

Encoding: Digital Transmission

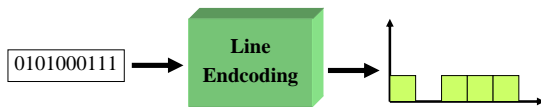
ผศ. ดร. อนันต์ ผลเพิ่ม
Asst. Prof. Anan Phonphoem, Ph.D.
anan@cpe.ku.ac.th
<http://www.cpe.ku.ac.th/~anan>
Computer Engineering Department
Kasetsart University, Bangkok, Thailand

Outline

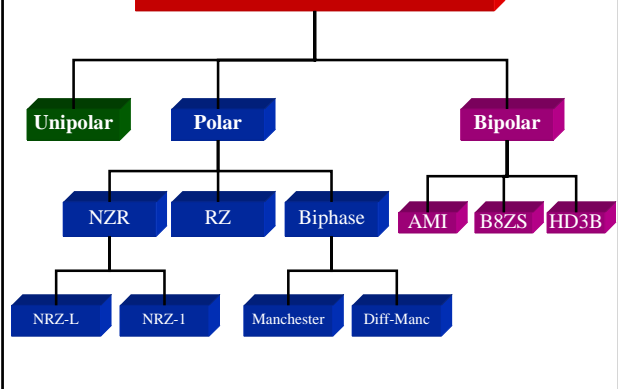
- Digital-to-digital conversion
 - Encode digital data into a digital signal
 - Sending computer data
- Analog-to-Digital conversion
 - Digitizing an analog
 - Sending voice in telephone (Decrease effect of noise)
- Digital-to-Analog conversion
 - Modulating a digital signal
 - Sending computer data through public telephone line
- Analog-to-Analog conversion
 - Modulating an analog signal
 - Sending music from radio station

Digital-to-digital conversion

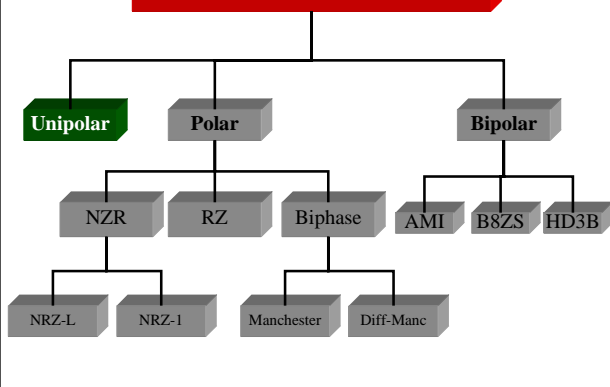
- Line Coding
- Encoding data into a digital signal



Digital to Digital Conversion

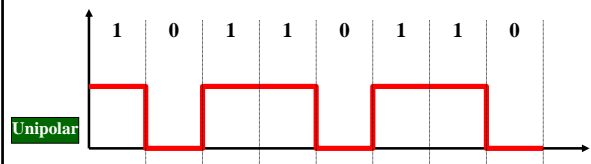


Digital to Digital Conversion



Unipolar Encoding

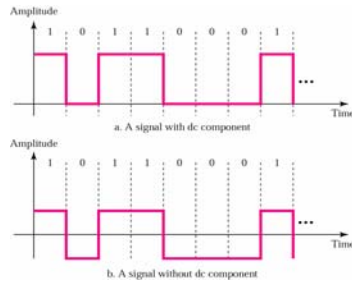
- One level of value; Very Simple
- Problem ?



General Problems of Digital-to-digital encoding

DC components

- Cannot pass through some system (eg. transformer)
- Extra energy residing on the line

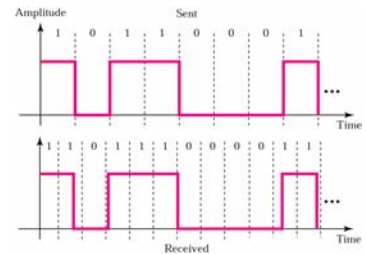


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General Problems of Digital-to-digital encoding

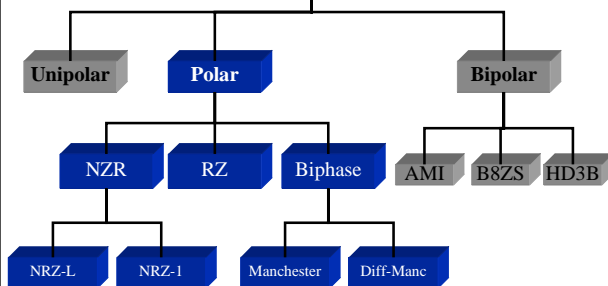
Synchronization

- Beginning/ending problem (111111111)
- Distortion (1111 → 11111)
- Solved by
 - separate line
 - Self-synchronization



