

# **MP3s – Where Did All the Bits Go?**

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# Digital Music



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- The *gold standard* – CD Audio format
  - ❖ 44,100 samples per second (Hz)
  - ❖ 16-bit samples
  - ❖ 2 channels for stereo
  
  - ❖ 1.41 Mbits / second
  
- MP3 format
  - ❖ 64 – 256 kbits / second
  - ❖ Where did all the bits go?

# Background

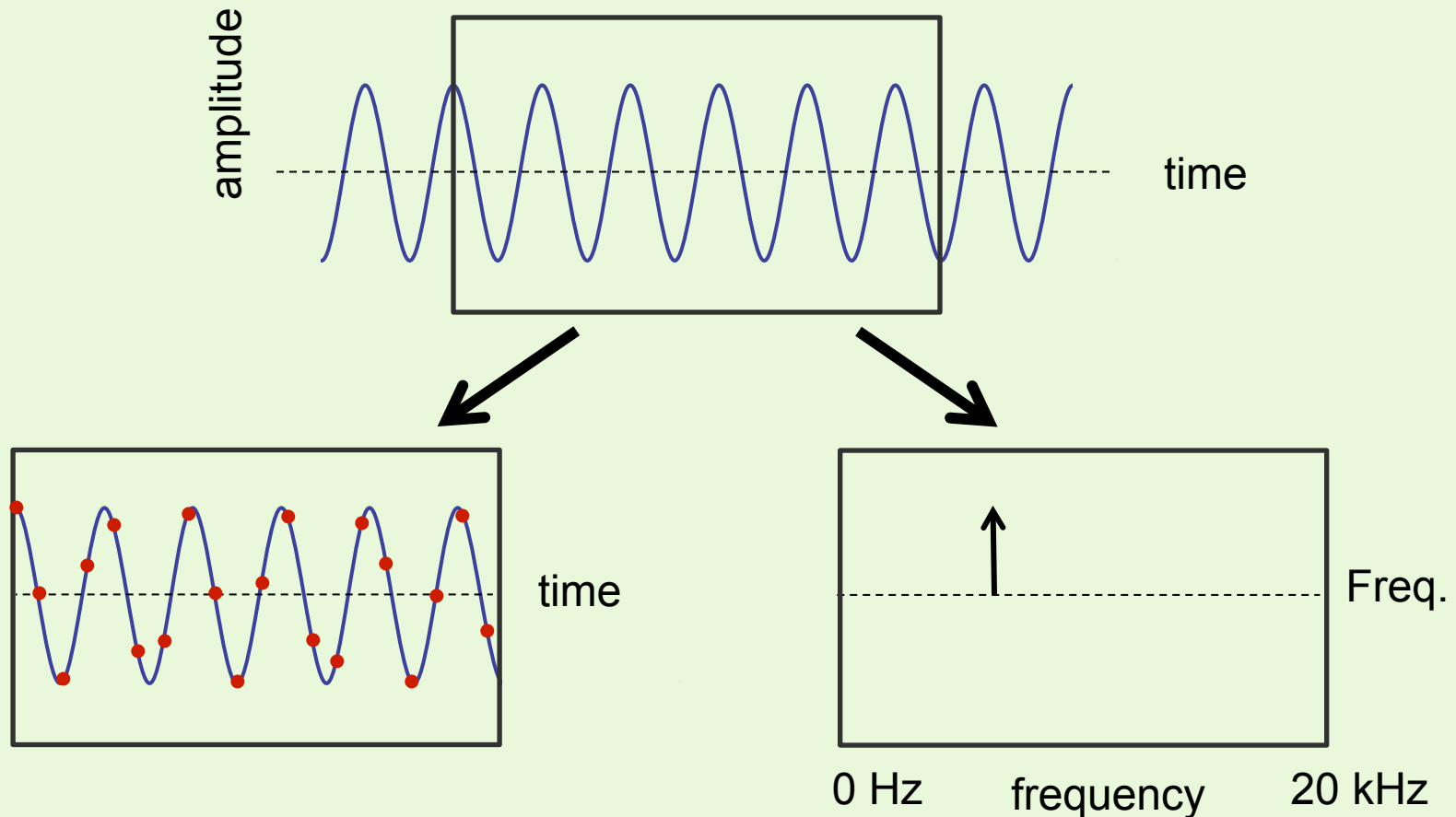


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- **Lossless compression**
  - ❖ Examples: WinZip, gzip, etc...
  - ❖ 2-4 :1 compression maximum
  - ❖ Audio does not compress and will yield ~706 kbits / second
  
- **Lossy compression**
  - ❖ Purposely *throw away* data
  - ❖ For audio, images, and video – minimized perceived loss in playback / display

