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Digital Broadcasting and Broadband Technologies (Master Studies)  
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**DBBT**

**Digital Broadcasting &  
Broadband Technologies**

# Digitalni radiodifuzni sistemi i tehnologije

## Izvorno kodovanje - audio

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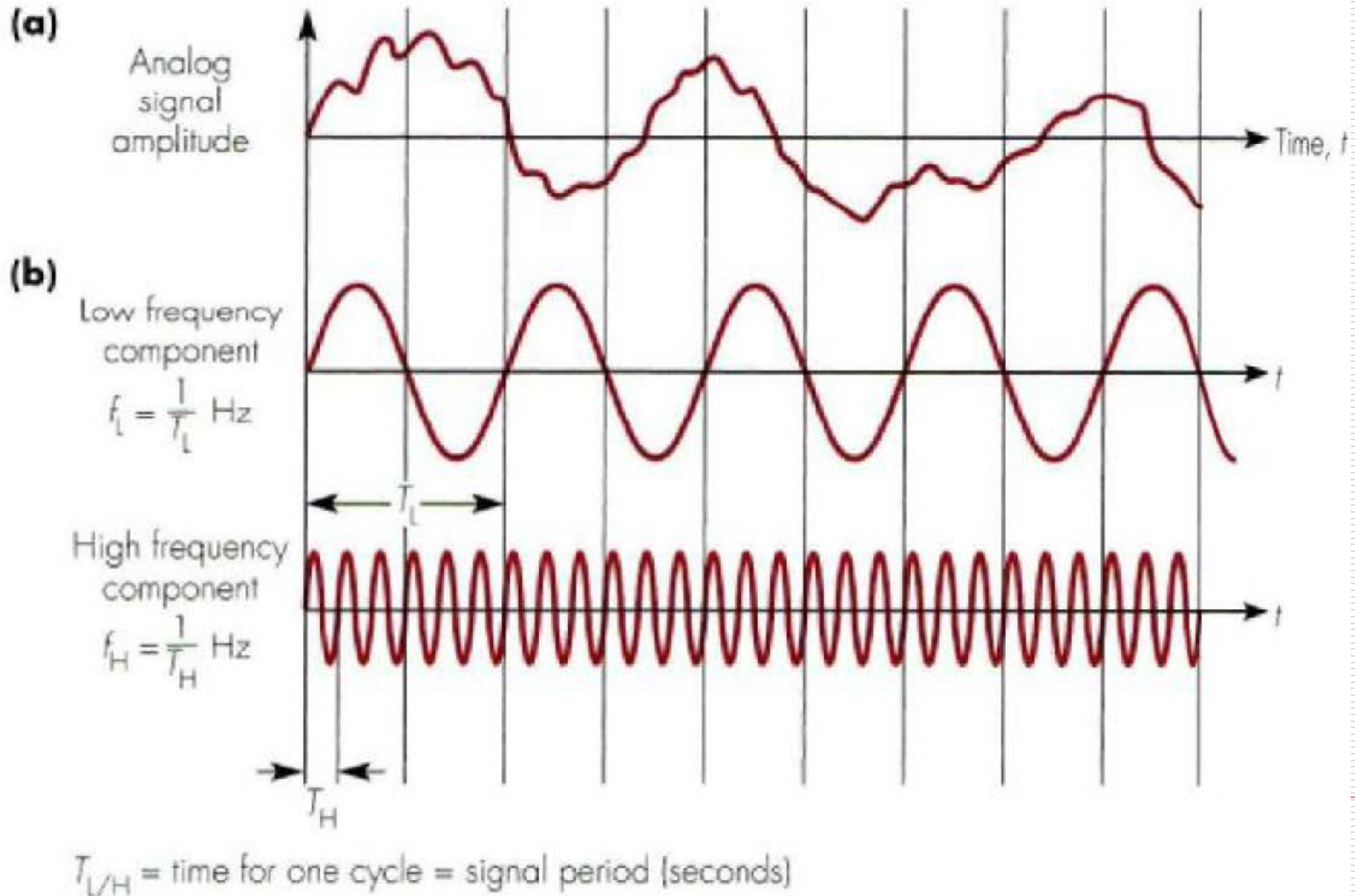
***Banja Luka, 2017.***

# Analogni audio signal

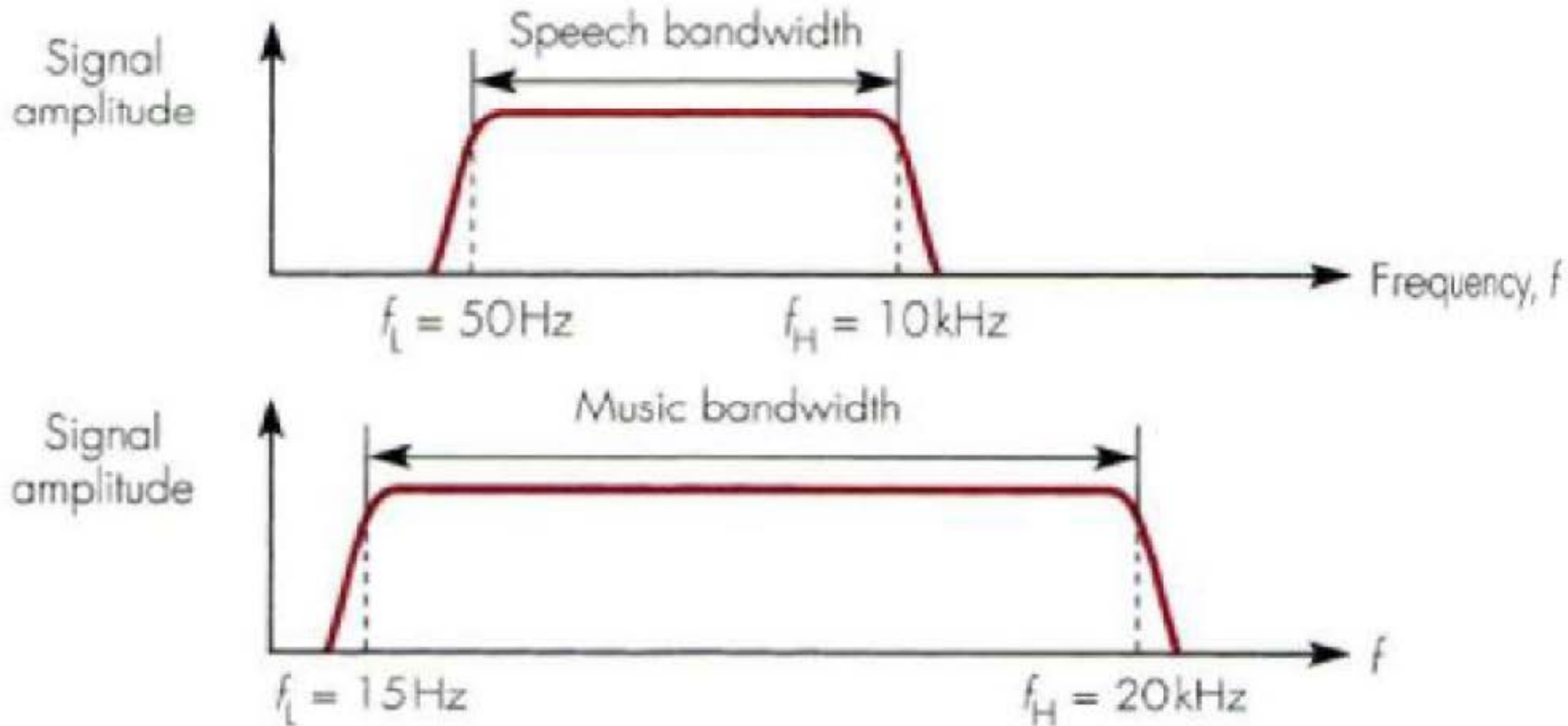
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- > Fourier analysis: decomposition into sine signals
  - > Signal bandwidth: speech 50Hz - 10kHz  
music 15Hz - 20kHz
  - > Channel bandwidth: PTSN line 300Hz-3,4kHz only!
-

