CS311: Data Communication

TRANSMISSON OF DIGITAL SIGNAL - II

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Outline of the Lecture

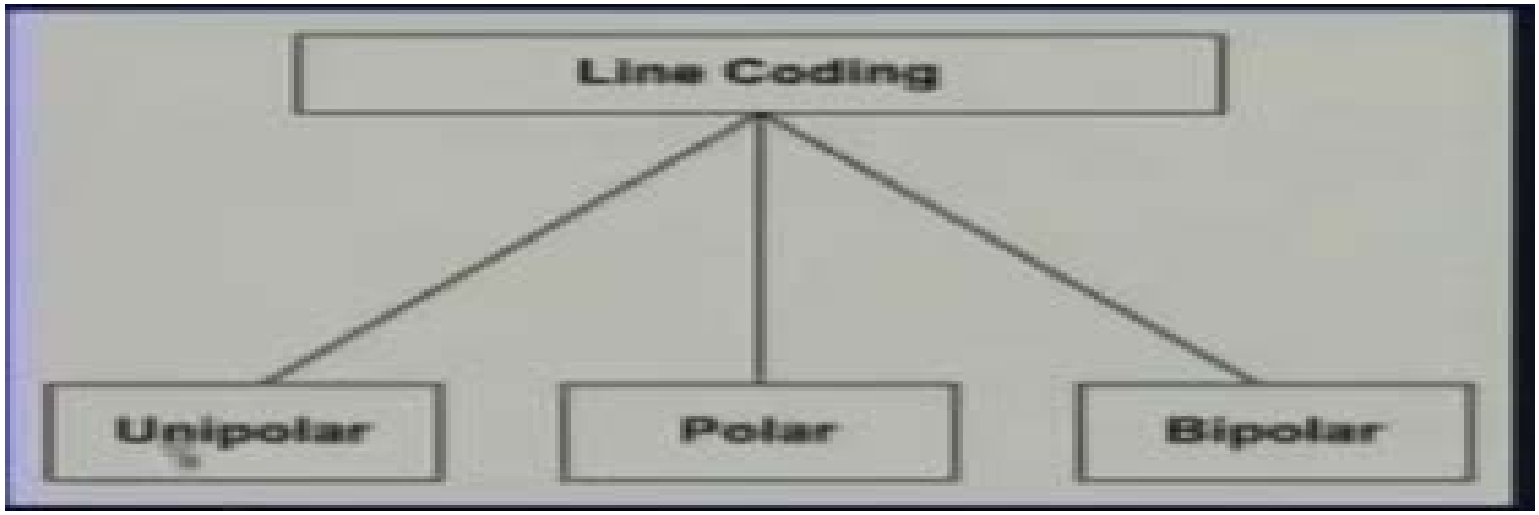
- Introduction
- Scrambling Coding schemes
- Basic concepts of block coding
- Block coding steps
- Conversion of analog data to digital signal
- Two basic approaches:
  1. Pulse coding modulation
  2. Delta modulation
     - Limitations of PCM and DM
     - Comparisons of the two approaches

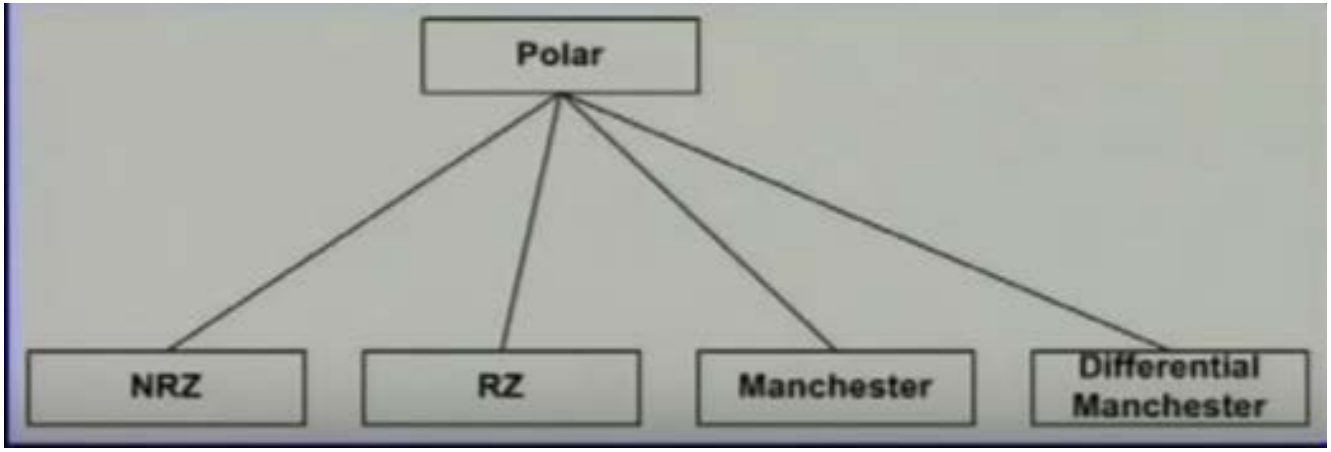
Transmission of digital signal

On completion,the students will able to:

