

-- International Training Course in EEPIS --

Information can be "information"
if and only if human can use.

- Audible sound and inaudible sound -

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Introduction (1/3)

- Computer can process information very well.
- However, can computer think?
 - In some extent, I think YES. But, in some extent!
- By the way, WHAT IS INFORMATION?
- If there are too many information, is it still INFORMATION for us?
- I would like to say NO!

Introduction (2/3)

- Do you agree with me about the following passage?

INFORMATION can be "INFORMATION"
if and only if
it is acceptable to human being.

<<Not only Quality but also Quantity>>

- This is why we, computer scientists and engineers,
need to understand the human beings.

Introduction (3/3)

- Why sound?

- It is very important to us.

- Spoken language : Speech

- Without speech sound, acquisition of language becomes very hard.

- How about other sound?

- Without sound, we can not be feel fine.
 - ▷ fear, scare, uneasiness, etc.
 - Too much sound, we can be stressed.
 - ▷ noise pollution such as sound of automobile, KARAOKE, airplane.

- Definition of NOISE is relative.

What is the sound?

Sound is the very small fluctuation of air pressure.

- Air pressure : 101,300 [Pa]
- Smallest sound which we can hear : 20[μ Pa]
==> Ratio is 500,000,000 times!
- Maximum sound which we can hear : 20[Pa]
==> Ratio is 1,000,000 times!
= 120dB (ref. 20 μ Pa)

If we figure out in distance, they can be written as
1m VS 1,000km.

Can we hear any kind of sound ?

Answer is << NO! >>

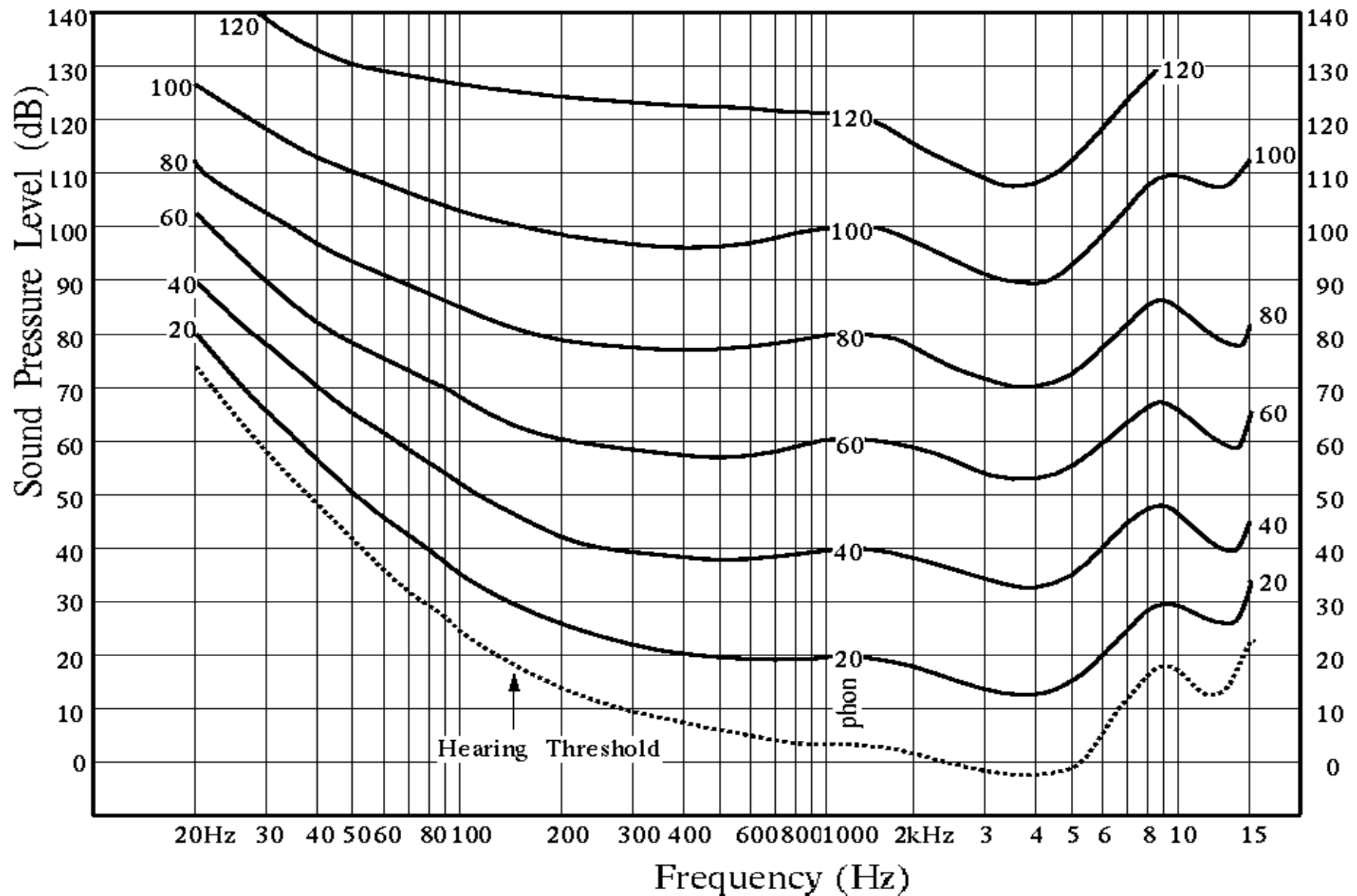
Very small sound can not be heard.