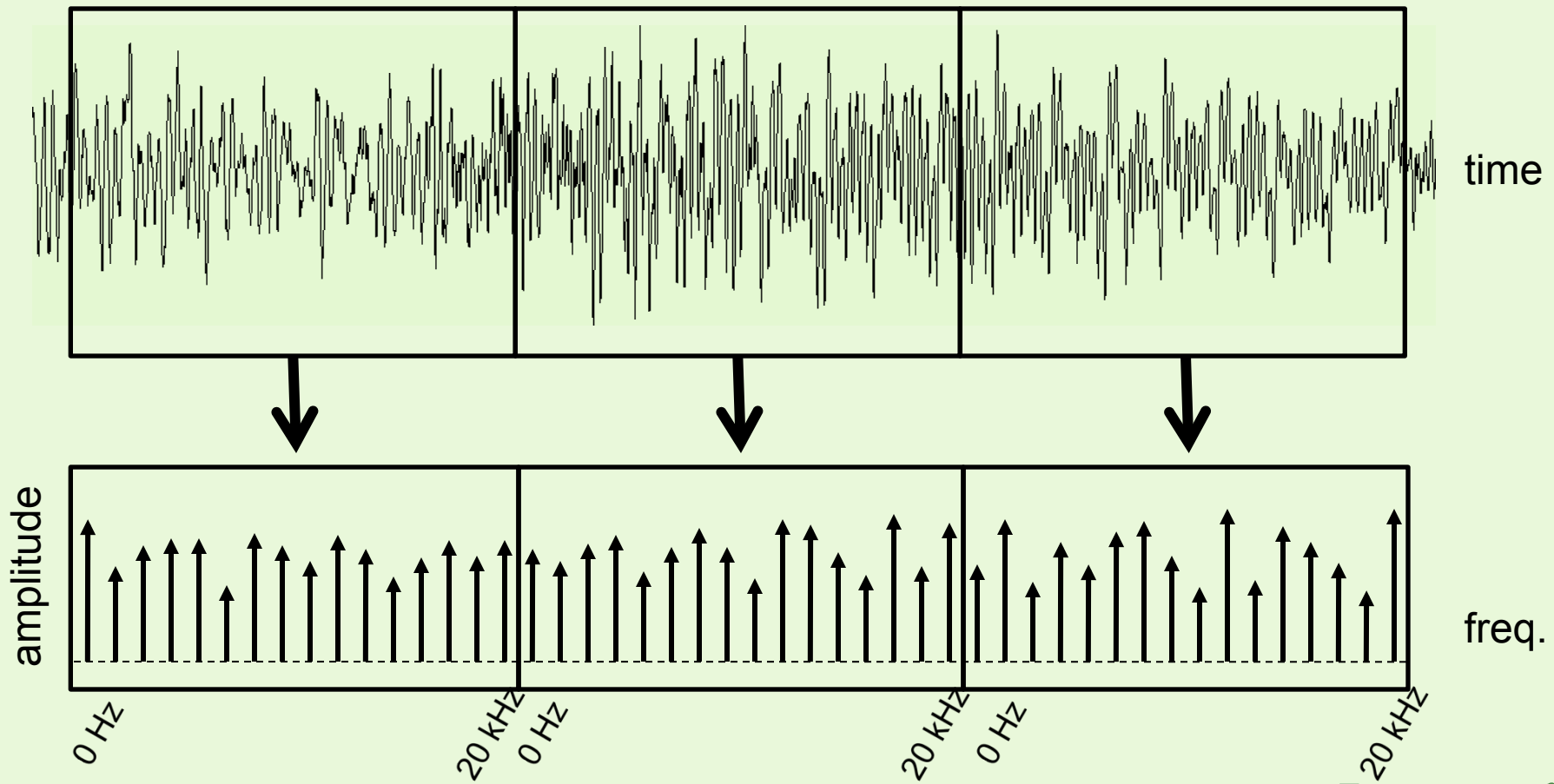
# Background

- Sound can sometimes be represented more compactly



# Background

## □ Generalizing to audio



# MP3 Compression



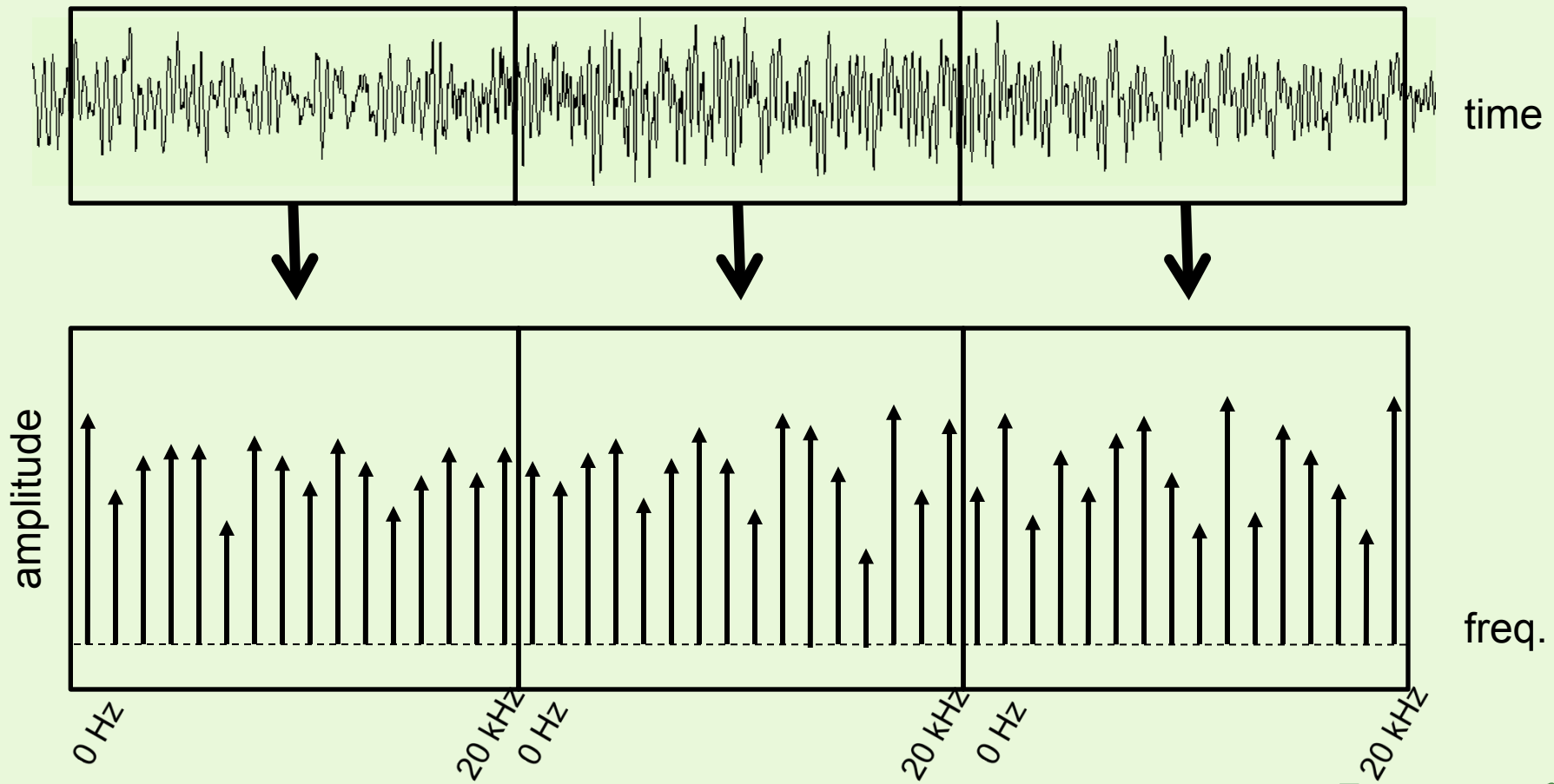
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- Major Components
  - ❖ Frequency domain transform
  - ❖ Remove signals that are *perceptually irrelevant*
  - ❖ Entropy encoding