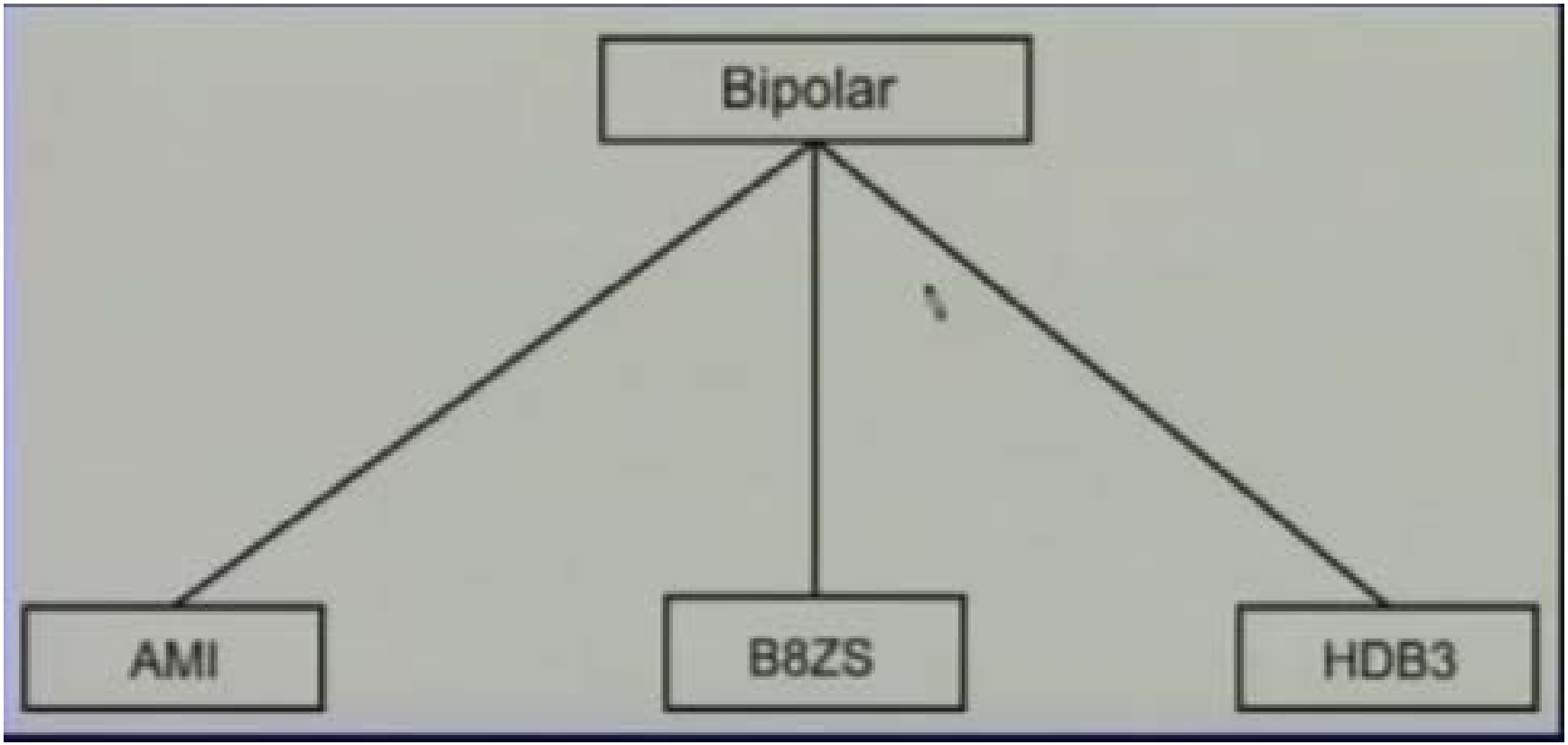
- Explain scrambling Coding schemes
- Explain the need for block coding
- Explain the operation of block coding
- Explain the coding techniques used for conversion of analog data to digital signal
- Distinguish between the coding techniques: PCM and DM
- Compare the advantages and limitations of PCM and DM