We have a pain when we hear too large sound.

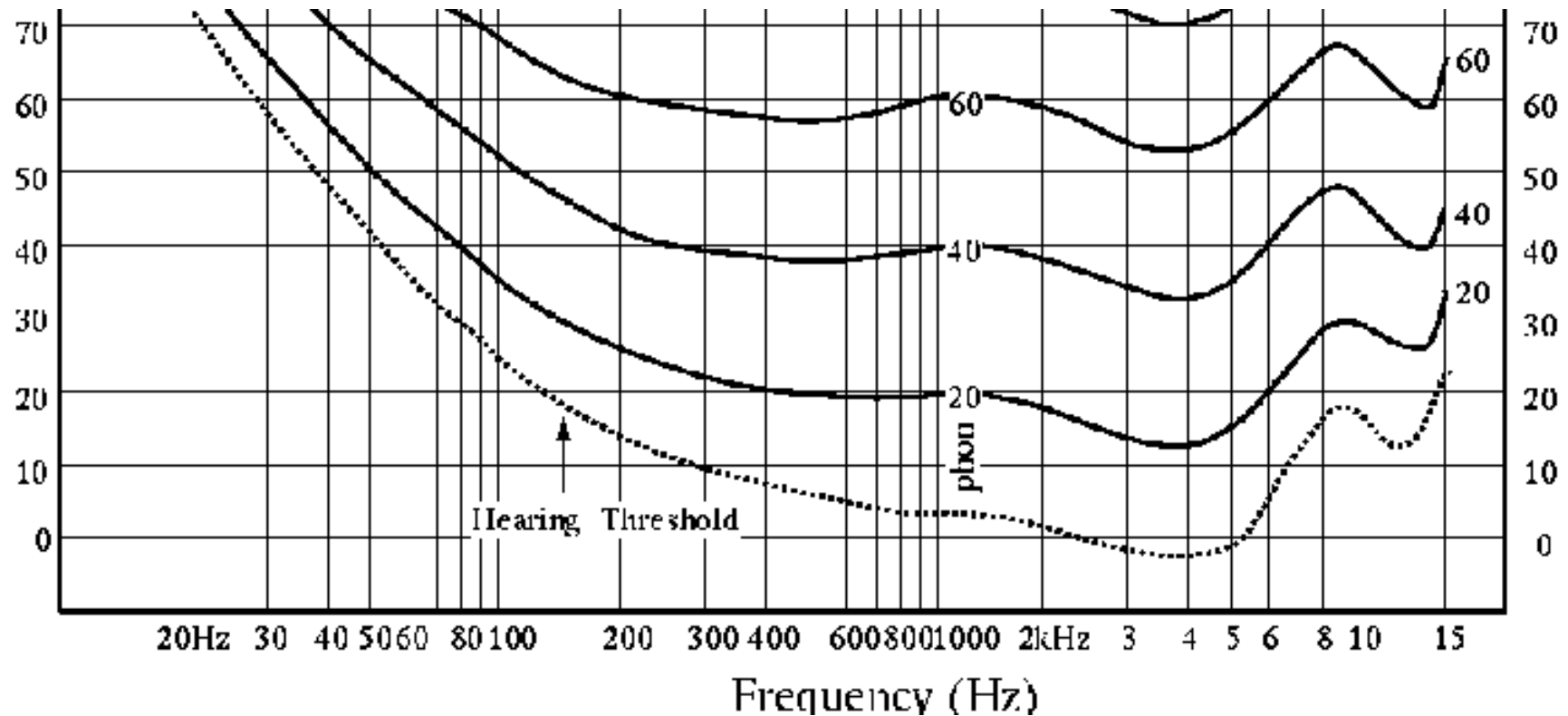
- Level of audible sound has obvious limits.
 - You can not hear very small sound.
 - You can feel very large sound, but it can not be a sound at all.
Just pain!
 - Limits depnd on frequency.

- Also, there are obvious limit in audible frequency.

What kind of sound we can hear?



Can you hear the small sound?



I will present the same tone whos level decreases step by step.

Would you try to count how many tone can you hear out of 12 repetivition.

When you watching TV with loud sound, you got a phone call.