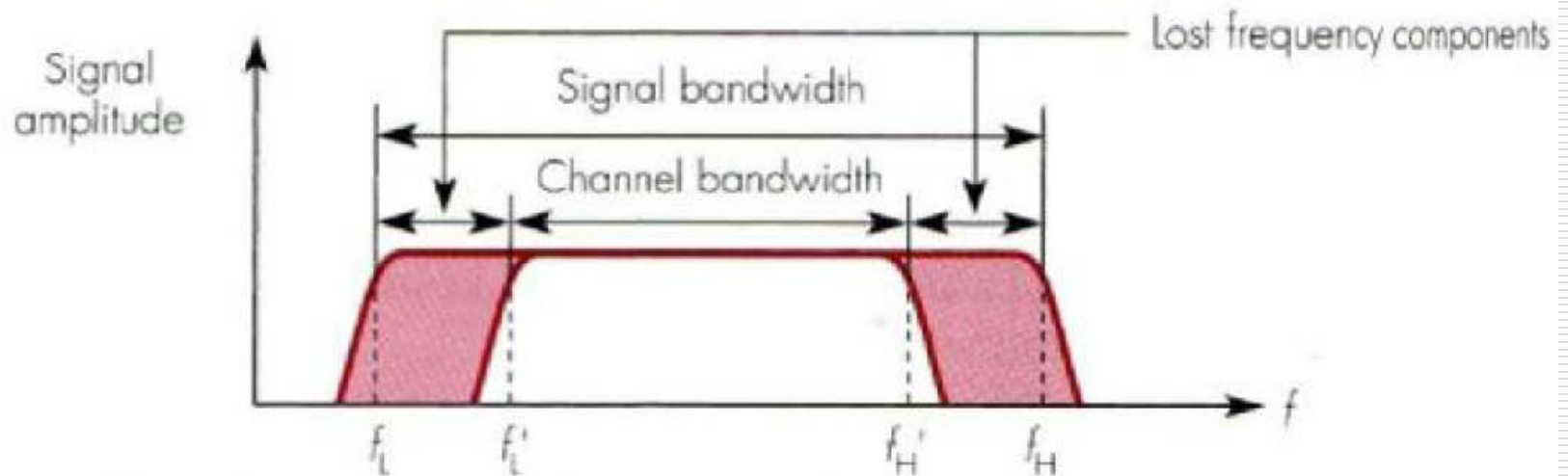
# Analogni audio signal



# Spektar audio signala



# Spektar audio signala

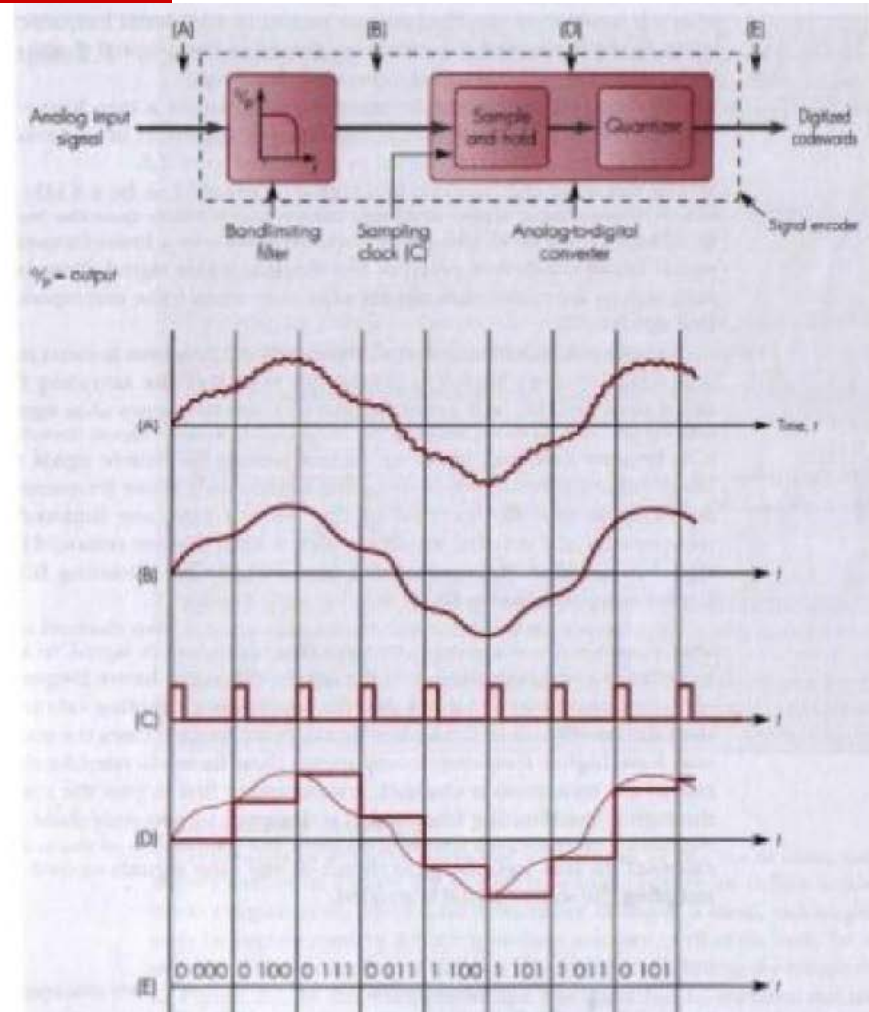


$f_L'$  and  $f_H'$  are known as the cut off frequencies of the channel

# A/D konverzija

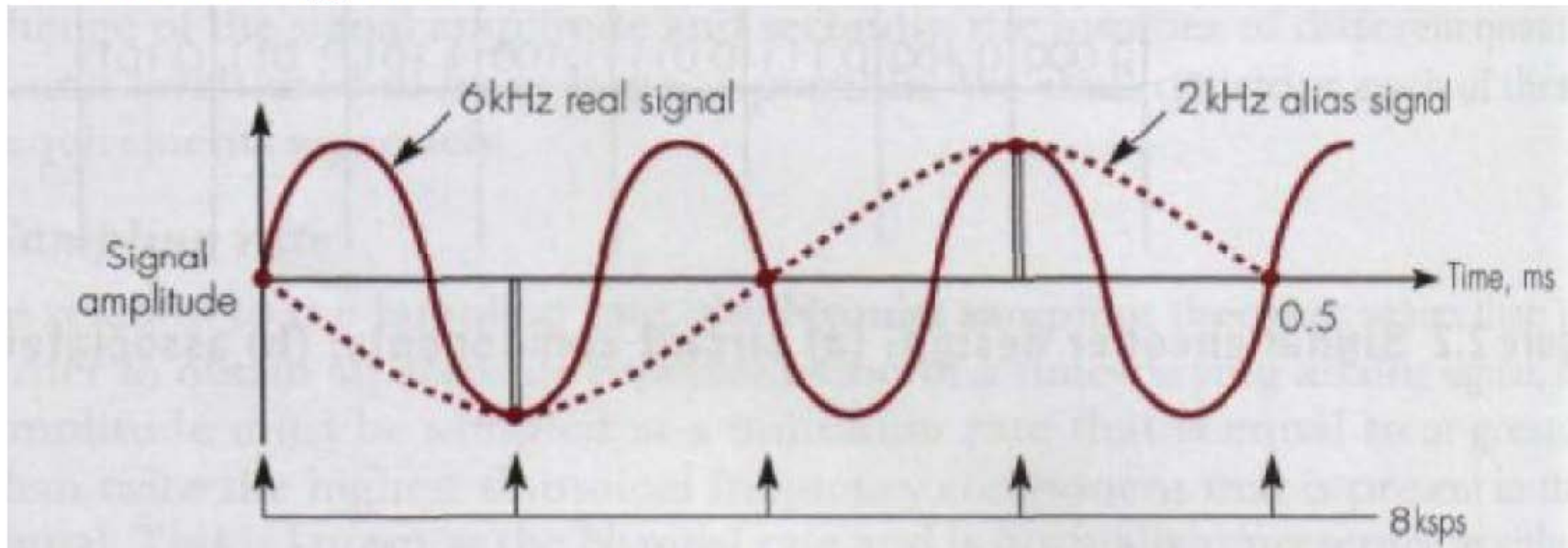
## ADC - Analog to Digital

- > Bandlimiting filter
- > Sample-and-Hold
- > Quantization
- > Codeword



# Aliasing - preslušavanje

- > Alias signals if sampling freq. is under  $2 * f_{\max}$
- > Nyquist theorem
- > Antialiasing filter