# MP3 Compression



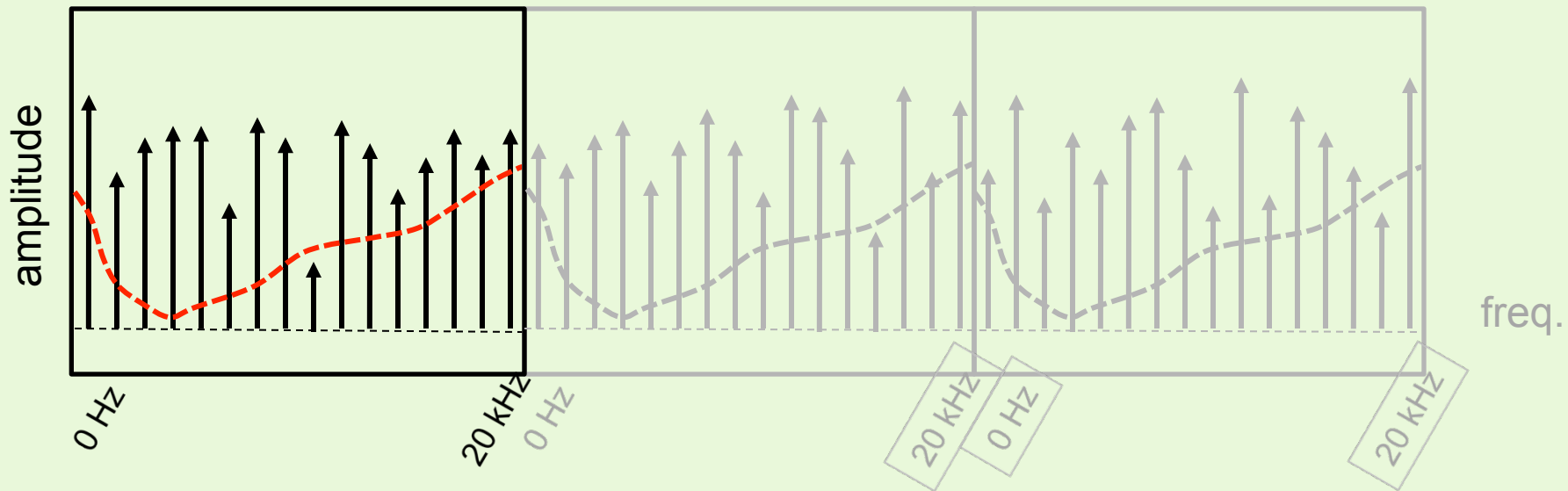
## □ Frequency domain transform



# MP3 Compression



- Remove signals that cannot be heard  
*Threshold of Quiet*

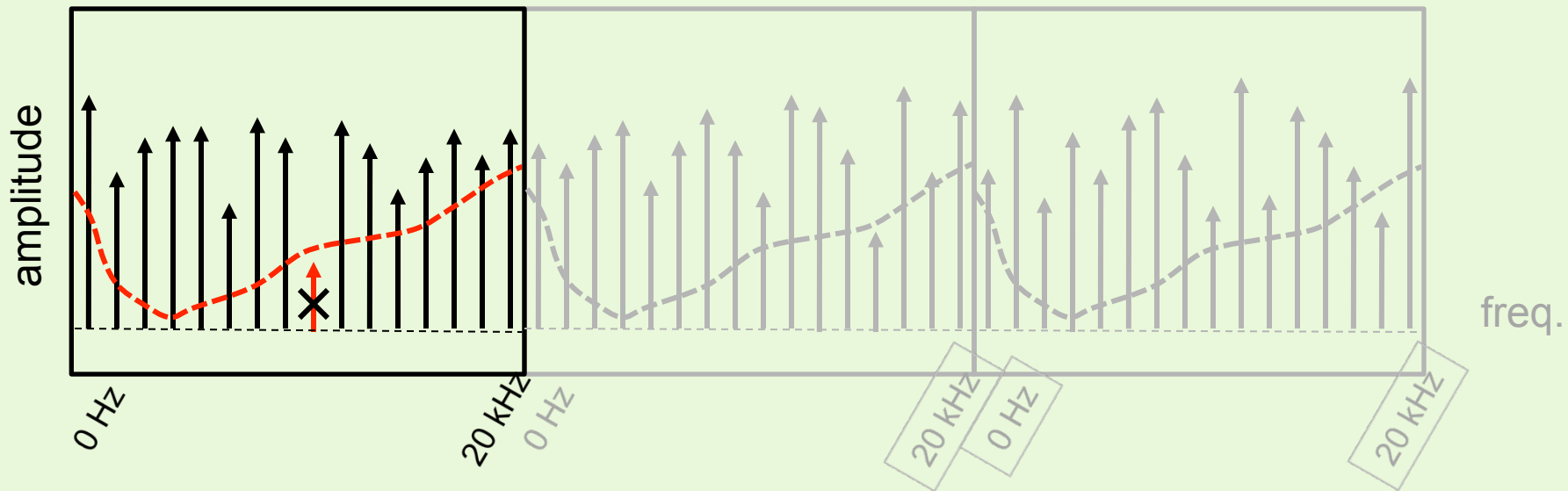




# MP3 Compression



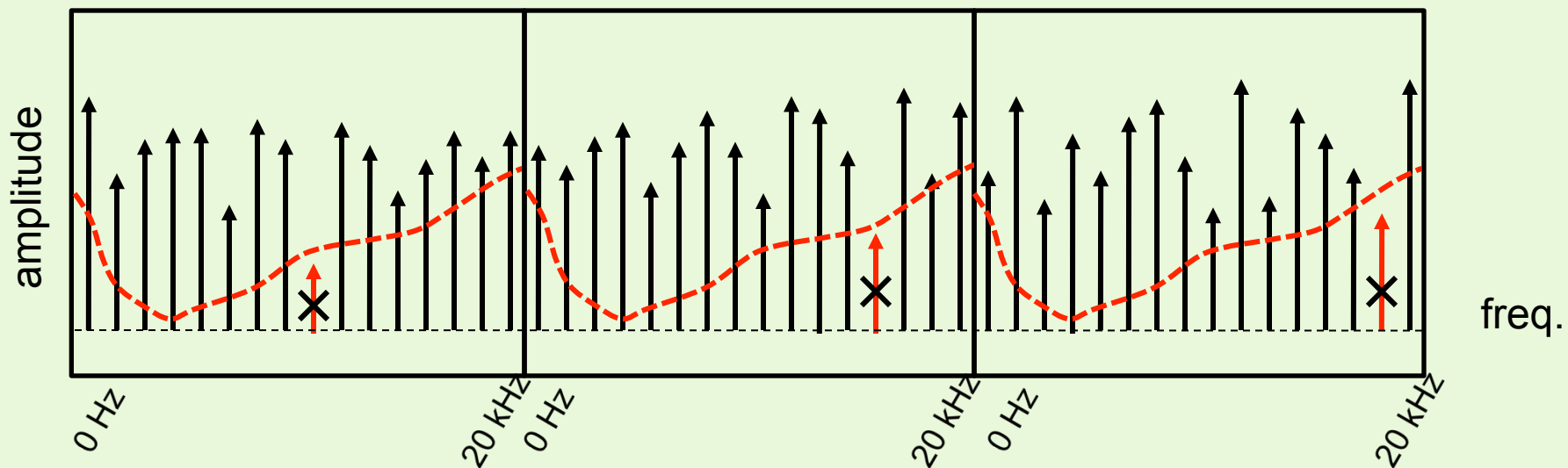
- Remove signals that cannot be heard  
*Threshold of Quiet*