- ☐ Have you ever have an experience such as
 - delay to notice the bell rang,
 - difficulty to hear the voice from other side.
- ☐ This phenomenon is called "Masking Phenomenon" because a loud sound hides a soft sound.
- ☐ This phenomenon occurs only on for simultaneous sounds but also temporally separated sounds .

Let's experience the masking phenomenon.

- You would hear the pair of sound;
 - 1) 1011Hz pure tone
 - 2) Mixture of 1011Hz + "F" Hz tone
Level of "F" Hz tone decreases step by step.
- Please count the number of pairs which you can hear as a "Pair."

We are listening only "loud" portion of sound.

- When we are listening a music, we can listening only part of sound.

- CD (Compact Disk) records all the information, but ...
 - we can not PERCEPT all of the sound reproduced.
==> If so, why do we need to record every thing?

- Following scheme uses on this phenomena;
 - MD (Mini-Disc) 1/4 of CD
 - MP3 (MPEG1/Layer3) 1/4~1/8
 - AAC (Satellite Broadcasting in Japan) 1/8~1/10

What is the required specification for Audio?

□ PCM coding used for CD:

- Quantization Resolution : 16bits

Dynamic range covers 96dB.

- Sampling Frequency : 44.1/48kHz

Effective frequency range is 20kHz.

□ Comparison with Audible range:

- Dynamic range is more than 120dB at 1kHz.

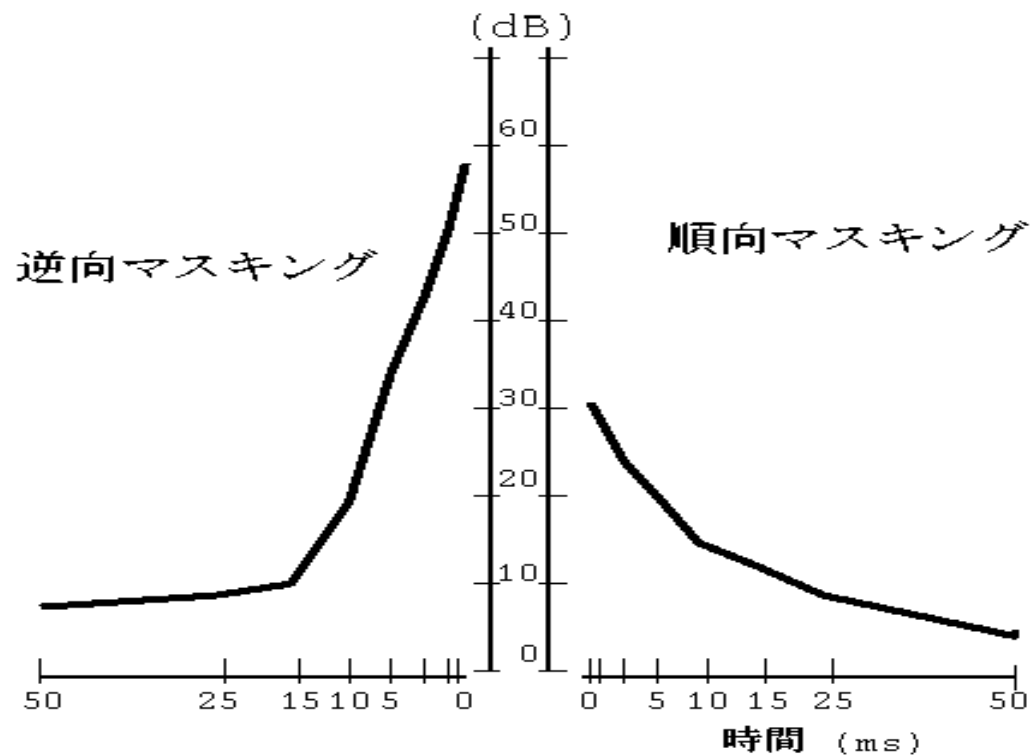
Needs 20 bits.

- Dynamic range at low and high frequency range is narrower.

less than 90dB at 60Hz $\Rightarrow$ 15 bit is sufficient.

If we can estimate the amount of masking,
we can make better coding scheme.