Summary of the coding techniques





Bipolar coding schemes



B8ZS

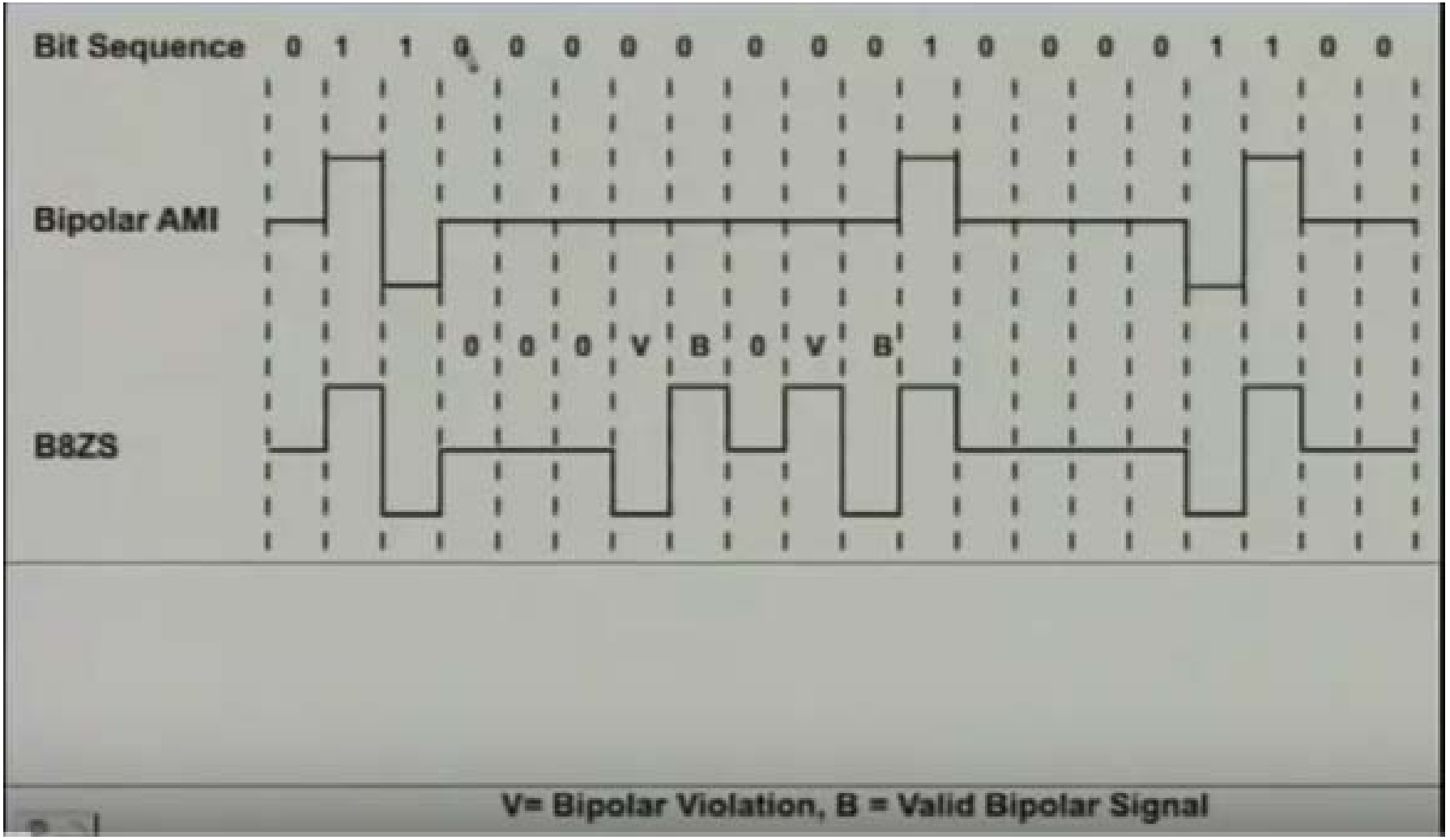
Bipolar with 8-zero substitution

- The limitation of bipolar AMI is overcome in B8ZS, which is used in North America
- A sequence of eight zero's is replaced by the following encoding

- A sequence of eight 0's is replaced by 000+-0+-, if the previous pulse was positive

- A sequence of eight 0's is replaced by 000-+0+-, if the previous pulse was negative

B8ZS


Bit Sequence
0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0
Bipolar AMI
0 0 0 V B 0 V B
B8ZS
V= Bipolar Violation, B = Valid Bipolar Signal

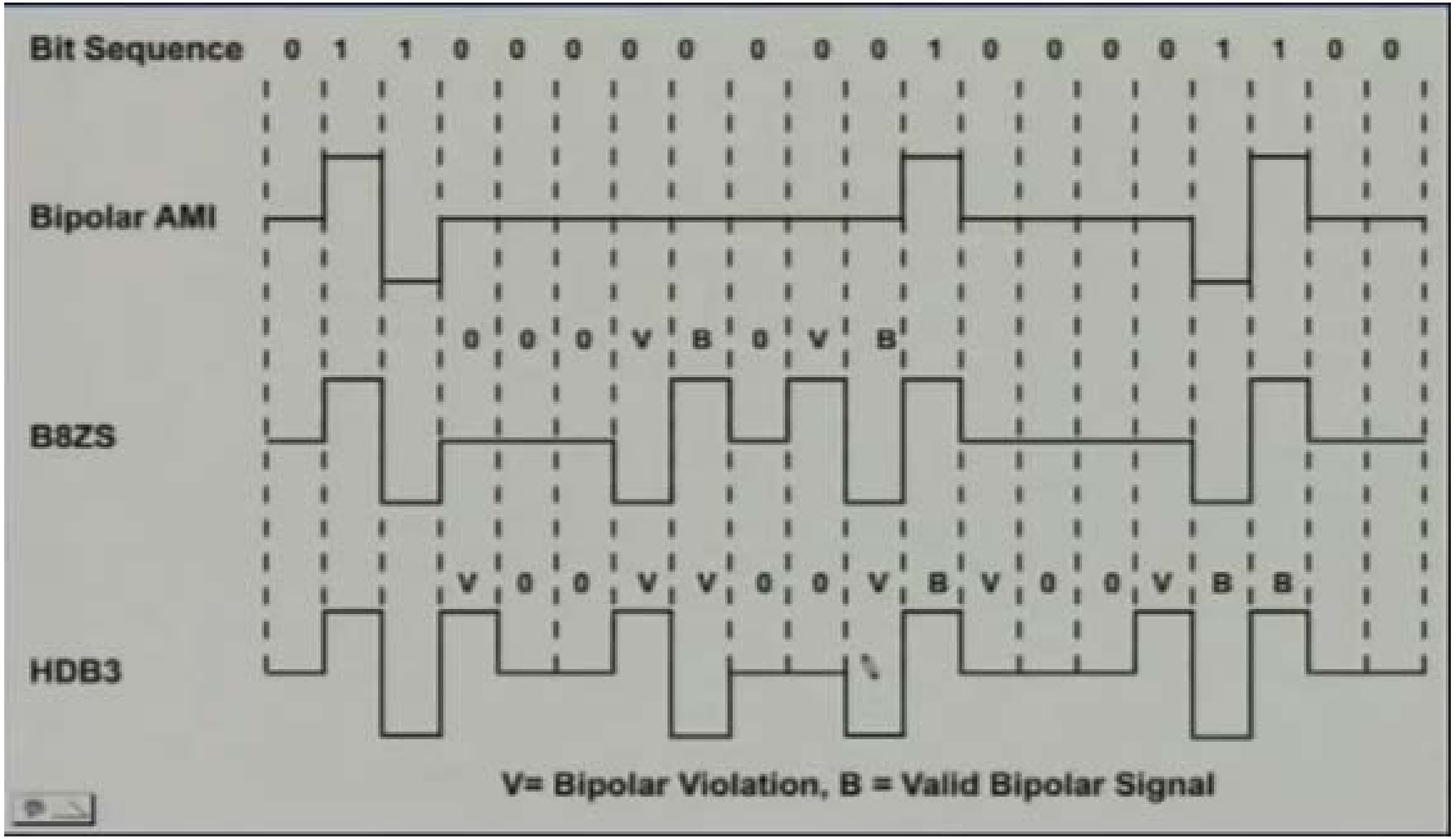
HBD3

➢ High density Bipolar-3 Zeros

- Another alternative, which is used in Europe and Japan is HBD3.
- It replaces a sequence of 4 zeros by a code as per the rule given in the above table

HDB3 substitution rule		
Polarity of the Preceding pulse	Number of bipolar pulses (ones) since last substitution	
	odd	even
−	000 −	+ 00 +
+	000 +	− 00 −