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Digital to Digital Conversion



Nonreturn to Zero-Level (NRZ-L)

- Two different voltages for 0 and 1 bits
 - Absence of voltage = zero
 - Positive voltage = one
 - Normally, Negative = one and positive = zero
- Voltage constant during bit interval
 - no transition (no return to zero voltage)

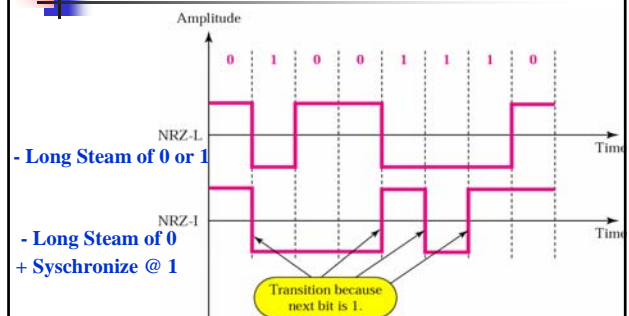
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Nonreturn to Zero Inverted

- Transition
 - Low-to-high or high-to-low denotes binary 1
 - No Transition denotes binary 0
- Constant voltage pulse for duration of bit

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Nonreturn to Zero (NRZ)



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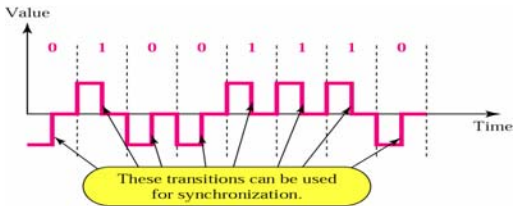
NRZ pros and cons

- Pros
 - Easy to engineer
 - Make good use of bandwidth
- Cons
 - dc component
 - Lack of synchronization capability
- Used for magnetic recording
- Not often used for signal transmission

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Polar Encoding RZ (Return to Zero)

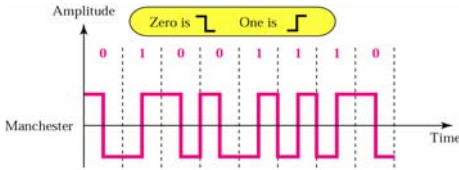
- Three levels (+ - 0)
- 2 signal changes per bit → more BW
- + Synchronization



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Biphase - Manchester

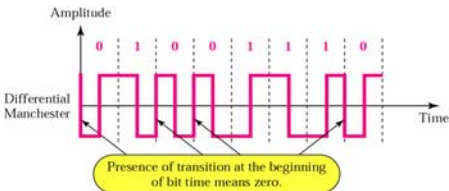
- Transition in middle of each bit period
- Transition serves as clock and data
 - Low-to-high represents one
 - High-to-low represents zero
- Used by IEEE 802.3



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Biphase - Differential Manchester

- Midbit transition is clocking only
 - Transition at start of bit represents zero
 - No transition at start of bit represents one
- Used by IEEE 802.5

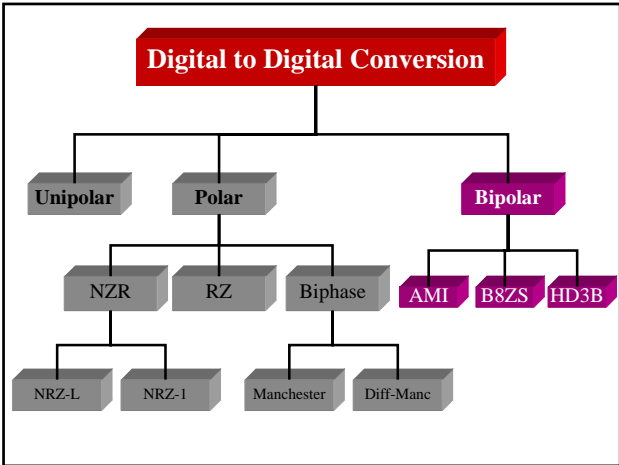


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Biphase Pros and Cons

- Cons
 - At least one transition per bit time and possibly two
 - Maximum modulation rate is twice NRZ
 - Requires more bandwidth
- Pros
 - Synchronization on mid bit transition (self clocking)
 - No dc component
 - Error detection
 - Absence of expected transition