Temporal masking of pure tone by broadband noise

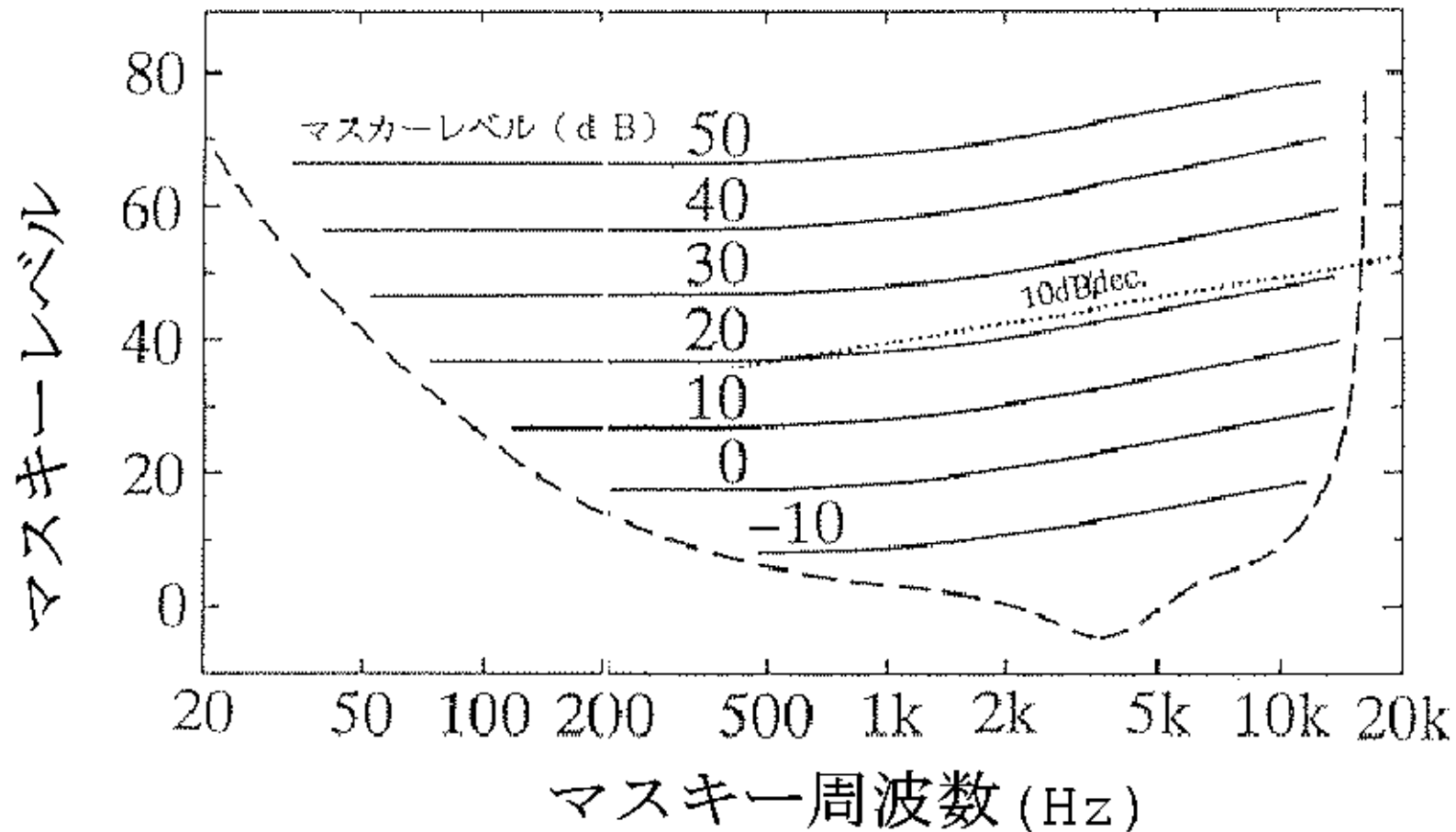


This figure shows the results of psychoacoustical experiments on pure tone masking by white noise.

White noise : 90dB SPL, duration = 50ms

Tone : 1kHz, duration = 5ms

Level Dependency of Masking



Masking pure tone by broadband noise whose level varied from -10dB to +50dB. (Dotted line shows the threshold of hearing.)

Ordinate : Sound Pressure Level

Abcissa : Frequency of pure tone

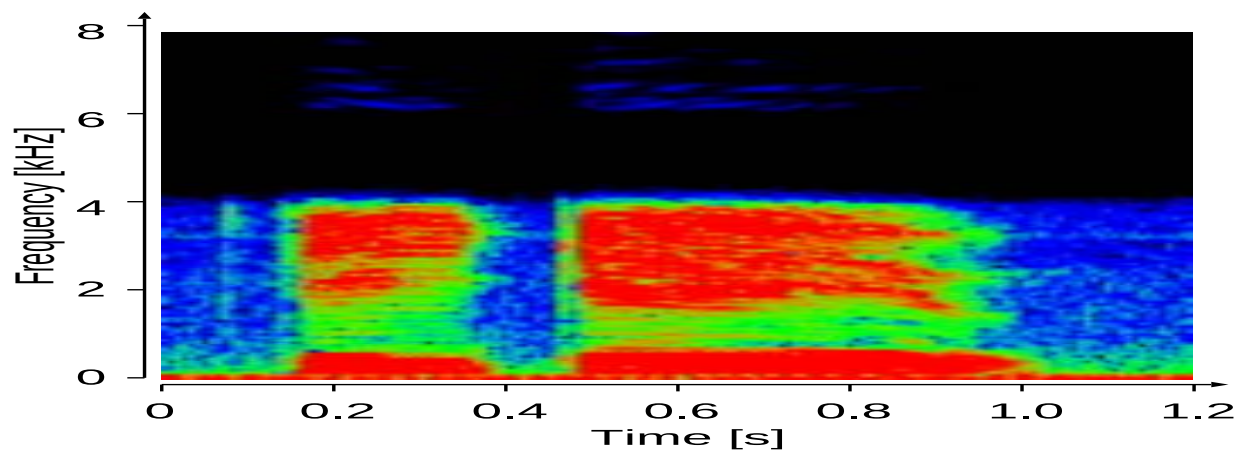
Energy Summation on Masking Phenomenon

- Amount of Masking:
 - Flat when $f \leq 500\text{Hz}$
 - Increase 10dB / decade when $f > 500\text{Hz}$.