HBD3

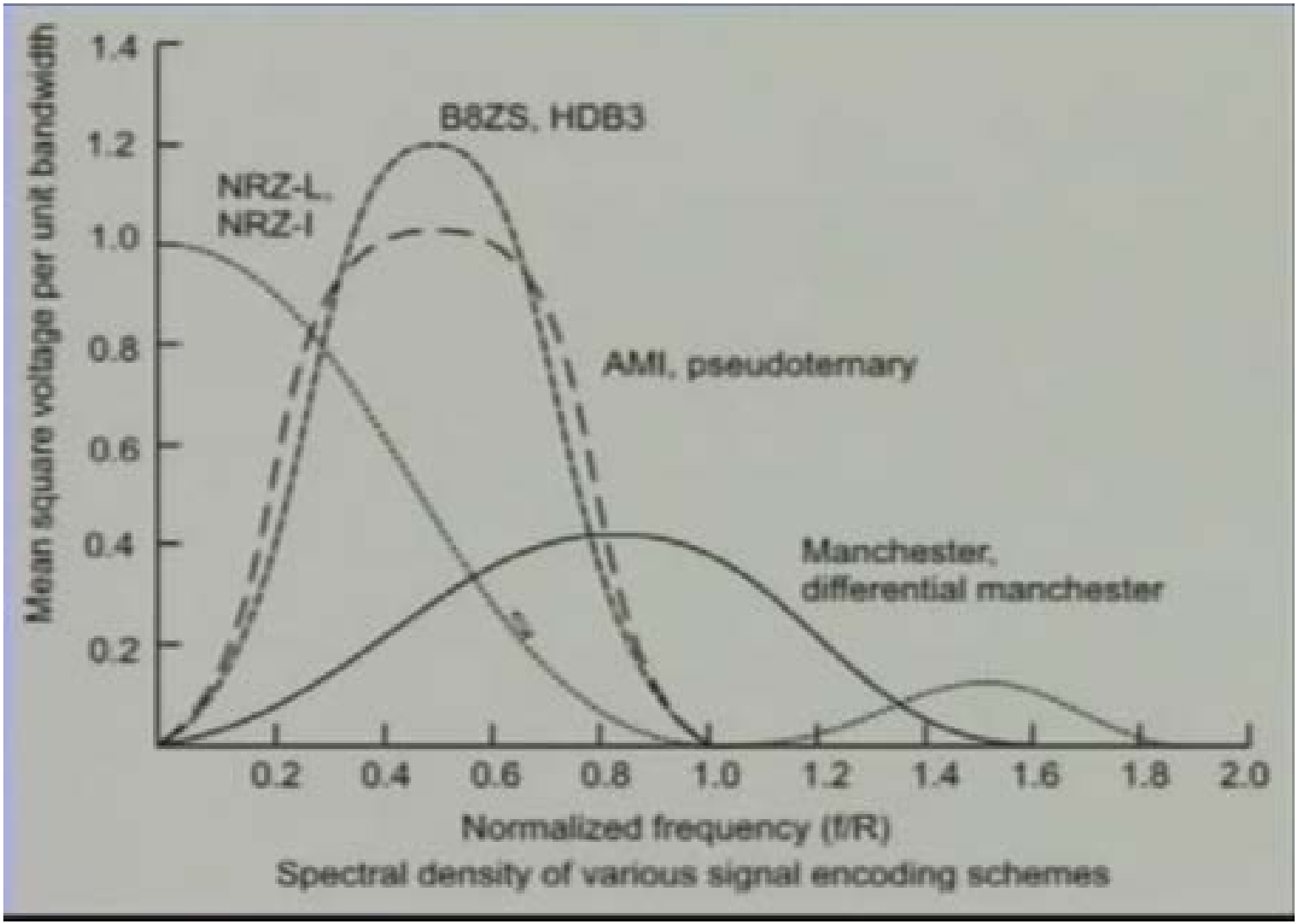

Bit Sequence
0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0
Bipolar AMI
0 0 0 V B 0 V B
B8ZS
V 0 0 V V 0 0 V B V 0 0 V B B
HDB3
V= Bipolar Violation, B = Valid Bipolar Signal

B8ZS and HBD3

Characteristics B8ZS and HBD3

- Three levels
- No DC component
- Good synchronization
- Most of the energy is concentrated around a frequency equal to half the data rate
- Well suited for high data-rate transmission over long distances