# MP3 Compression

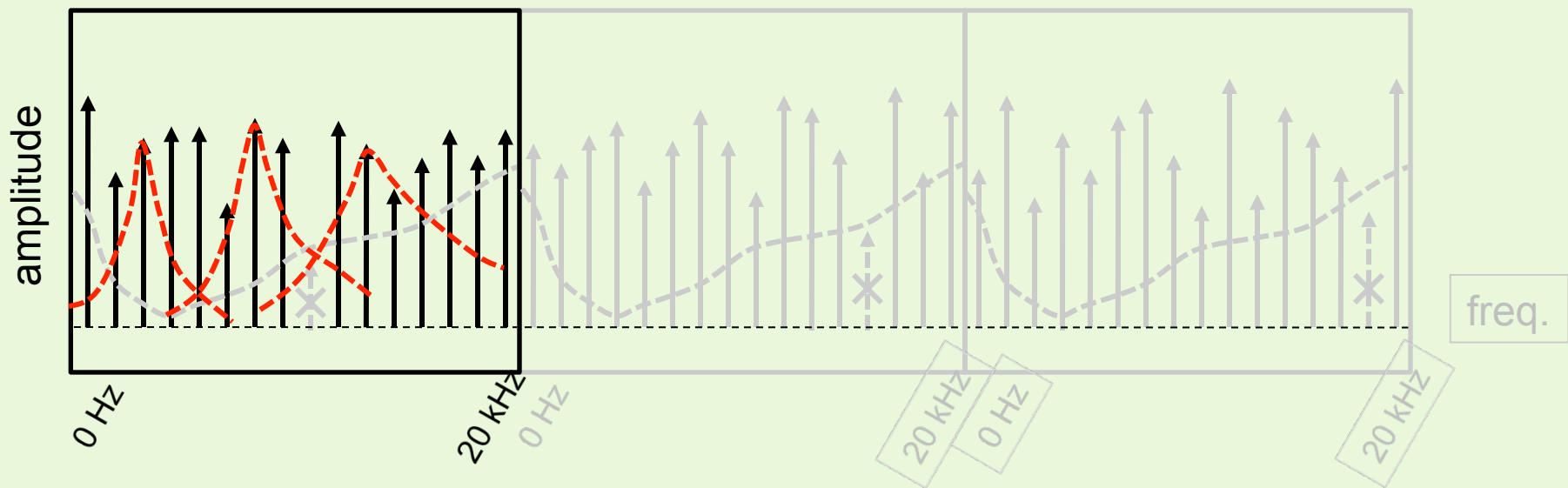


- Remove signals that cannot be heard  
*Threshold of Quiet*



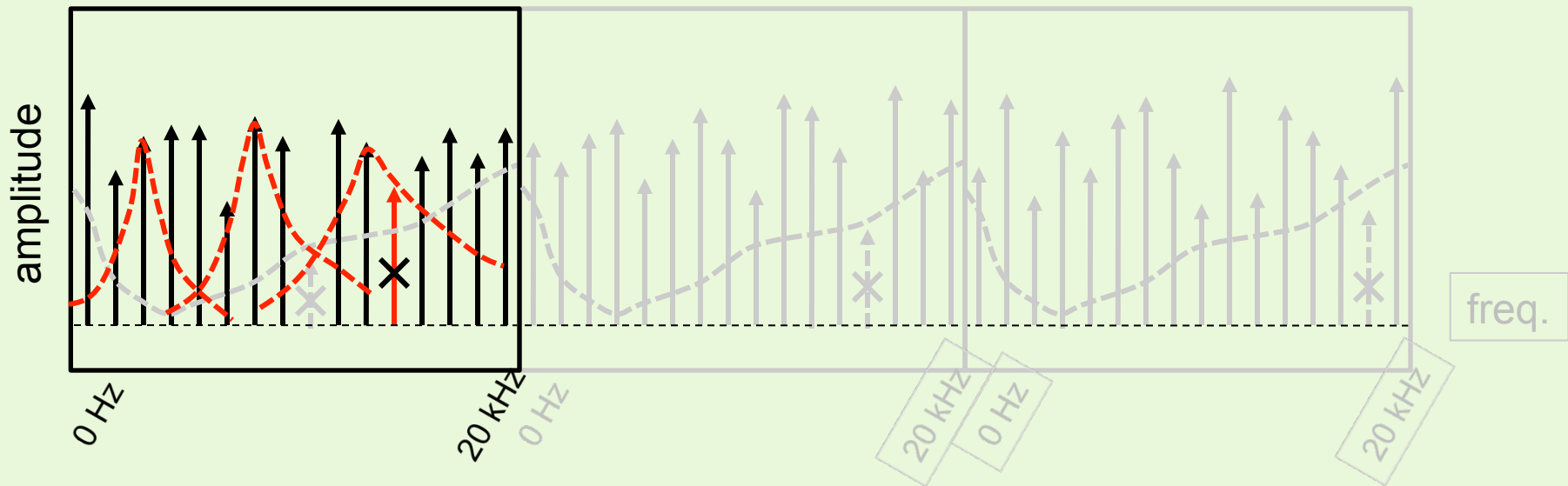
# MP3 Compression

- Remove signals that cannot be heard  
*Frequency Masking*



# MP3 Compression

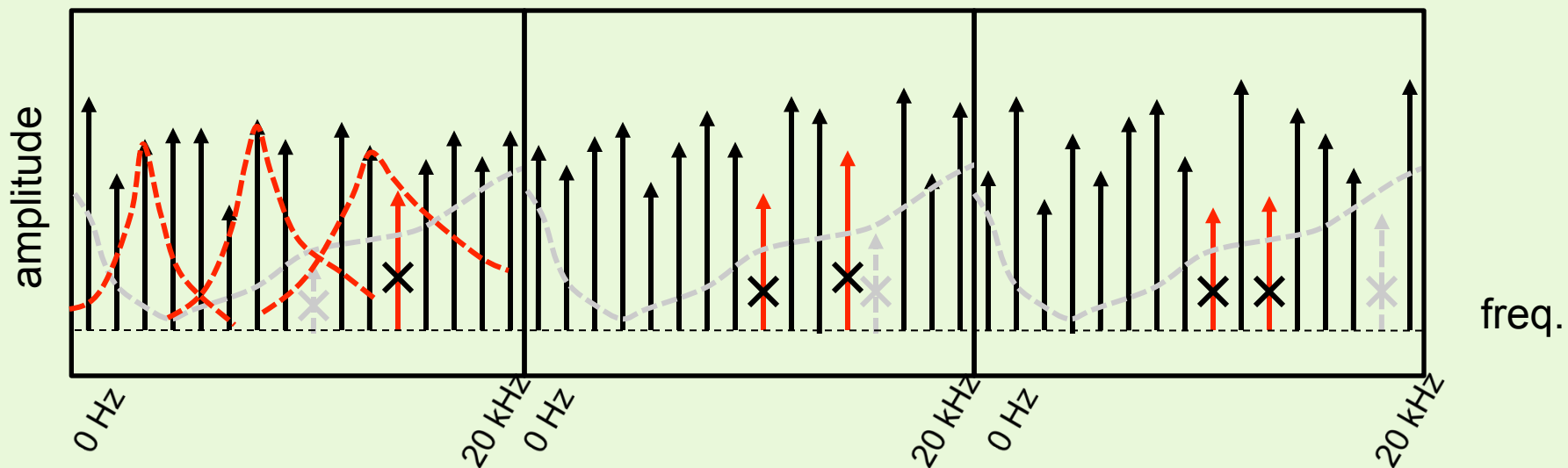
- Remove signals that cannot be heard  
*Frequency Masking*