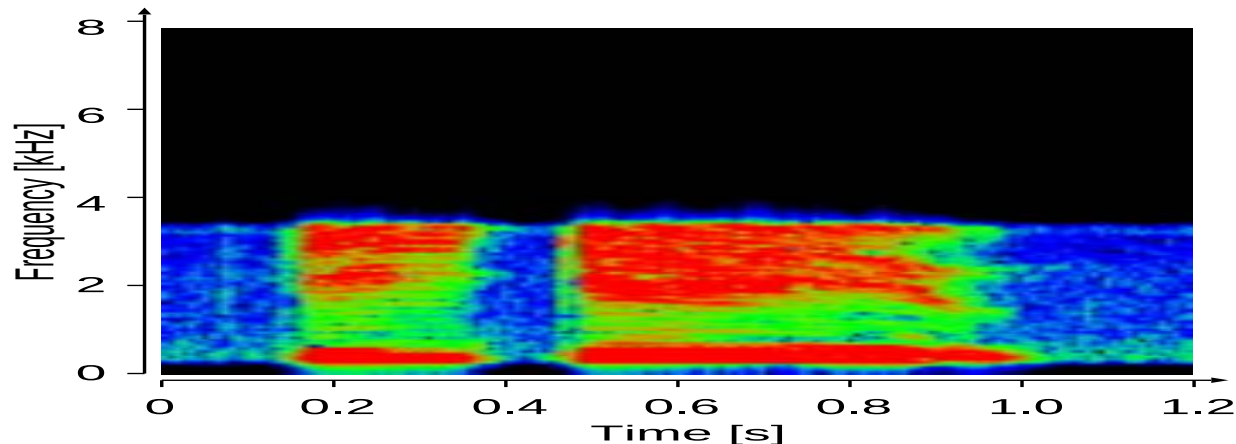
- Energy of Masking is accumulated over certain range of frequency.
 - Band width is constant where $f \leq 500\text{Hz}$, but increase where $f > 500\text{Hz}$.
 - This band is called as CRITICAL BAND.

According the catalogs of those kind of data, we can build a Psychoacoustic Model on a computer and utilize it for coding scheme.

Estimation by psychoacoustic model (#1-1)

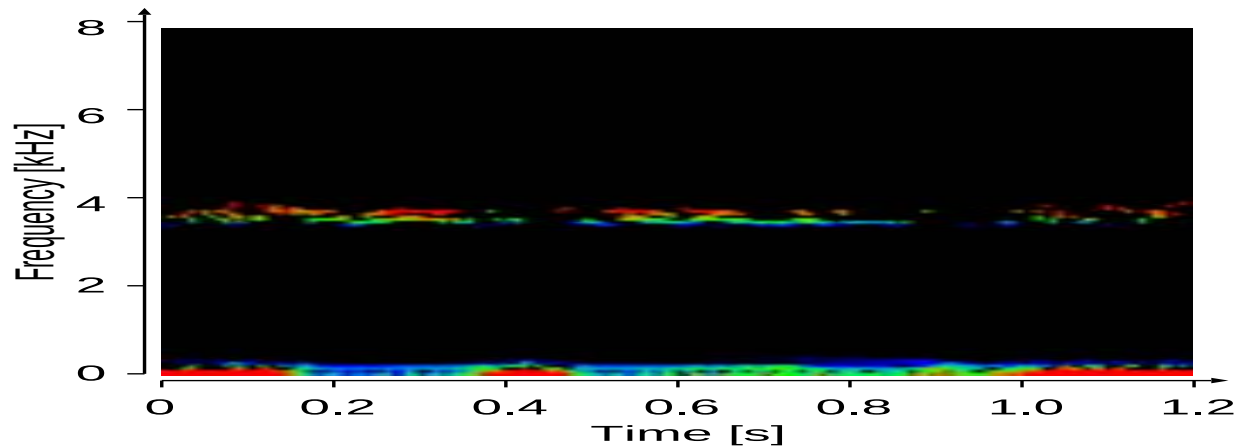


Original Speech Signal Spectrum (/tee-kei-yu/)