BANDWIDTH COMPARISION

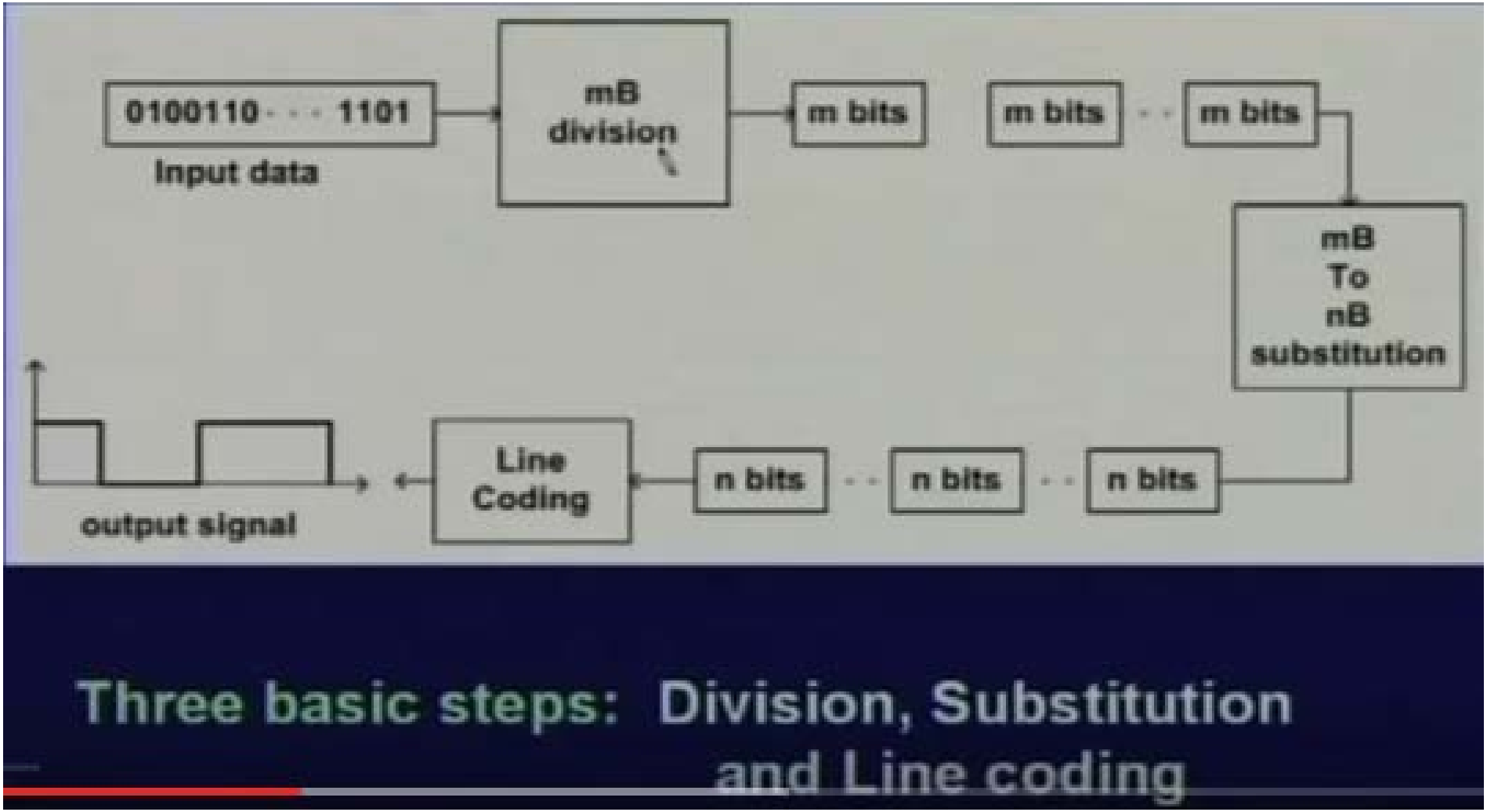


Spectral density of various signal encoding schemes

Block Coding

- Block coding was introduced to improve the performance of the line coding
- Introduces redundancy to achieve synchronization
- Also allows error detection to some extent

Block Coding



Example: 4B/5B encoding

- The 5-bit code has no more than one leading zero and no more than two trailing zeros
- More than three consecutive 0's do not occur
- Normally line coding with NRZ-l

Data Sequence	Encoded Sequence	Data Sequence	Encoded Sequence
0000	11110	Q (Quiet)	00000
0001	01001	I (Idle)	11111
0010	10100	H (Halt)	00100
0011	10101	J (start delimiter)	11000
0100	01010	K (start delimiter)	10001
0101	01011	T (end delimiter)	01101
0110	01110	S (Set)	11001
0111	01111	R (Reset)	00111
1000	10010		
1001	10011		
1010	10110		
1011	10111		
1100	11010		
1101	11011		
1110	11100		
1111	11101		

4B/5B encoding

Block Coding

-8B/10B

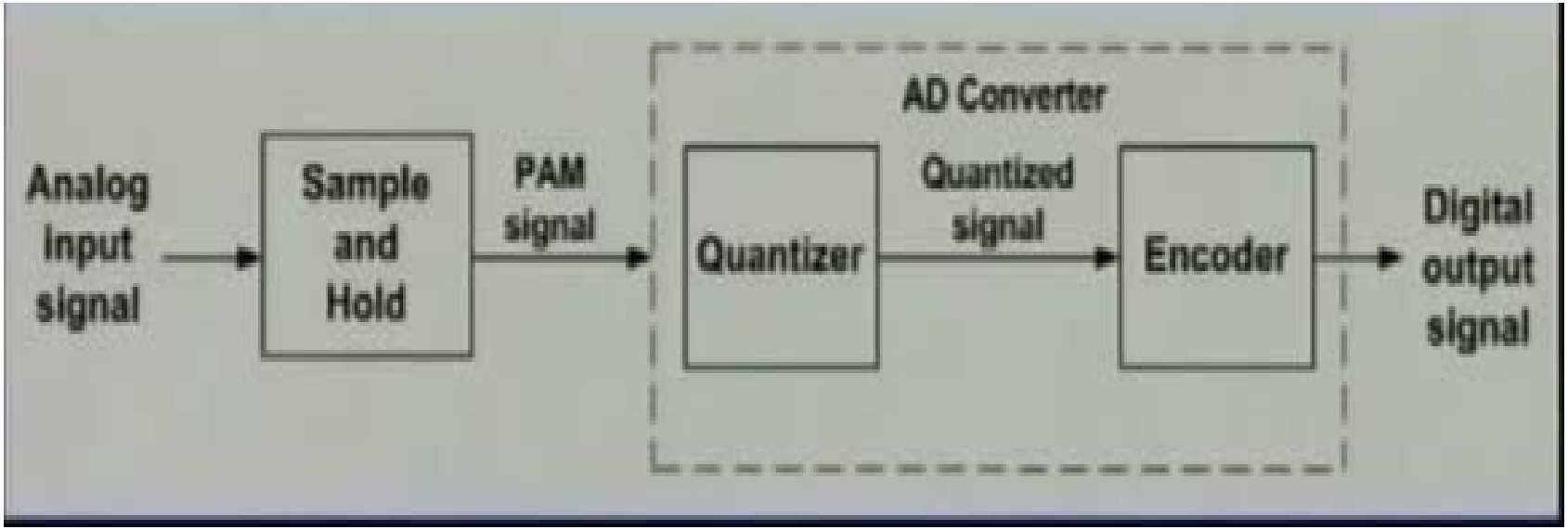
- 8-bit data blocks are substituted by 10-bit code
- Provides more error detection capability
- Leads to increase in bandwidth
- Bandwidth can be reduced by using suitable line coding , 8B/6T
- Example:8B/6T 3F -0+-0+