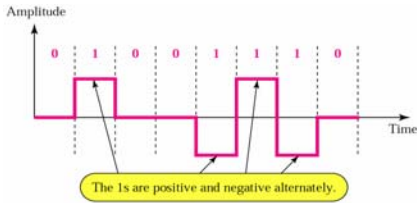
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Bipolar Alternate Mark Inversion (AMI)

- “1” are positive and negative alternately

- Long Stream of 0 + DC component = 0



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Bipolar With 8 Zeros Substitution (B8ZS)

- If octet of all zeros and *last voltage pulse preceding was positive*
 - Encode as 000+-0+-
- If octet of all zeros and *last voltage pulse preceding was negative*
 - Encode as 000-+0+-
- Causes two violations of AMI code
- Unlikely to occur as a result of noise

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High Density Bipolar 3 Zeros (HDB3)

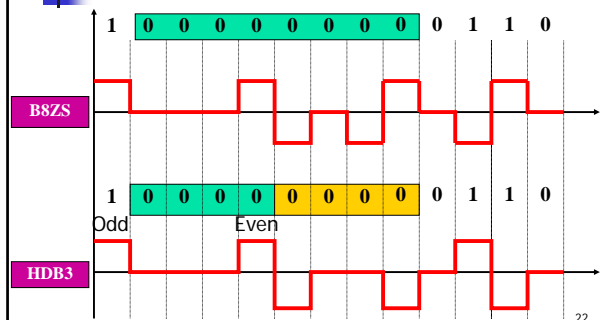
- String of four zeros replaced with one or two pulses
- Observe the number of “1” after last violation (to be odd or even)
- If no “1” after last violation (e.g. 0000 then 0000), assume to be even (no “1” at all)

Odd+ → 000+
 Odd- → 000-
 Even+ → -00-
 Even- → +00+

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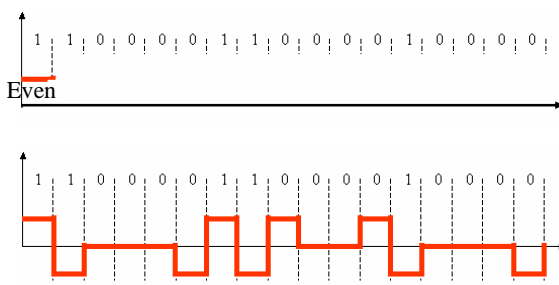
Bipolar

(solved long stream of “0” → using violation)



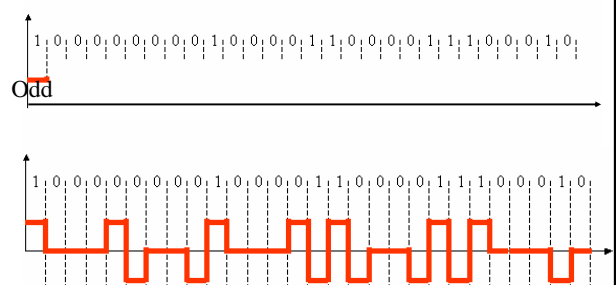
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HDB3: Example 1



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HDB3: Example 2



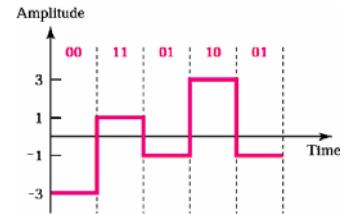
Other Schemes

- 2B1Q (Two Binary, One Quaternary)
- MLT-3 (Multiline Tx, three Level)

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2B1Q

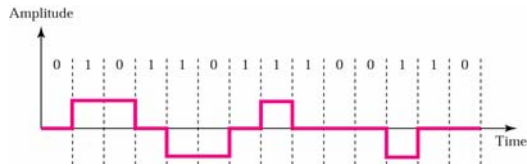
- Four Voltage levels
- Each pulse represents 2 bits



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MLT-3

- Similar to NRZ-I
- Uses 3 levels of signals (+1, 0, -1)
- Transition from one level to the next at the beginning of a 1 bit
- No Transition at the beginning of a 0 bit



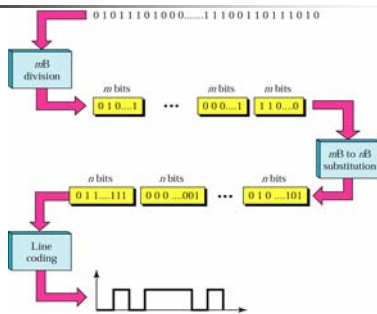
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Block Coding