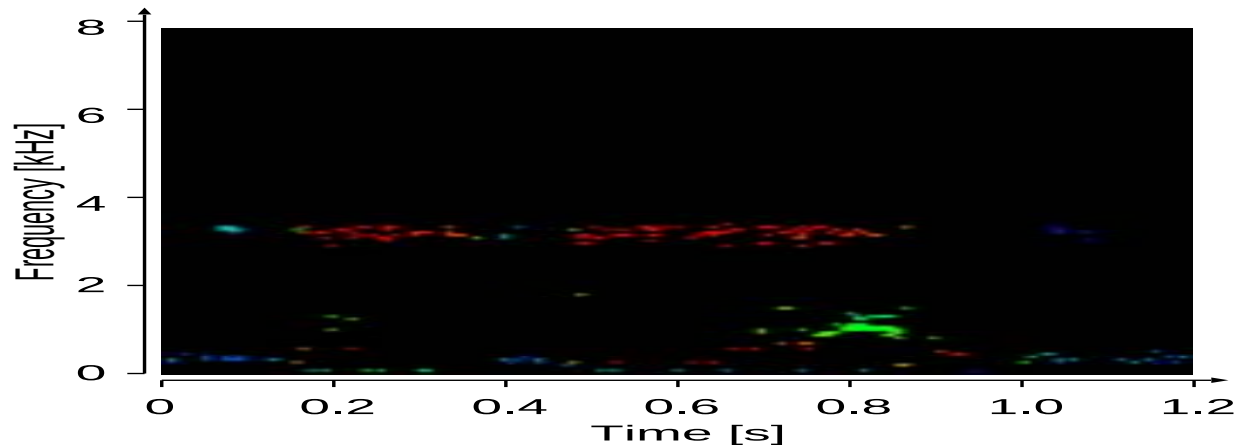


Band limited Speech Signal Spectrum (/tee-kei-yu/)
(300Hz - 3500Hz for phone)

Result of Estimation by model (#1-2)

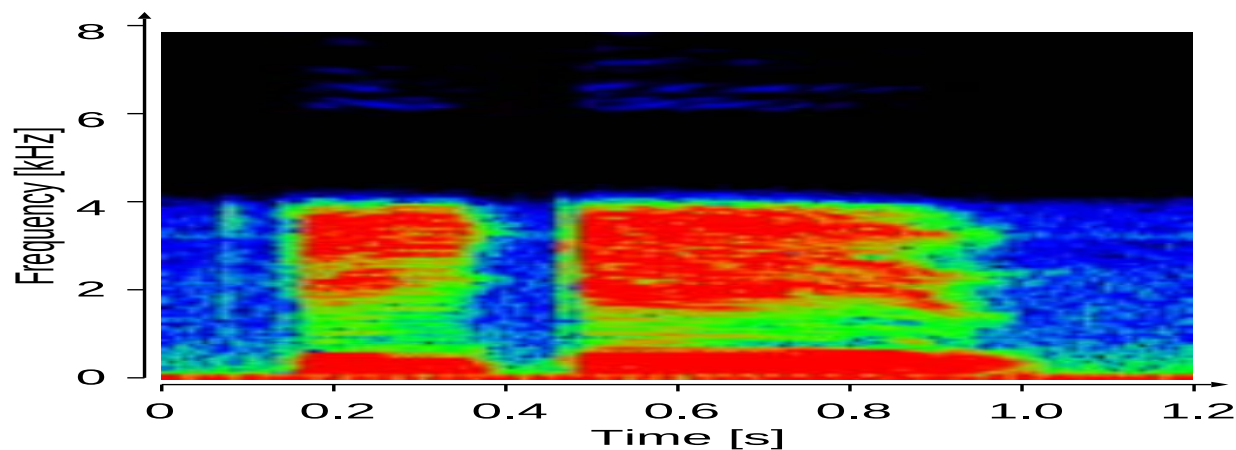


Estimated Portion which can be detected as DISTORTION.

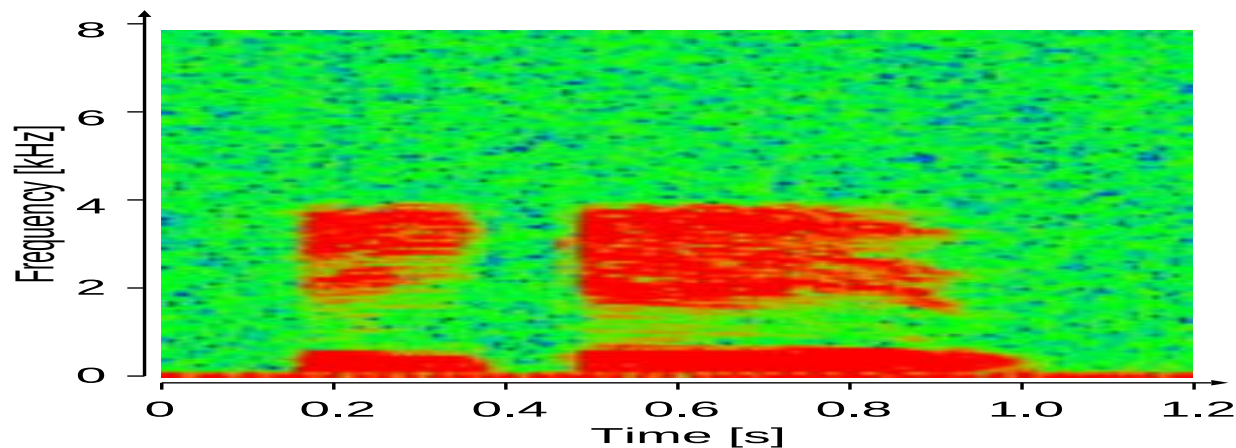


Estimated Portion which can be perceived as NOISE.