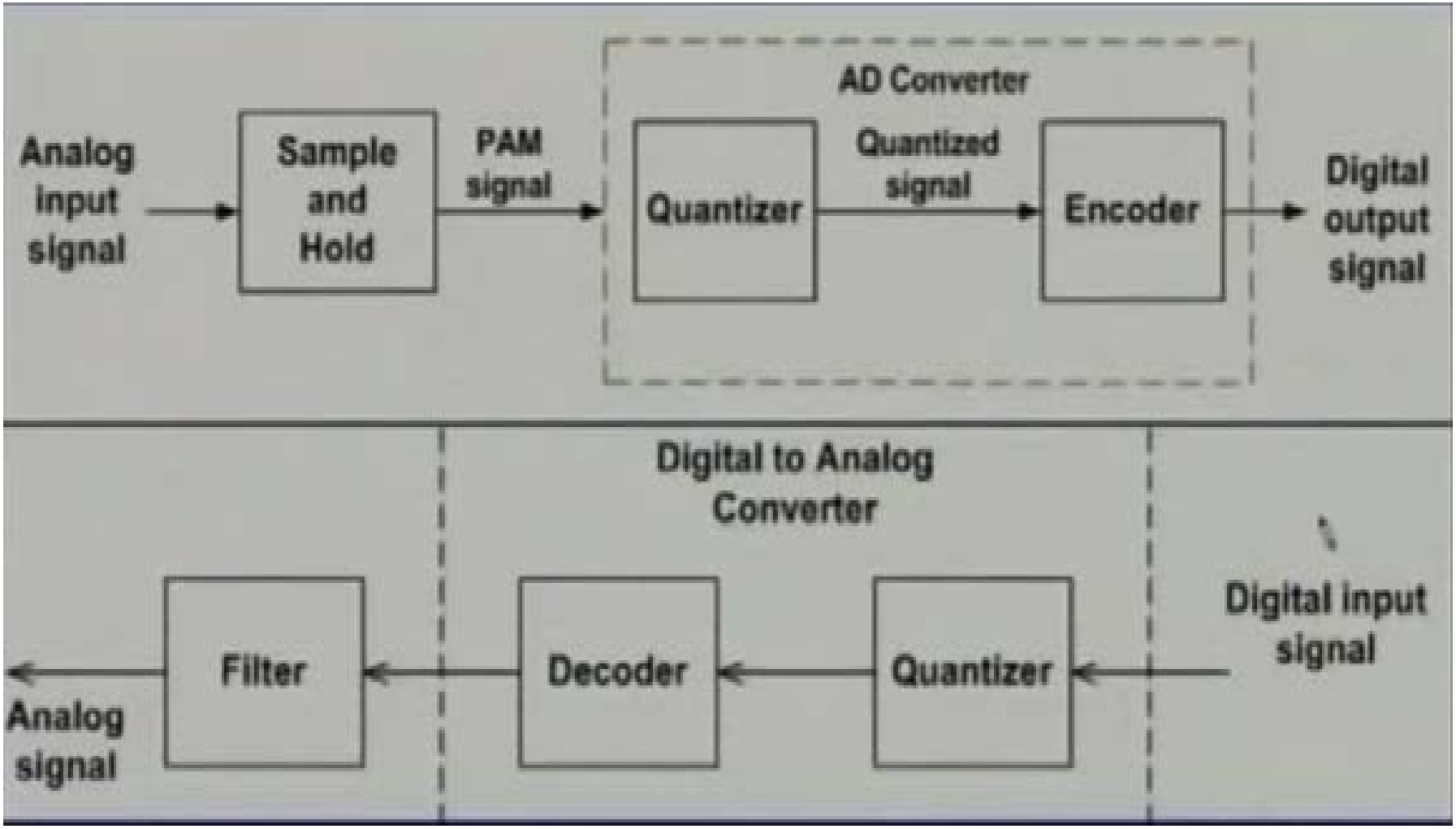
Analog Data-Digital Signal

- Analog data such as voice, videos and music are to be converted into digital signal for communication through transmission media.
- Two basic approaches
  - -Pulse Code Modulation (PCM)
  - -Delta Modulation (DM)

Pulse Code Modulation

- Sampling -> PAM
- Quantization
- Line coding




AD Converter
Analog input signal
Sample and Hold
PAM signal
Quantizer
Quantized signal
Encoder
Digital output signal
Digital to Analog Converter
Digital input signal
Filter
Decoder
Quantizer
Analog signal

Example:- Input signal-voice-Bandwidth 4 kHz

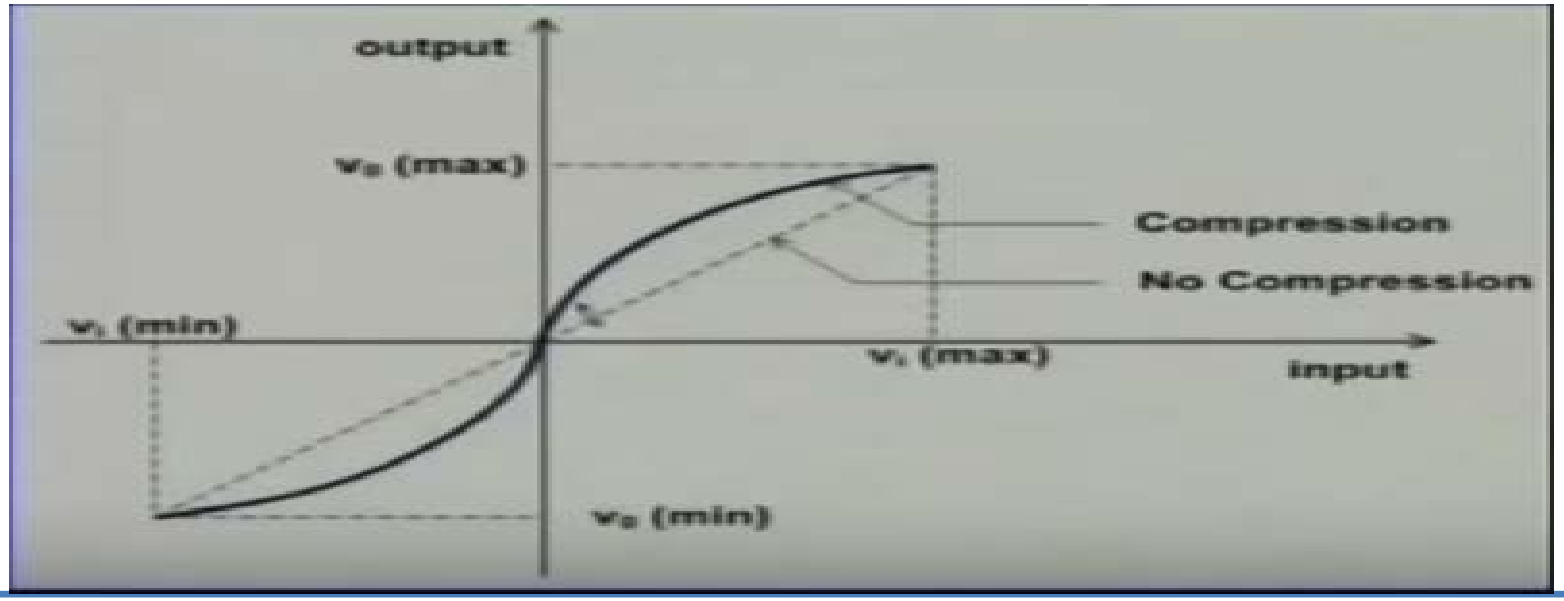
- Sampling Frequency- at least twice the highest frequency in the input signal (Nyquist Theorem)
- Sampling 8 kHz
- 8-bit ADC is used for conversion to digial data of 64 Kbps