# MP3 Compression



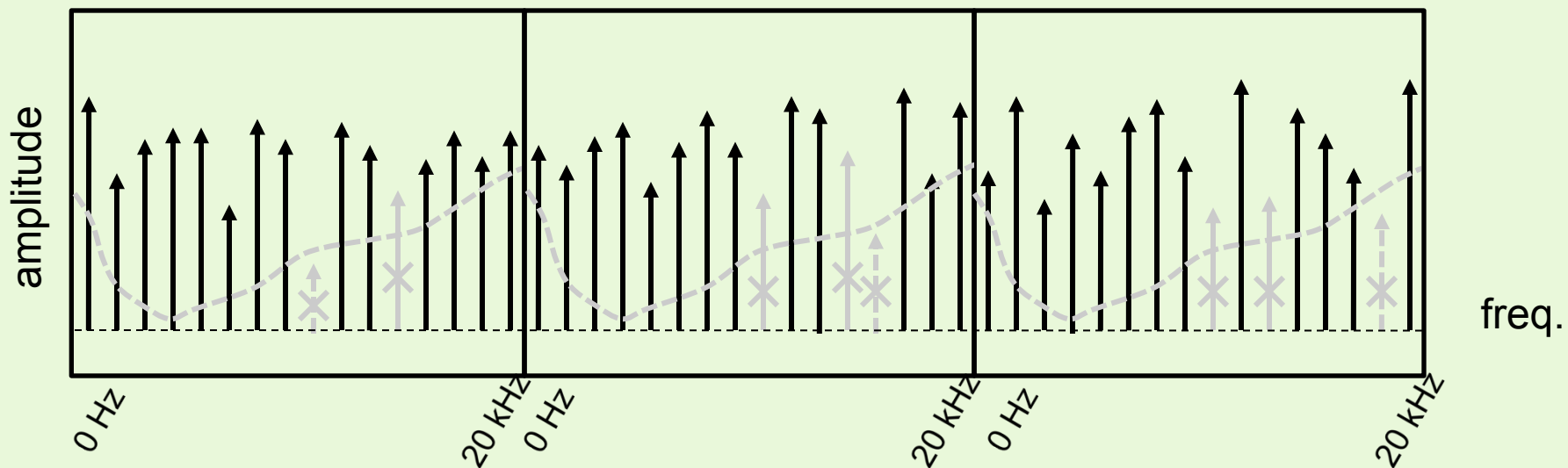
- Remove signals that cannot be heard  
*Frequency Masking*



# MP3 Compression

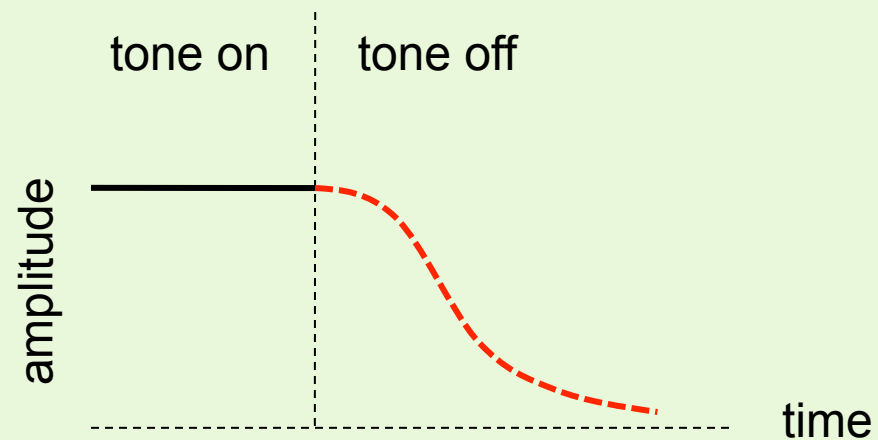


- Remove signals that cannot be heard  
*Frequency Masking*



# MP3 Compression

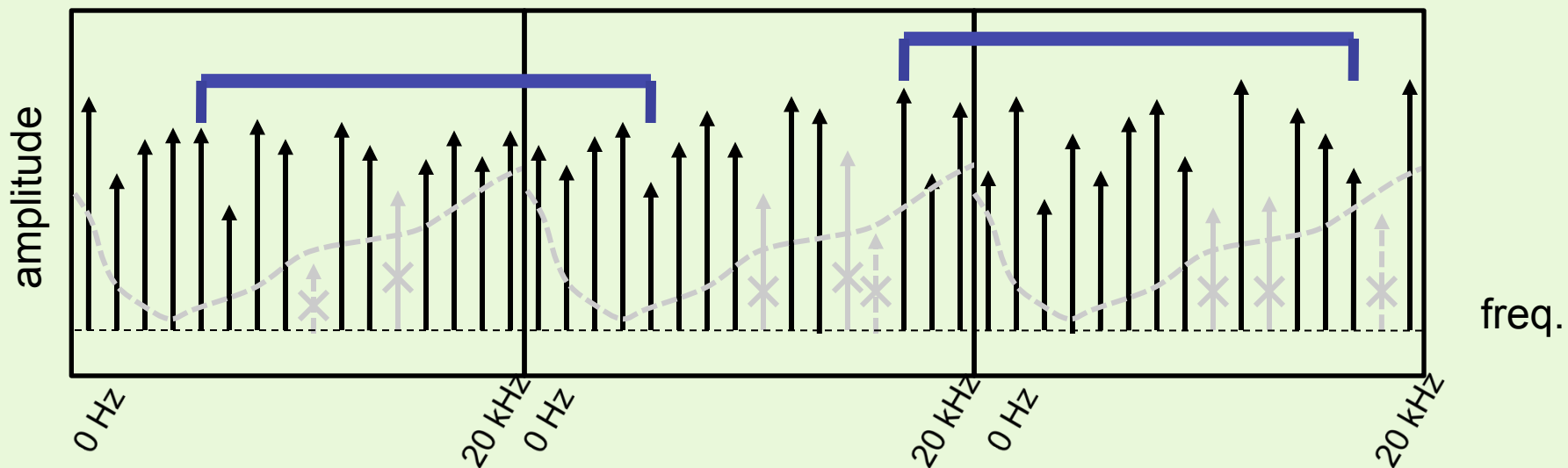
- Remove signals that cannot be heard  
*Temporal Masking*



