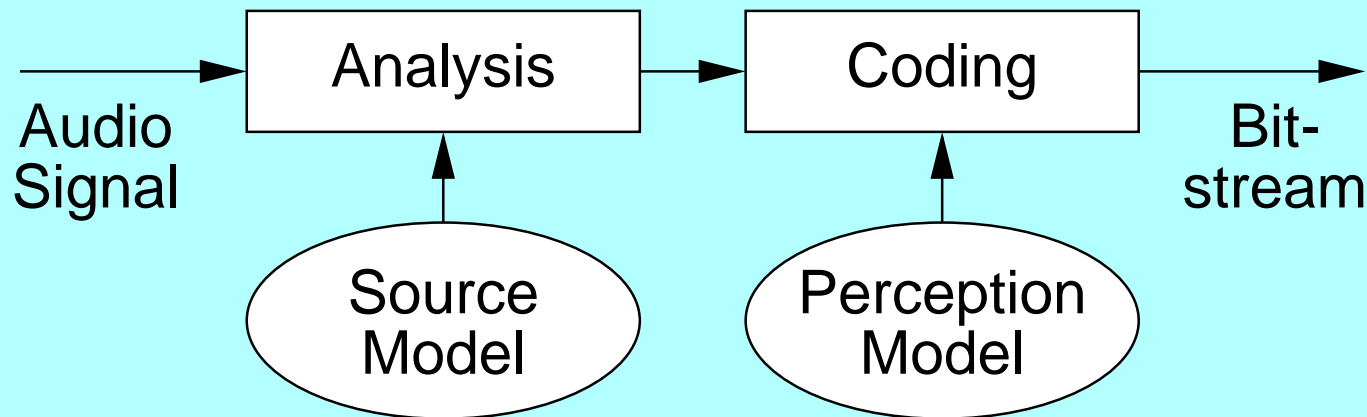# Perceptual Audio Coders –
# What to listen for:

# *Artifacts of Parametric Coding*

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# Introduction:  Parametric Coding



**Established coding techniques:**

- Speech coding:  Excitation + Resonances (CELP)
  $\Rightarrow$ source model extensively exploited

- Audio coding:  Spectral Decomposition (MPEG-1/2)
  $\Rightarrow$ perception model extensively exploited

$\Rightarrow$ waveform coding techniques

# Introduction:  Parametric Coding

## What is Parametric Audio Coding?

- Idea:  use "abstract" representation of audio signals (*musical score is more compact than waveform*)

  - decompose input signal into components
  - select appropriate source models for components
  - describe components by model parameters
  - use perception models to pick relevant compon.s

  $\Rightarrow$ attractive for very low bitrate coding

- <u>Sound</u> represented by model parameters
  $\Rightarrow$ <u>waveform</u> approximation not necessary

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# Introduction:  Parametric Coding

**Examples of Parametric Coders:**

- Sinusoidal coding

$$\hat{x}(t) = \sum_{i=1}^{N} a_i(t) \cdot \sin(\varphi_i + 2\pi \int_0^t f_i(\tau)\, d\tau)$$

- Extentions to sinusoidal coding:  +noise, +transients

- MPEG-4 HVXC (parametric speech coder)

- MPEG-4 HILN (parametric audio coder)

- Q-Design QDMC (?)

$\Rightarrow$ various approaches, ongoing development

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# Introduction:  Coder Example

**Example: MPEG-4 Parametric Audio Coder HILN**

("<u>H</u>armonic and <u>I</u>ndividual <u>L</u>ines plus <u>N</u>oise")