Quantization Error

- Because of quantization, error is introduced
- Quantization error depends on step size
- Use of uniform step size leads to poorer S/N ratio for small amplitudes signals
- With the constraint of a fixed number of levels, the situation can be improved using variable step size
- Companding : Use of non-linear encoding during quantization

- The steps are close together at low signal amplitude and further apart at high signal amplitude and this improves the S/N ratio

COMPRESSOR-EXPANDER



Limitations of PCM

- The PCM signal has high bandwidth
- To send voice signal a data rate of 56/64 Kbps is required
- To overcome this problem a techniques known as Differential PCM (DPCM) can be used
- It is based on the observation that voice signal changes slowly
- So difference between two consecutive sample values, instead of the sample values, may be sent

DPCM

- DPCM: The difference between the sample values, rather than the sample values, is encoded
- It can be achieved in a number of ways

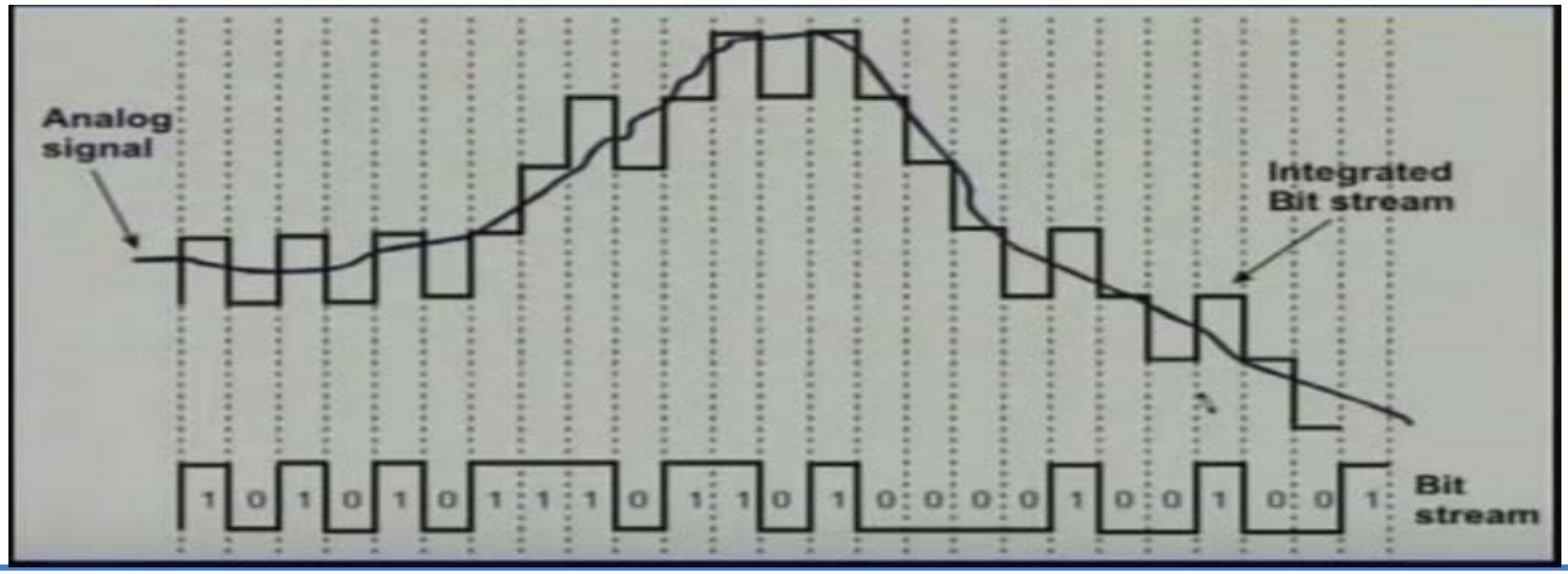
  -Analog

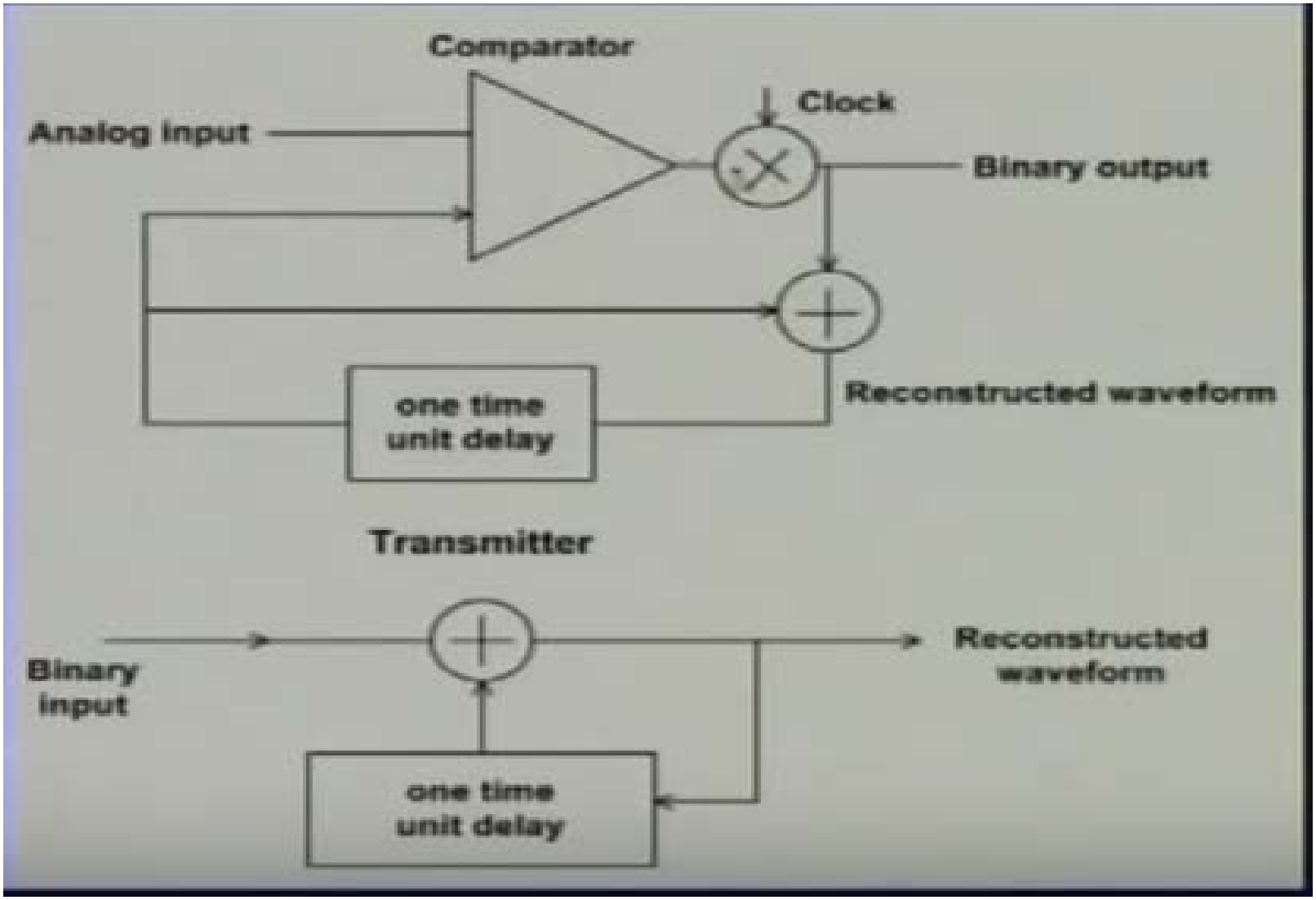
  -Mixture of analog and digital

  -Digital

Delta Modulation

- DM: It is a special case of DPCM
- If the difference between analog input and the feedback signal is positive, then encoded output is 1, otherwise 0
- Only one bit is sent at a time