- Improve the line coding performance
- Need redundancy
 - To ensure synchronization
 - To detect errors
- Steps in Transformation
 - Division
 - Substitution

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Block Coding

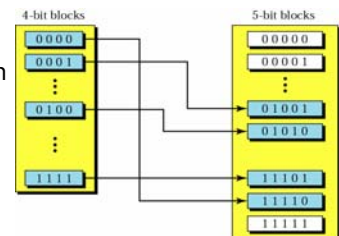


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Substitution

For 4B/5B
Choose 5-bit pattern that help in

- Synchronization
- Error detection



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4B/5B Encoding

Data	Code	Data	Code
0000	11110	1000	10010
0001	01001	1001	10011
0010	10100	1010	10110
0011	10101	1011	10111
0100	01010	1100	11010
0101	01011	1101	11011
0110	01110	1110	11100
0111	01111	1111	11101

Data	Code
Q (Quiet)	00000
I (Idle)	11111
H (Halt)	00100
J (start delimiter)	11000
K (start delimiter)	10001
T (end delimiter)	01101
S (Set)	11001
R (Reset)	00111

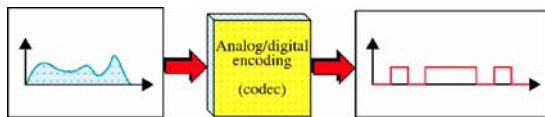
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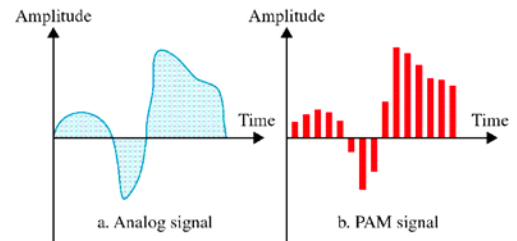
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Analog to Digital Encoding



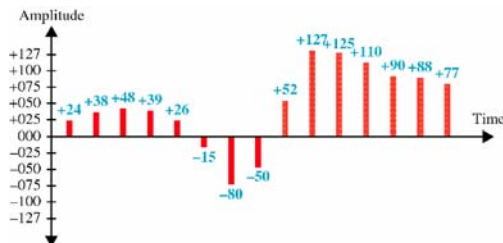
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Step 1: Pulse Amplitude Modulation(PAM)



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Step 2: Quantized PAM Signal



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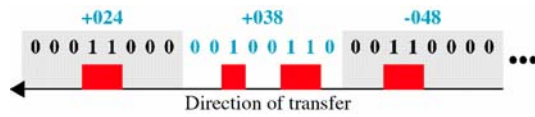
Step 3: Quantizing Using Sign and Magnitude

+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

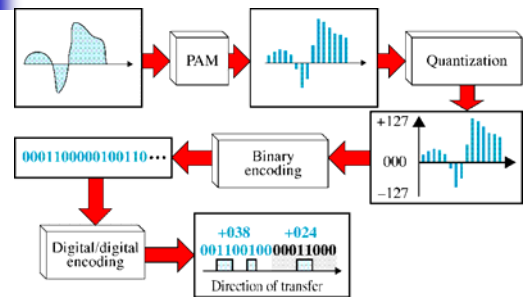
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Step 4: Pulse Code Modulation (PCM)



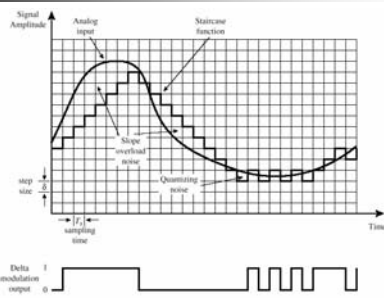
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From Analog to PCM



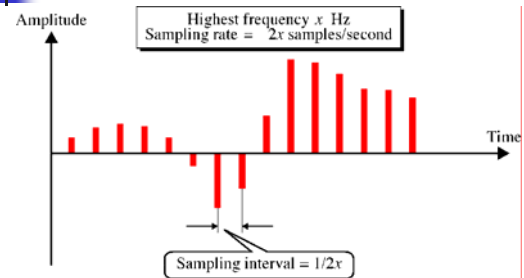
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From Analog to PCM



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Nyquist Theorem



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Sampling rate

Question We want to digitize the human voice.
What is the bit rate, assuming 8 bits per sample?

Solution

- The human voice normally contains frequencies from 0 to 4000 Hz.
- Sampling rate = $4000 \times 2 = 8000$ samples/s
- Bit rate = sampling rate \times number of bits per sample
= $8000 \times 8 = 64,000$ bps = 64 Kbps

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