# MP3 Compression



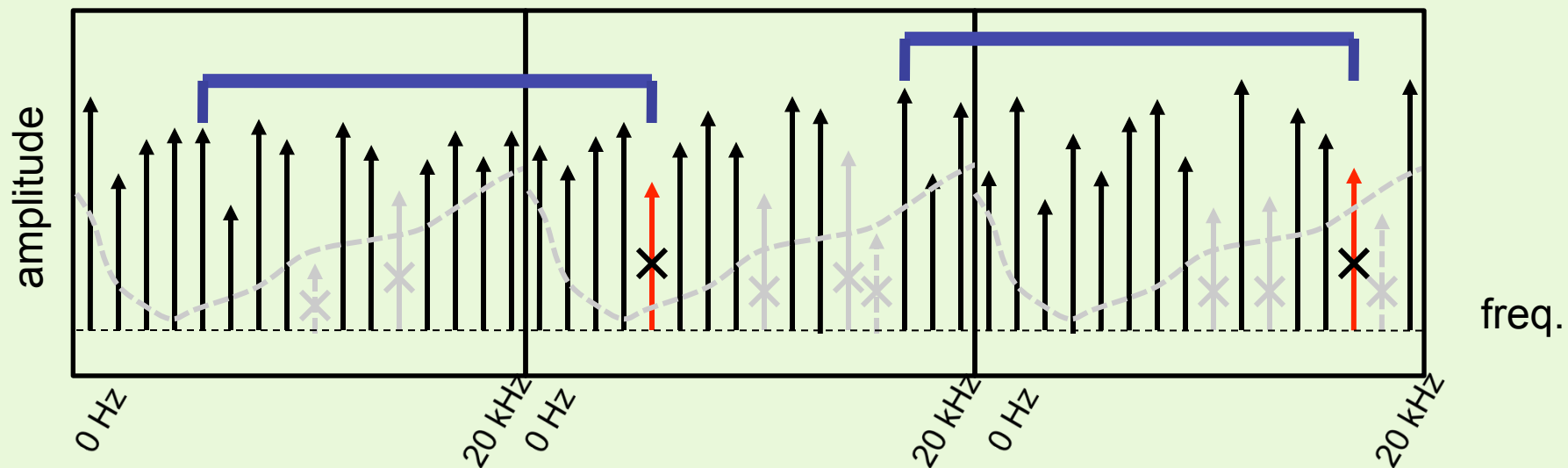
- Remove signals that cannot be heard  
*Temporal Masking*





# MP3 Compression

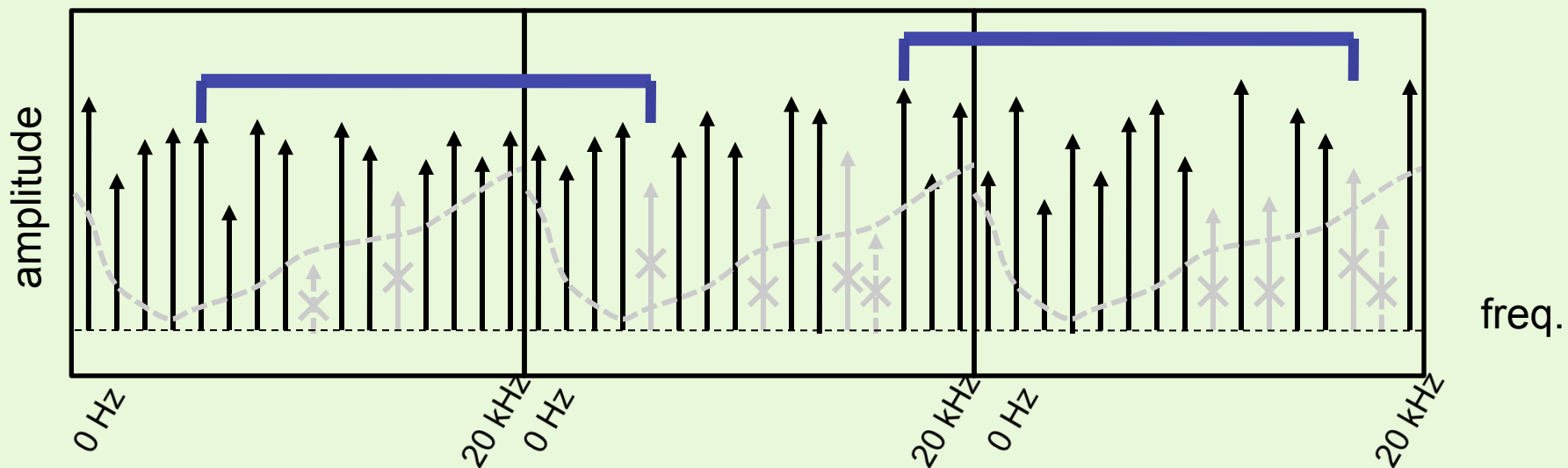
- Remove signals that cannot be heard  
*Temporal Masking*