# Kvantizacija

## Quantization

> quantization interval

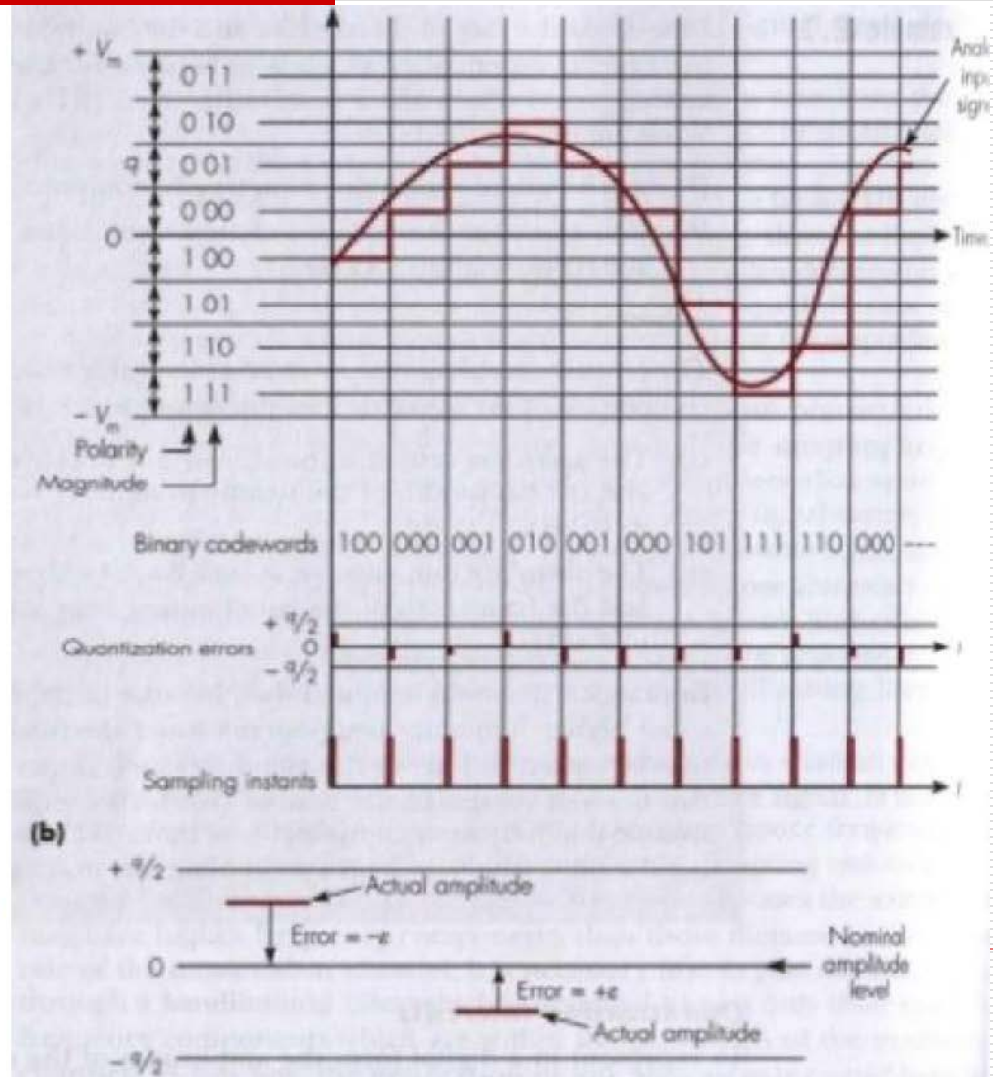
$$q = 2 * V_{max} / 2^n$$

> quantization error

> quantization noise

> dynamic range [dB]

$$D = 20 * \log_{10}(V_{max} / V_{min})$$

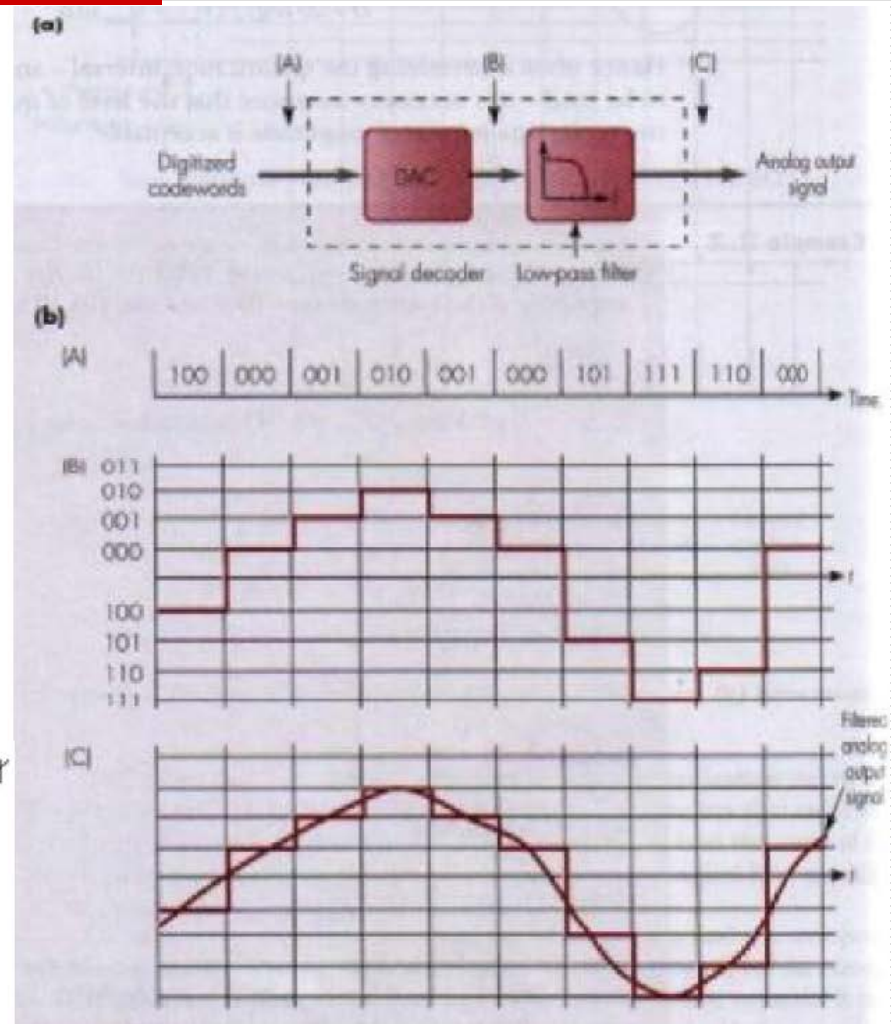
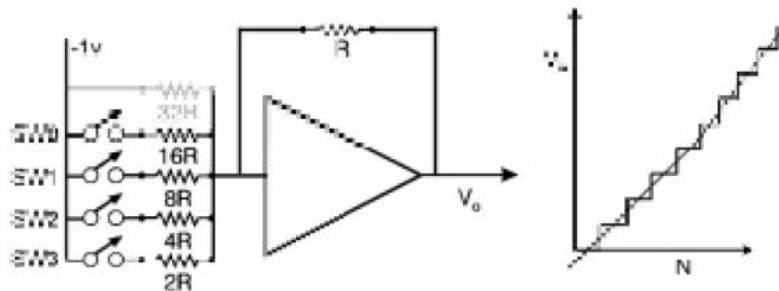


