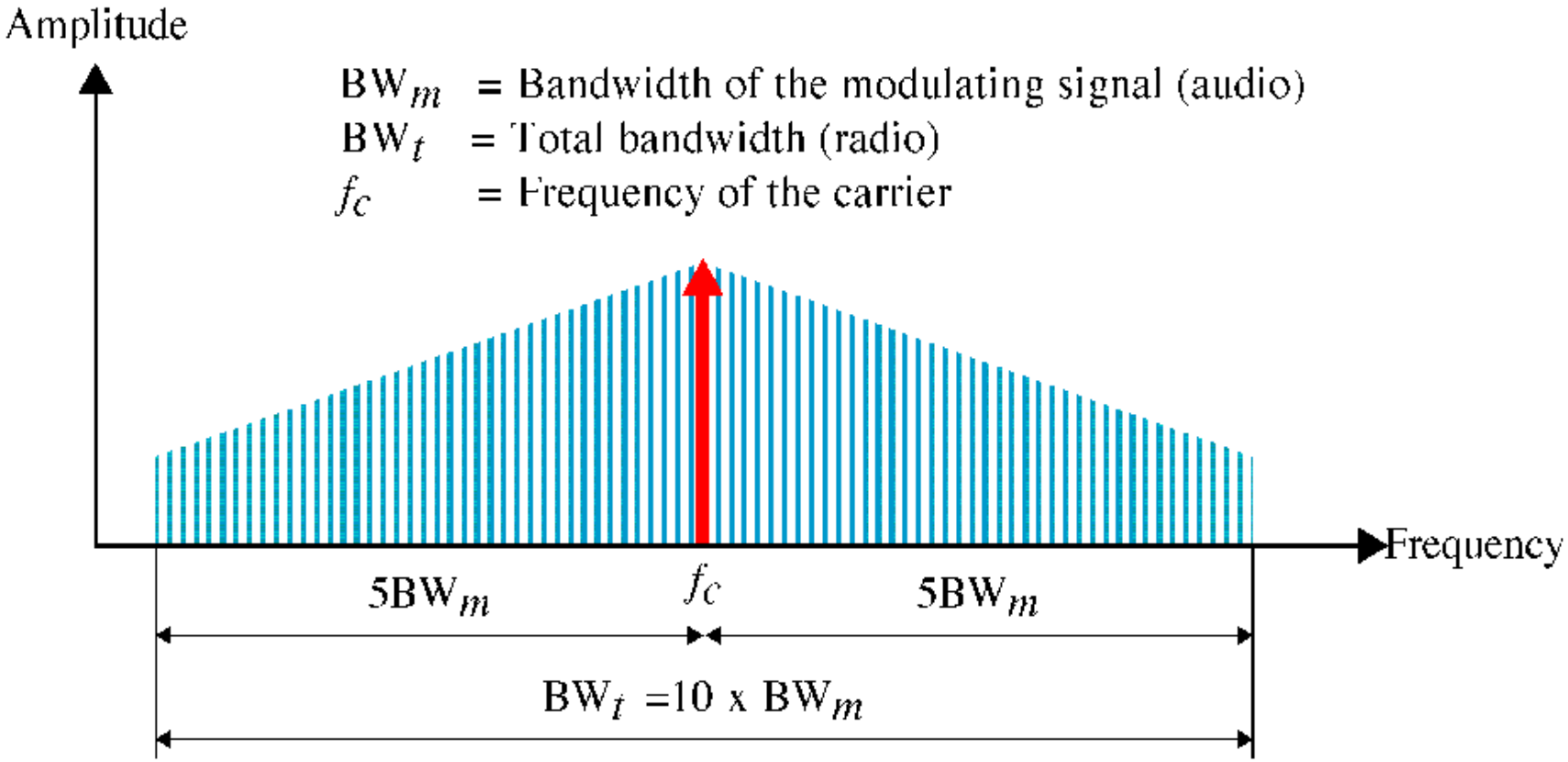
f_c = Carrier frequency of the station



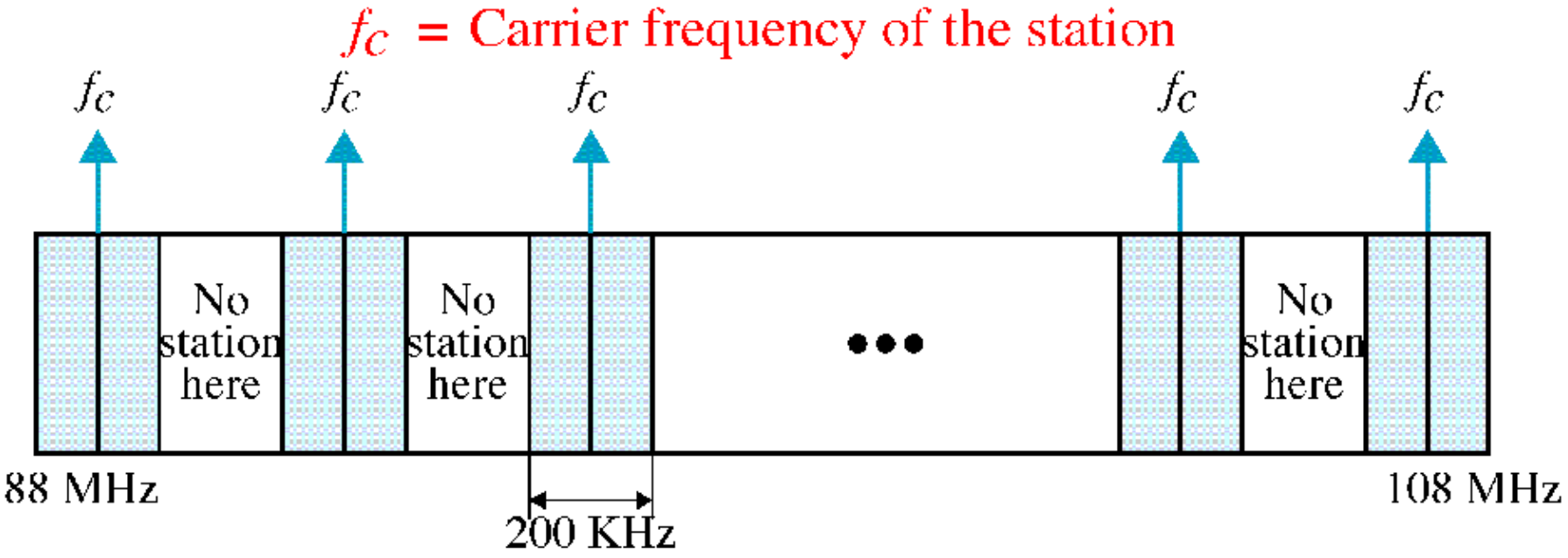
Frequency Modulation



FM Bandwidth



FM Band Allocation



Audio stereo = 15KHz → 150KHz

FCC → 200 KHz