Estimation by psychoacoustic model (#2-1)

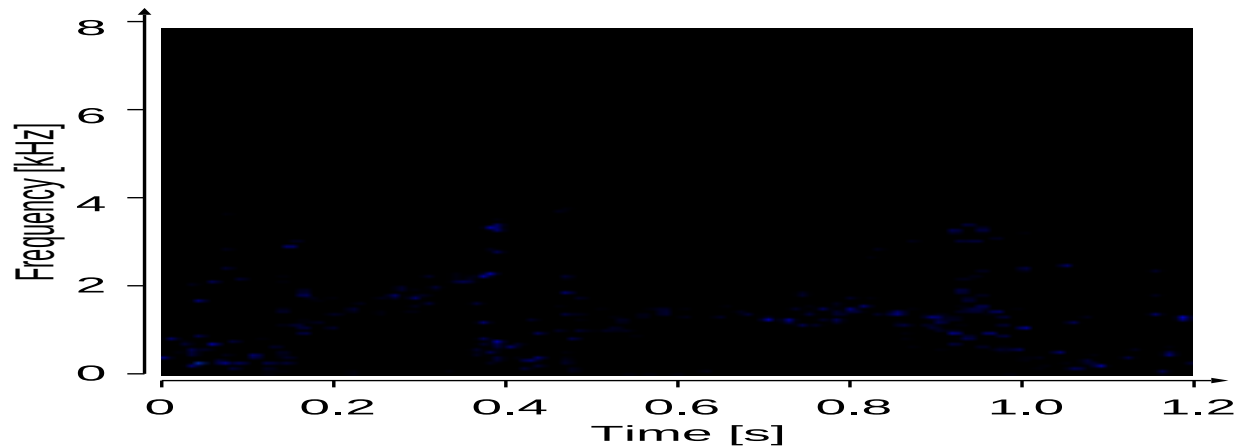


Original Speech Signal Spectrum (/tee-kei-yu/)

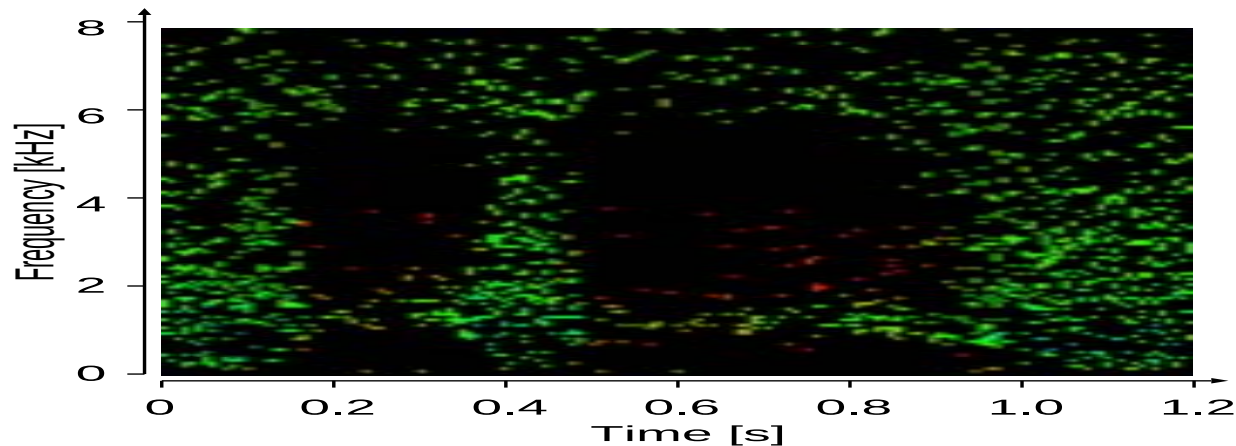


Spectrum of Speech Signal within a broadband noise

Result of Estimation by model (#2-2)



Estimated Portion which can be detected as DISTORTION.



Estimated Portion which can be perceived as NOISE.