# D/A konverzija

## DAC - Digital to Analog

> Low-pass filter

> Switch Summed Source



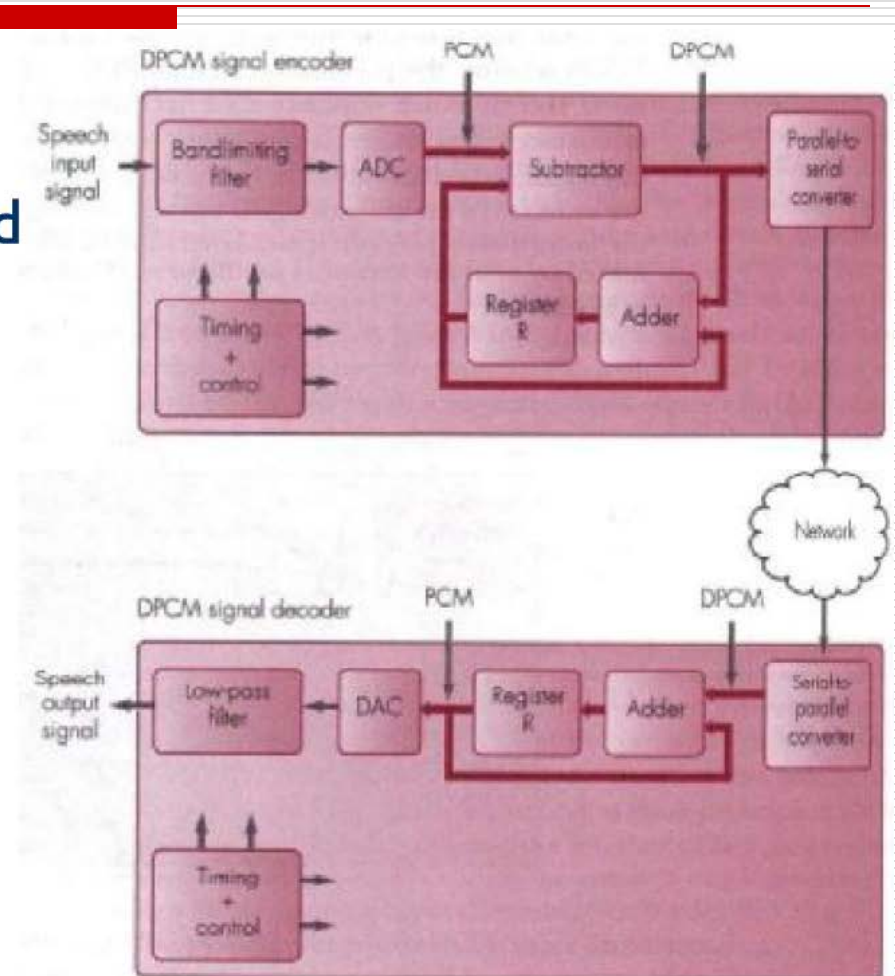
# PCM – Pulse Code Modulation

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- > 8b/sam EU / 7b/sam USA,JP - 64kbps / 56 kbps
  - > A-law / u-law to compress the speech signal
  - > Human senses have logarithmic sensitivity
  - > Expands dynamics for low amplitude signals
  - > Used to be analog, nowadays digital implementation
-

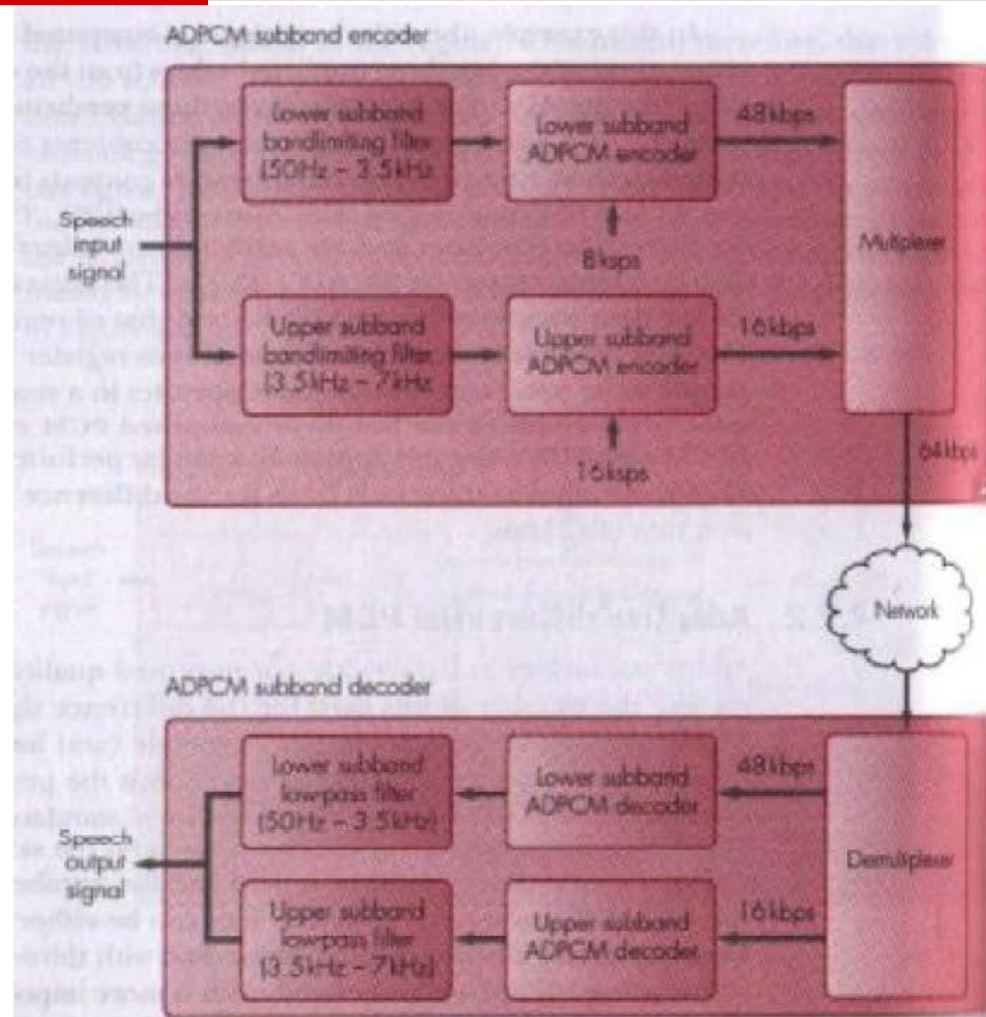
# DPCM – Differential PCM

- > Only sample difference encoded
- > Fewer bits to transfer
- > Saving only 1 bit
- > Predicted from more samples
- > Could save 2 bits



# ADPCM – Adaptive DPCM

- > ITU G.721 varies No bits
- > G.722 - subband coding
- > 50Hz-3.5kHz-7kHz
- > 16kbps upper band, 48kbps lower band
- > Multiplexing
- > Can be predictive (APC)



# Perceptual Coding

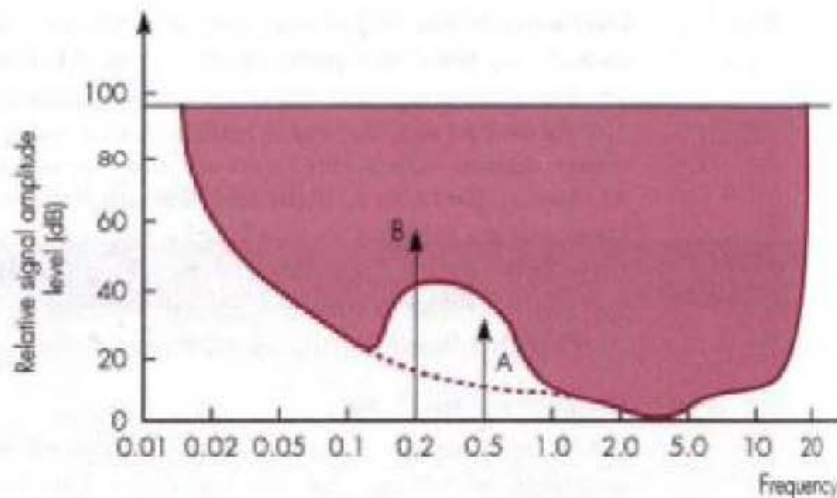
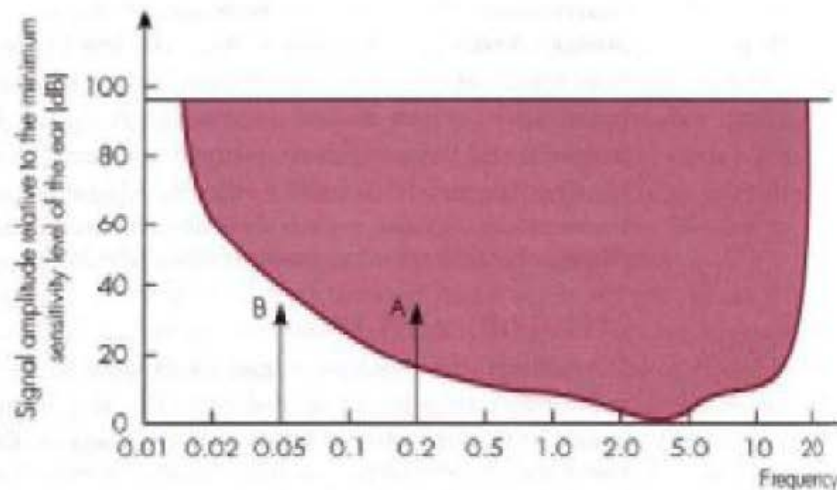
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- > Essential for Broadcast: user centred
  - > Psychoacoustic model of human ear
  - > Non-linear sensitivity
  - > Multiple signals - our DBT case - masking occurs
  - > Frequency and Temporal masking
-