**Component models and parameters in HILN:**

*harmonic lines:*    fundamental freq. & LPC spectrum
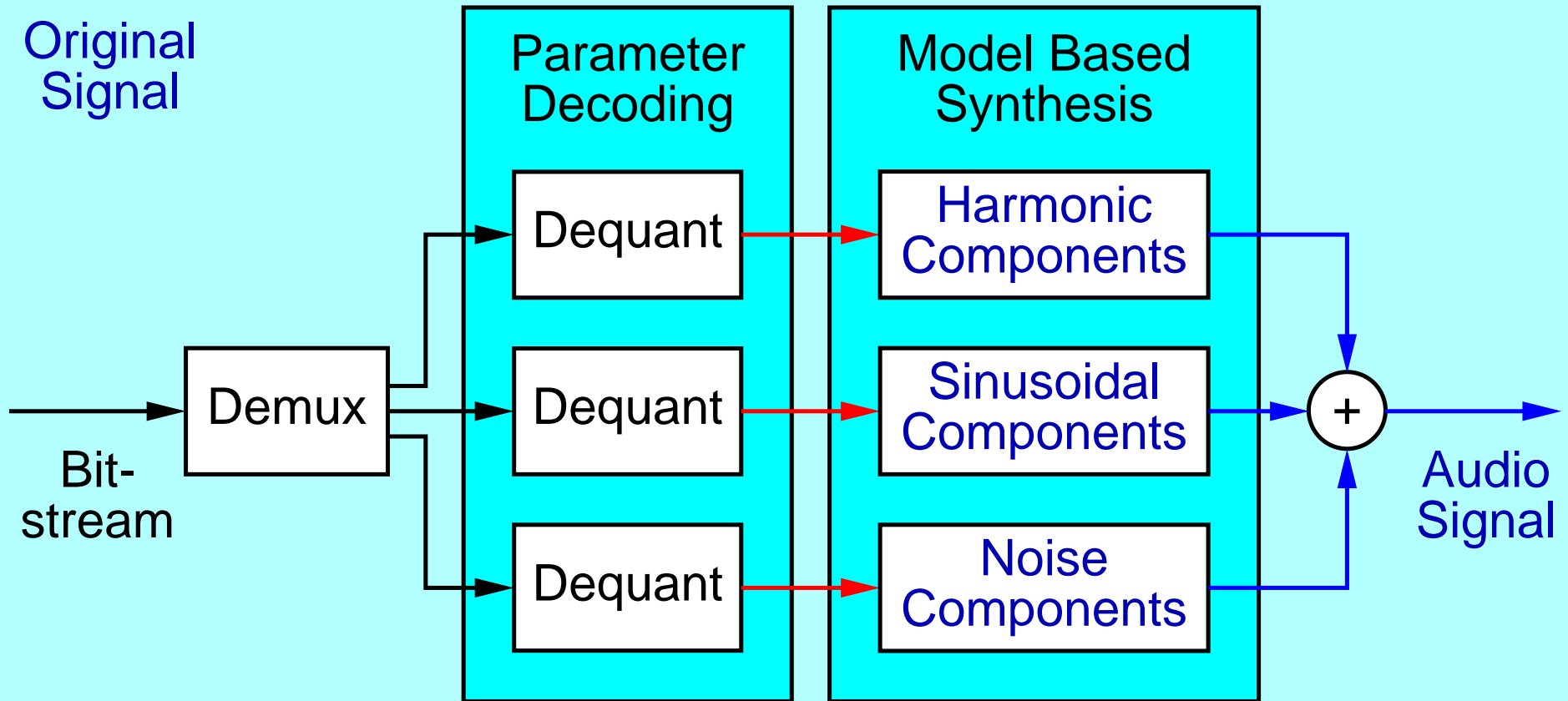
*individual lines:*    frequency & amplitude

[opt.: ampl. envelope, start phase]

*noise:*    LPC spectrum

Note:    non-deterministic decoder behaviour

(noise generator, random start phases)

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# Introduction:  Coder Example

## Example:  MPEG-4 HILN @ 6 kbit/s ($f_s$ = 16 kHz)



**Block diagram of HILN decoder**

# Potential Parametric Coding Artifacts

**Potential artifacts related to source models:**

- limitations of source models

- bad decomposition (hard decisions are problematic)

- bad parameter estimation

**Potential artifacts related to perception models:**

- quantisation (consider "just noticeable differences")

- selection of most relevant components

- is phase information irrelevant?
  (transients, clipping in sinusoidal synthesiser)

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# Examples of Artifacts

- Parametric coding:  no waveform approximation
  $\Rightarrow$ difference signal meaningless

  - original:  pop music
  - coded by parametric audio coder
  - difference signal (original-coded)

- Limitations of source models:
  model noise with sinusoids (e.g. applause)

  - original:  white noise
  - coded using 0 to 120 sinusoids

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# Examples of Artifacts

- Limitations of source models:
  no model for transient (percussive) components

  - original:  castanets
  - coded using sinusoids + noise
  - same, but with amplitude envelopes enabled

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# Examples of Artifacts

- Limitations of source models:
  specialised speech model not suitable for music

  – original:  speech
  – coded by parametric speech coder
  – original:  pop music
  – coded by parametric speech coder

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# Examples of Artifacts

- Bad signal decomposition:
many sinusoids forced on harmonic grid

  – original:  orchestral music
  – coded (harmonic component too strong)

- Bad signal decomposition:
many tonal components modelled as noise

  – original:  pop music
  – coded (noise component too strong)

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# Summary & Outlook

## Summary:  Parametric Coding

- attractive for very low bitrate audio coding

- new types of artifacts (sounds "synthetic" ?)

- more chances for "unlucky" decisions in encoder

## Outlook:  ongoing development

- parametric coding is still a young technique

- encoders will improve . . .

- parametric encoding = "auditory scene analysis" ?

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# further reading ...

- ## Parametric Audio Coding Bibliography

  `http://www.tnt.uni-hannover.de/~purnhage/`

- ## MPEG Audio Web Page
  (tutorials, test reports, etc.)

  `http://www.tnt.uni-hannover.de/project/mpeg/audio/`

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