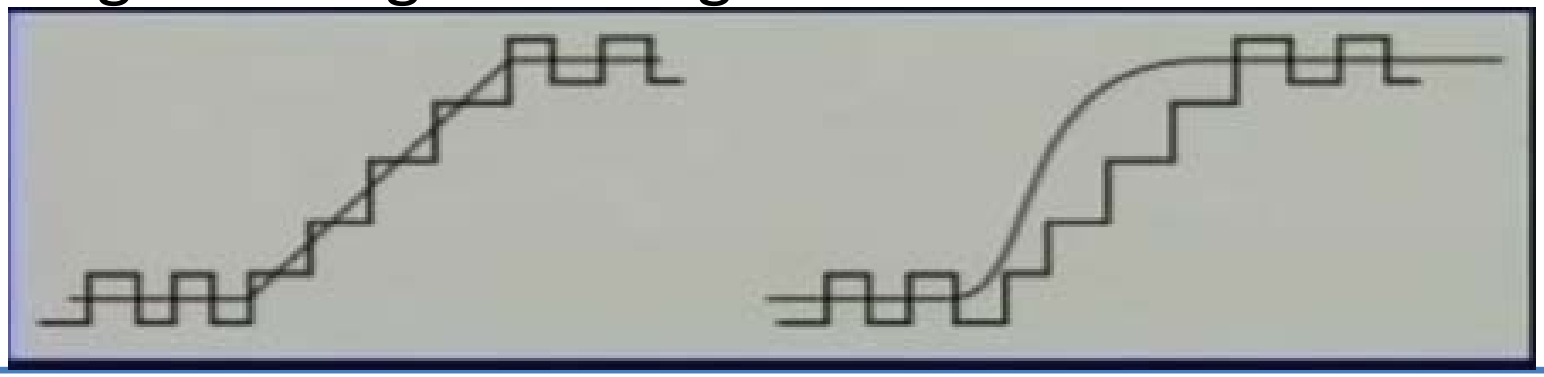

Comparator
Clock
Analog input
Binary output
one time
unit delay
Reconstructed waveform
Transmitter
Binary
input
Reconstructed
waveform
one time
unit delay

Delta Modulation Advantages

- Simplicity of implementation
- Each samples is represented by a single binary digit, which makes it more efficient than the PCM technique
- Two important parameters :
  - -The size of the step
  - -The sampling rate

Limitation of Delta Modulation

- Fixed step size leads to overloading
- Overloading occurs not only due to higher voltage but due to its slope
- Slope-overloaded
- This problem can be overcome using adaptive delta modulation
- The steps sizes are small, when the signal changes are small and sizes are large, when the signal changes are large



PCM Versus DM

- PCM: For the voice signal with 256 quantization levels the data rate is 64 Kbps
- This requires a channel having bandwidth of 32KHz
- More complex hardware
- DM: To obtain comparable quality, a sampling rate of 100 KHz is required
- If compromise in quality and intelligibility is allowed, DM requires lesser bandwidth
- Simpler hardware

Applications of Encoding Techniques

- Manchester Encoding is used in Ethernet LAN
- Differential Manchester is used in Token Ring LAN
- 4B/5B-NRZI encoding is used in FDDI LAN
- PCM is used in public Switched Telephone Network(PSTN)

Thanks!