# Frekvencijsko maskiranje

## Frequency Masking

- > Non-linear sensitivity
- > If signals have close  $f$  louder masks within **critical bandwidth**
- > This is dependant on  $f$

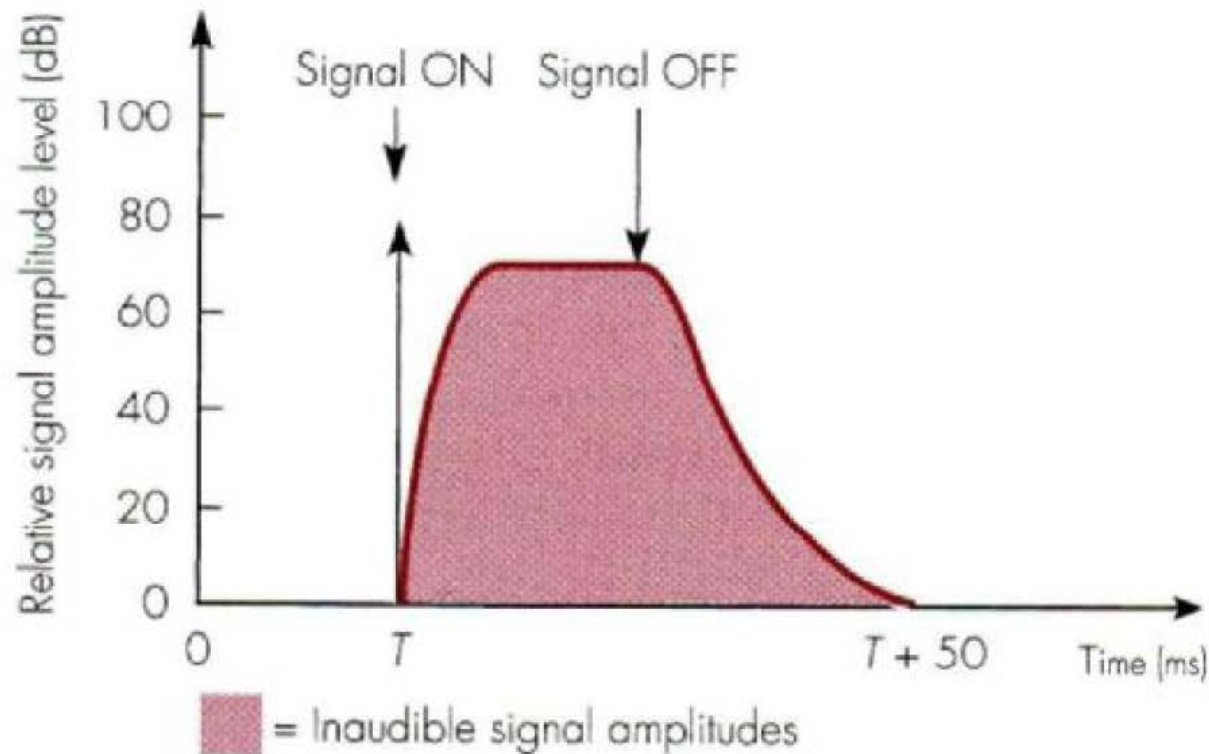


■ = Hearing sensitivity of the human ear

# Vremensko maskiranje

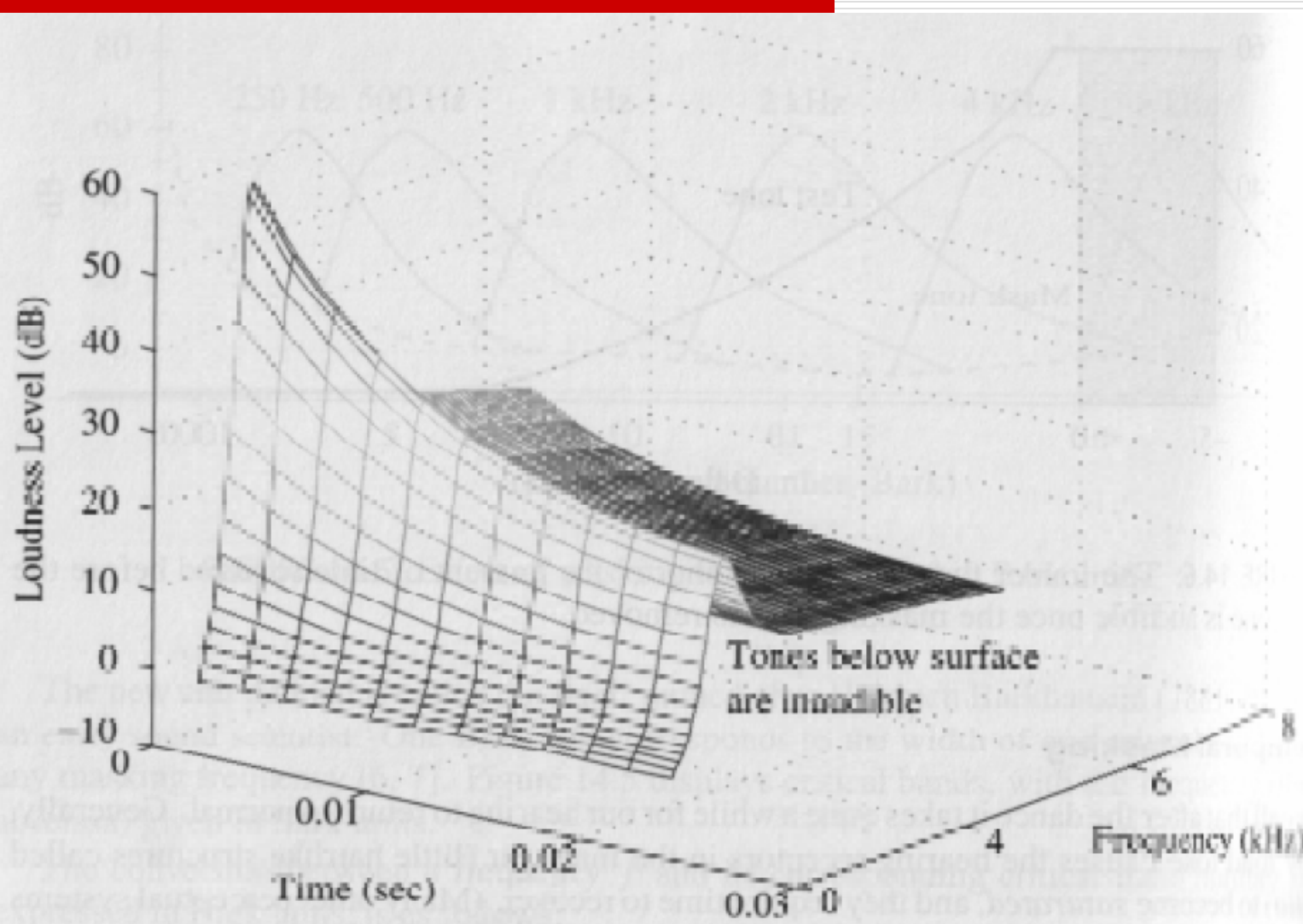
## Temporal Masking

> Critical bandwidth is frequency dependant





# Psihoakustička kriva maskiranja-1KHz



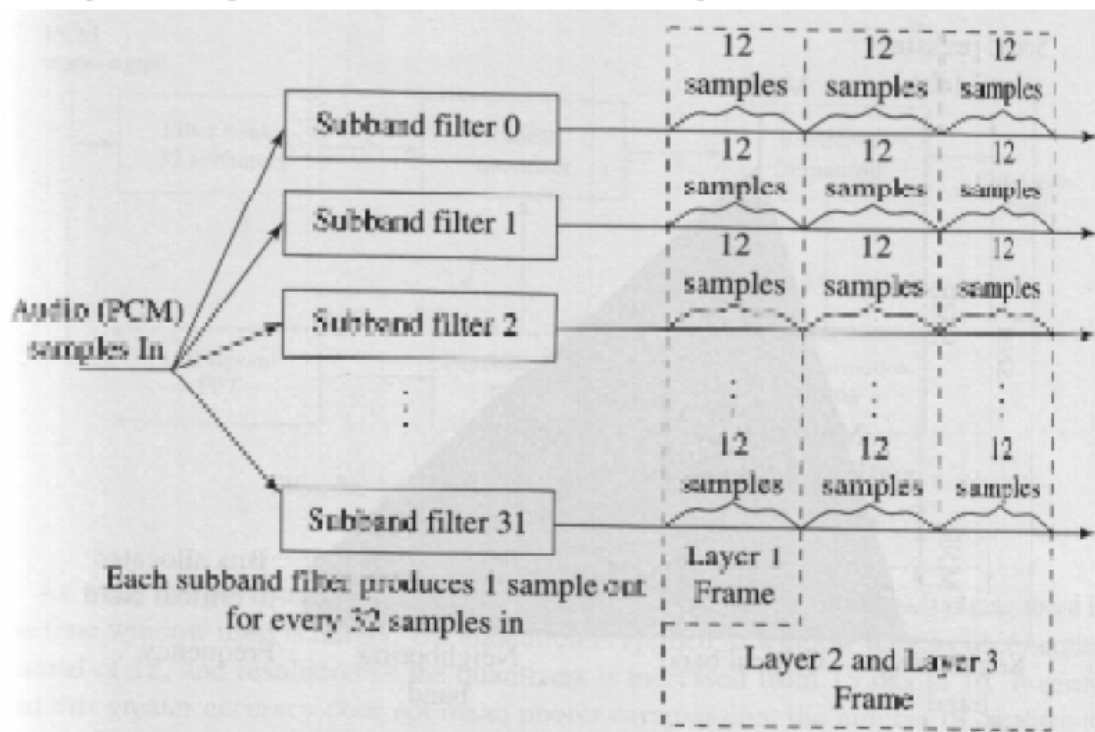