# MP3 Compression



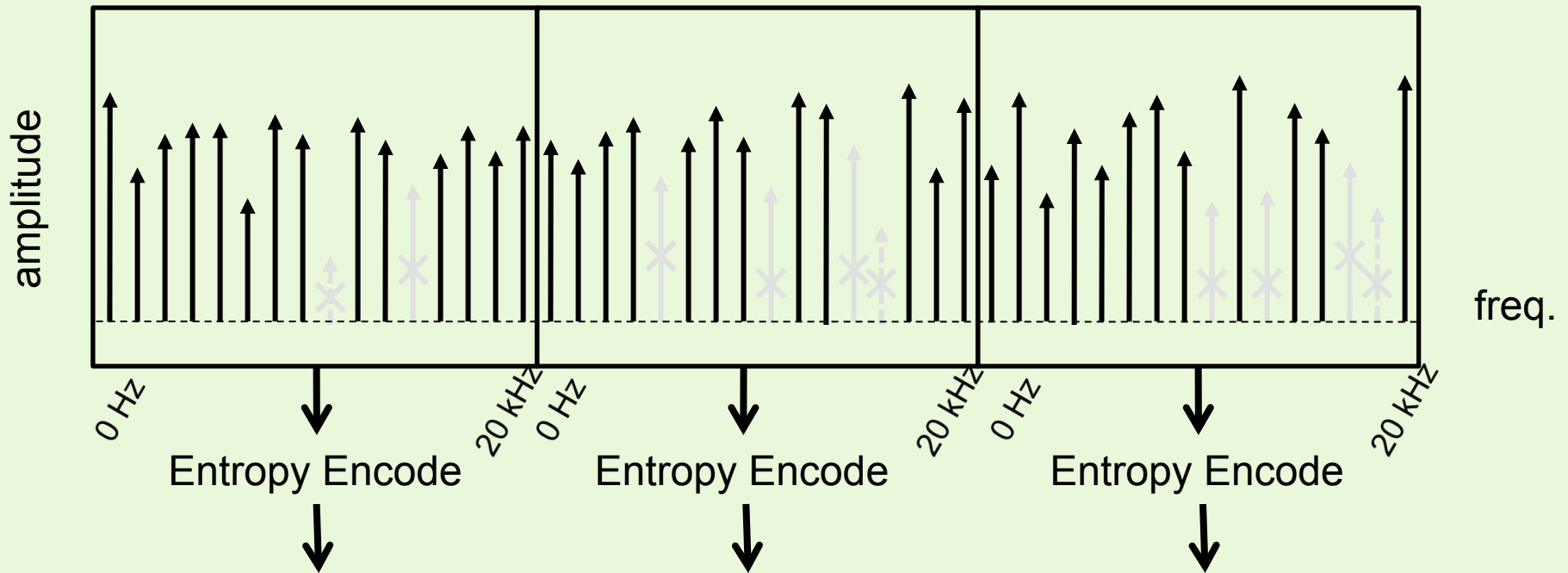
- Remove signals that cannot be heard  
*Temporal Masking*



# MP3 Compression

## □ Entropy Encoding

- ❖ Employ standard *Lossless* compression on remaining signal



00010001011101001100101010010100100101010010101000101010010111010010011101011101010110101010001011001...

# Summary



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- **MP3 compression yields 10:1 compression fairly easily**
  - ❖ Uses frequency domain transform of data
  - ❖ Removes signals we cannot hear to minimize perceptual loss
  - ❖ Employs entropy encoding on remaining frequency data
  
- **Interested?**
  - ❖ Fall Quarters – Introduction to Multimedia Networking



# My Words of Wisdom



- **3 deep stack maximum**
  - ❖ Organize so that the audience only needs to keep track of two to three things at a time
  - ❖ Need to summarize and finish each section to allow audience to “pop” it off of their stack
  
- **Just because you know it doesn’t mean it has to go in the presentation**
  - ❖ Pitch presentation at right level of audience and for the right length of time
  
- **Never go over time**
  - ❖ Be mindful of where you are in your talk at all times
  - ❖ Know how to adjust / drop information from you talk
  - ❖ Just because you practiced it in 40 minutes does not mean it will be delivered in 40 minutes.



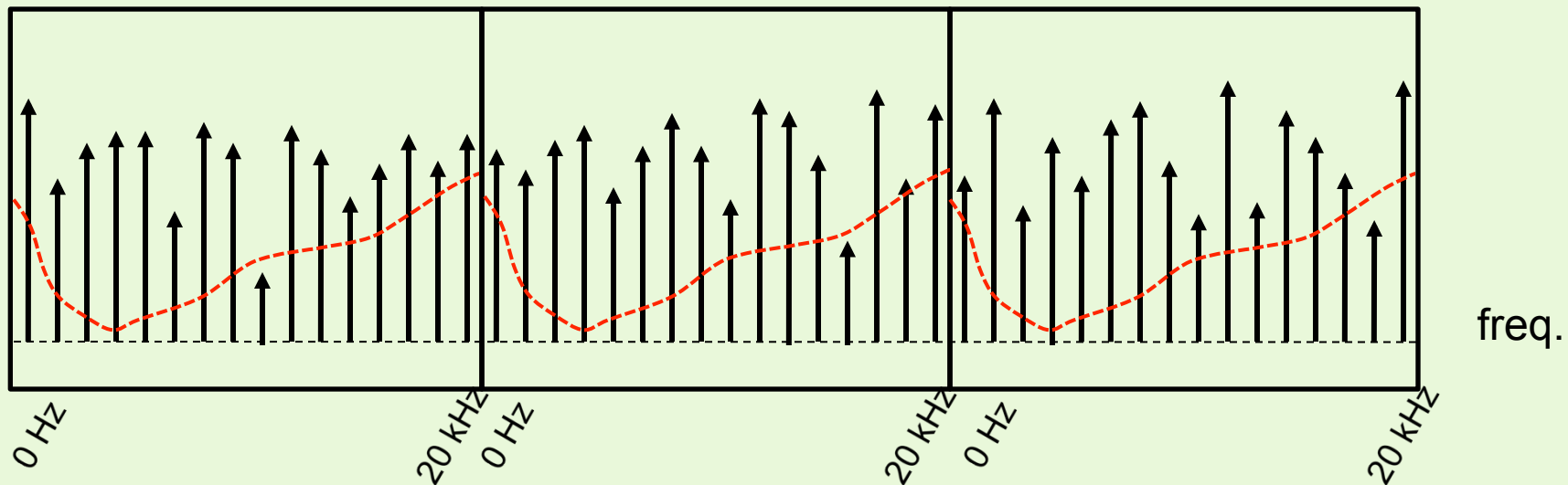




# MP3 Compression



- Remove signals that cannot be heard  
*Threshold of Quiet*



# MP3 Compression



- Remove signals that cannot be heard  
*Threshold of Quiet*