# MPEG audio: layers

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- > A part of MPEG-I video compression standard
  - > Layer 1 - 32-448kbps - HiFi@192kbps - DAT
  - > Layer 2 - 32-192kbps - HiFi@128kbps - DVB [MUSICAM]
  - > Layer 3 - 64kbps - HiFi@64kbps - ISDN audio
  - > Compatible - Headers have same format
-

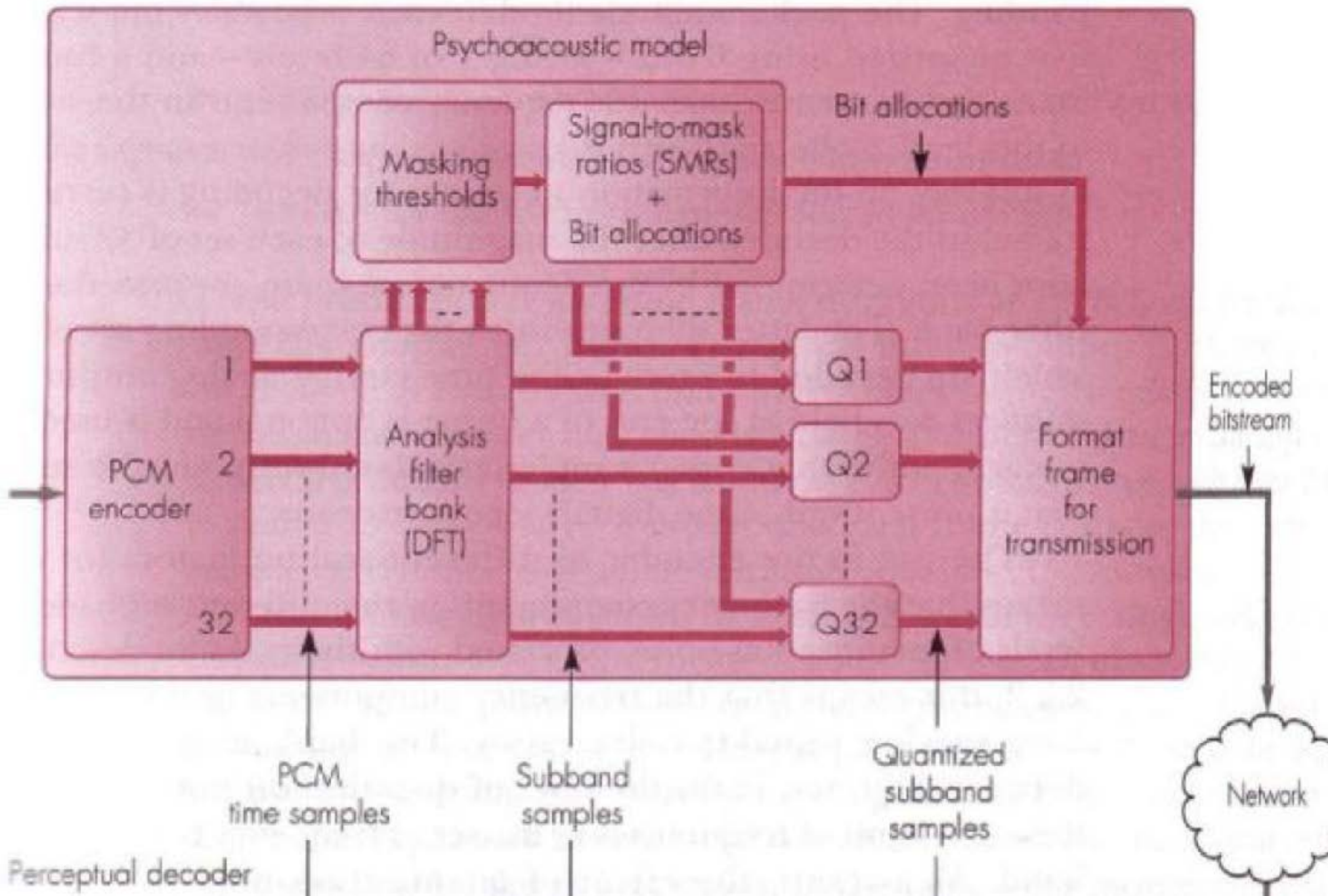
# MPEG audio: ulaz i podopsezi

- > Input is PCM 8-24 b/sam
- > Signal divided into frequency subbands - analysis filters
- > Subbands uniform 32 regions (@16kHz:500Hz)

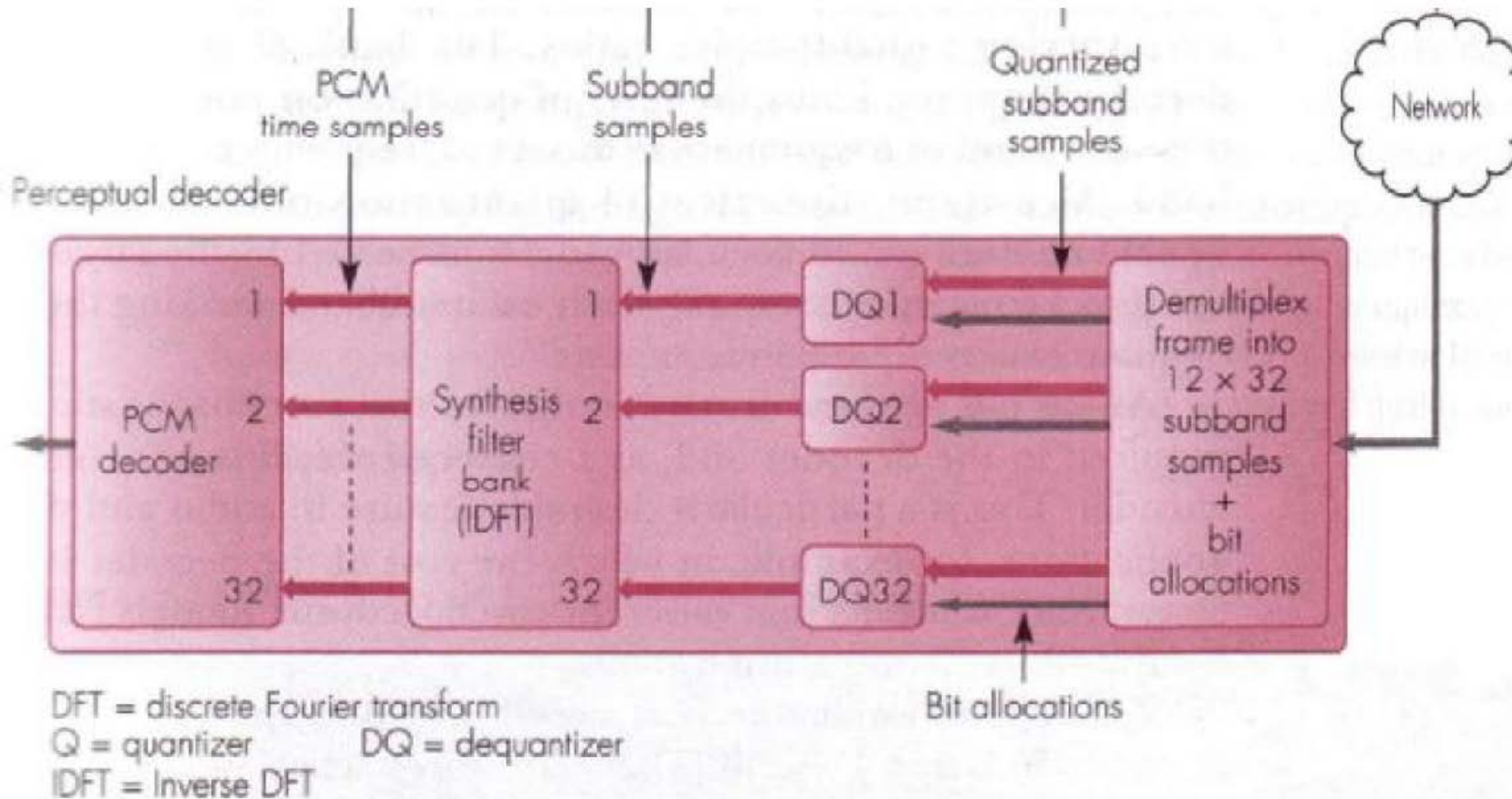


# Audio koder

Perceptual encoder

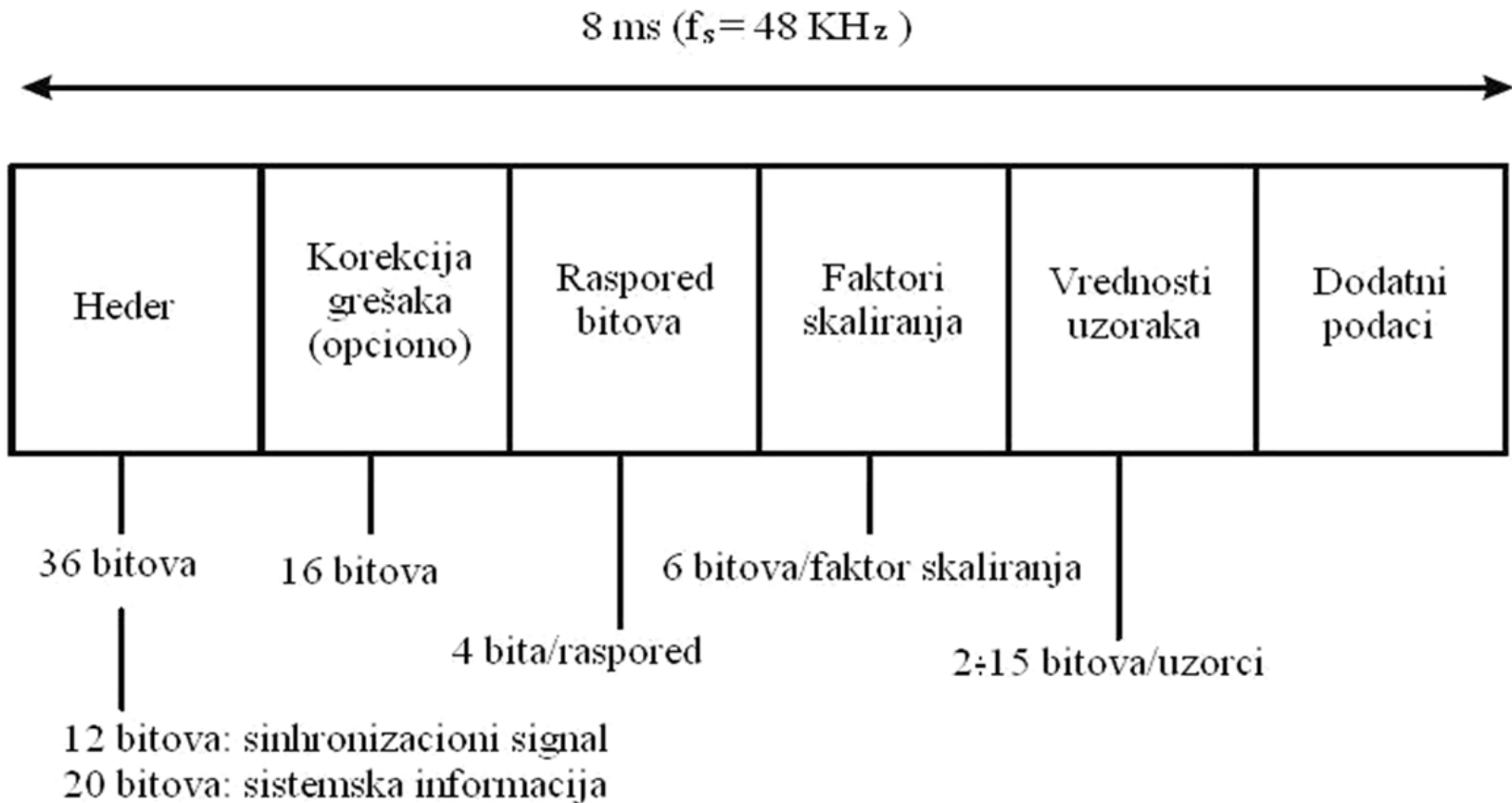


# Audio dekodeer

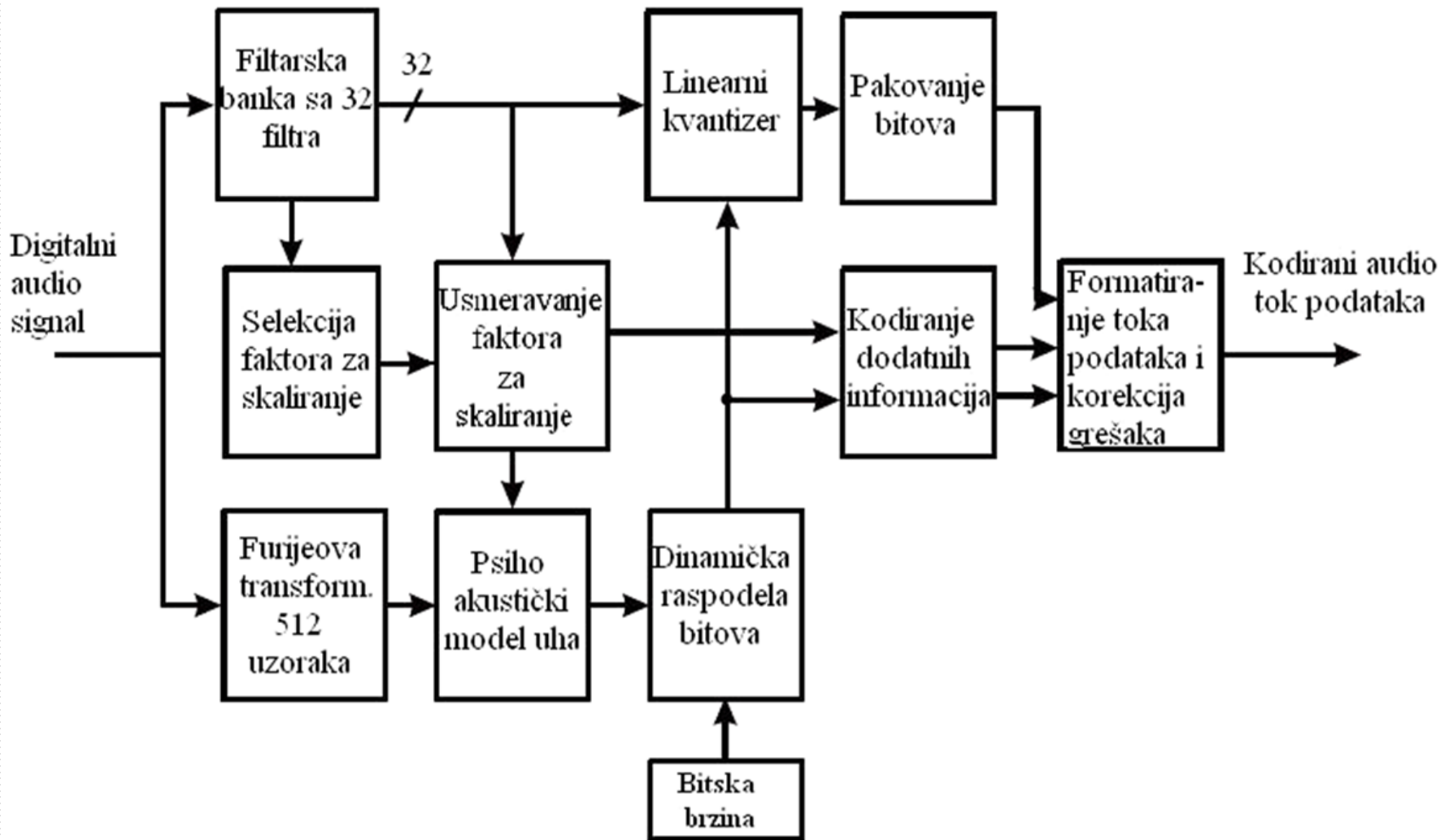




# MPEG layer 1 – bit stream

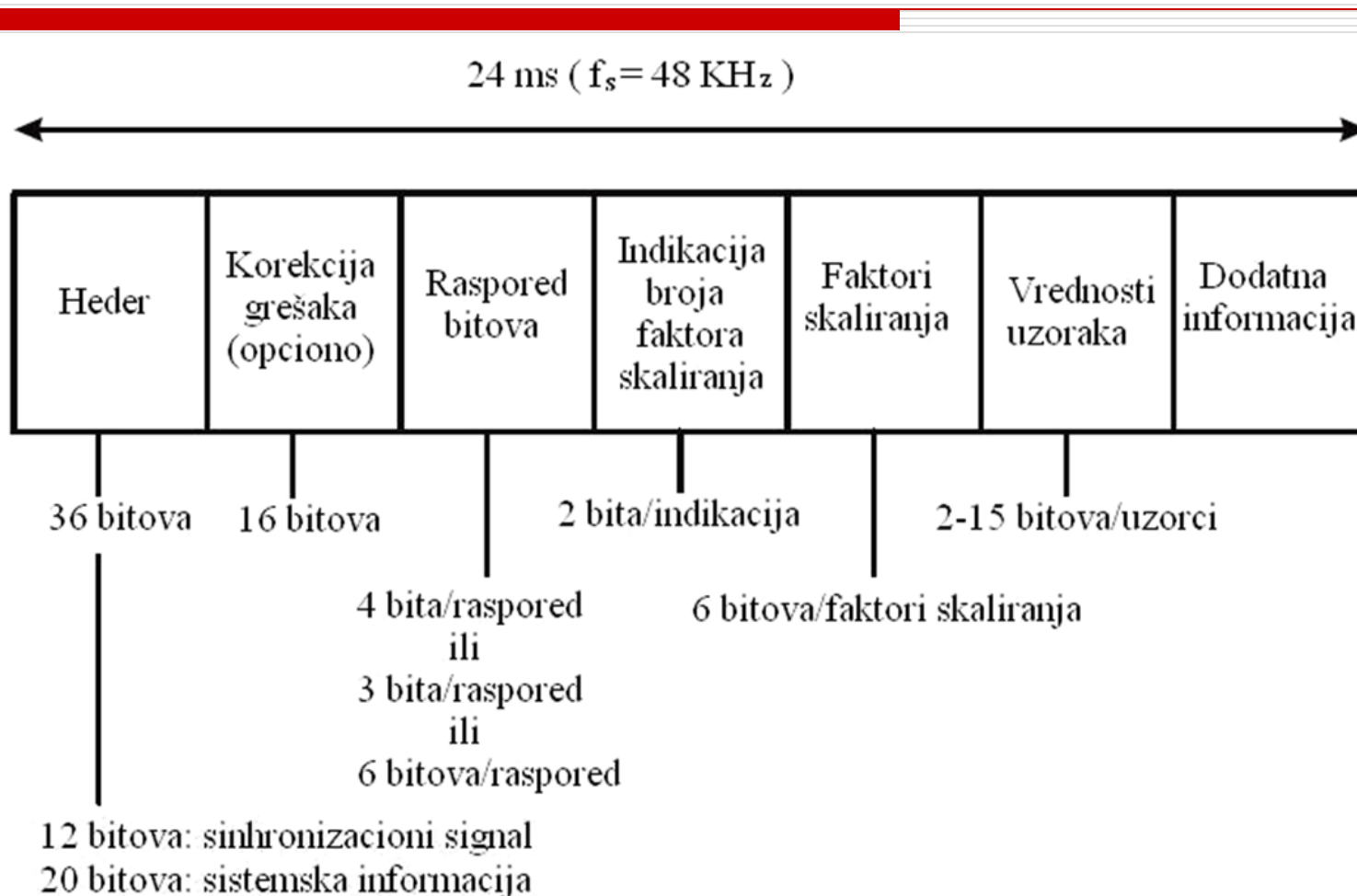


# MPEG layer 2 audio koder



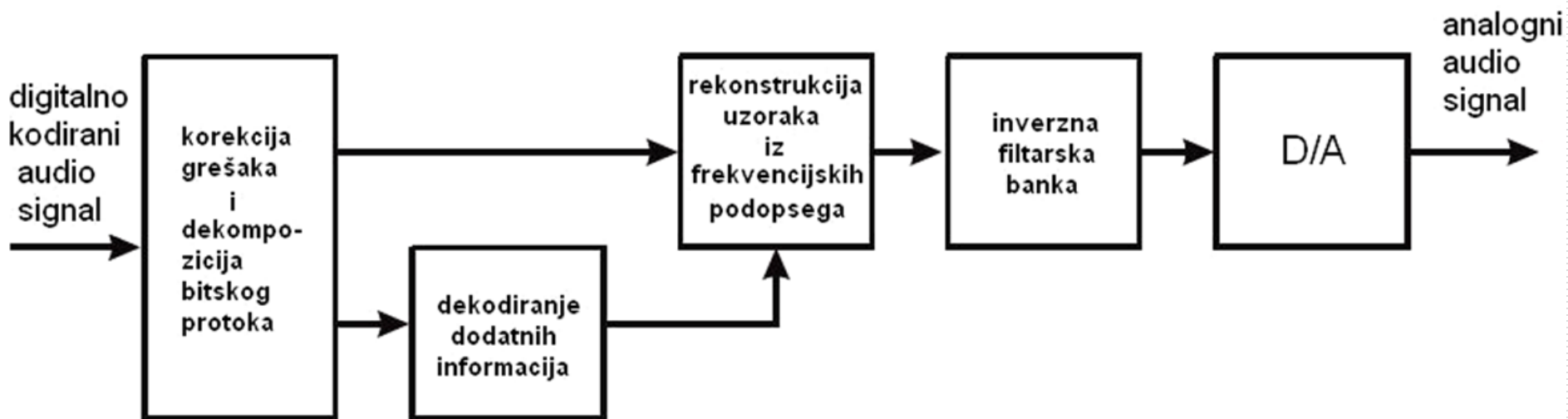


# MPEG layer 2 – bit stream



# MPEG layer 1 i 2 audio dekodier

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