Redundancy of Signal and Coding Scheme

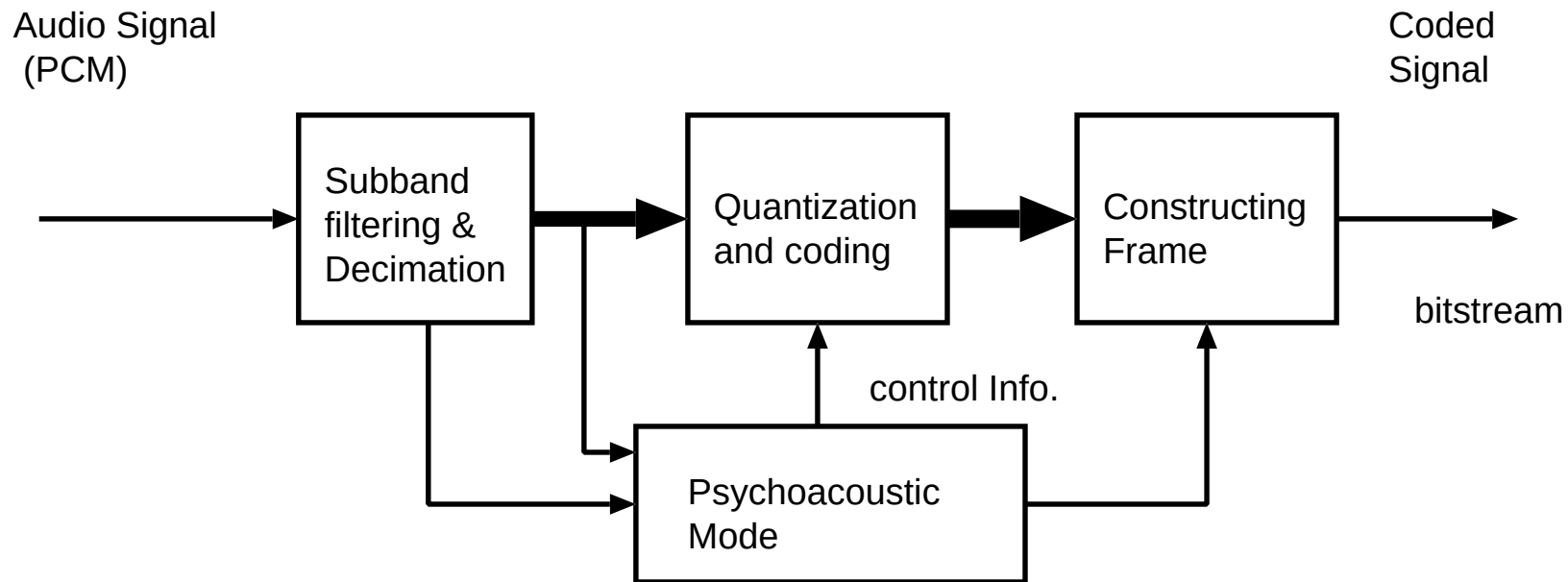
- Signal which is not necessary to be coded:
 - Signal whose level is less than the THRESHOLD.
 - Signal which is masked by other signal.

Also,

- Quantization noise can be as large as it can be masked by other signal.

From those tips, we can reduce "bit rate" of signal.

Coder of MPEG 1 / Audio



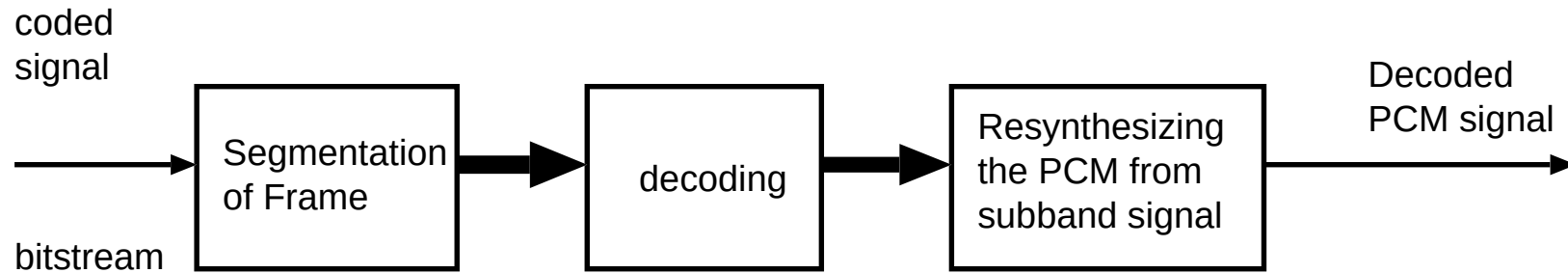
32ch subband

Threshold estimation using psychoacoustical model

Model controls the quantization and coding scheme

- Coding scheme is not standardized at all.
That the quality of coded signal is depends on the RECORDER system.

Decoder MPEG 1 / Audio



Error Correction for bit stream signal
Decoding of subband coded signal

- Decoding scheme is defined strictly in ISO standard.

The same bit streams has to be the decoded as exactly the same
PCM signal.

Concluding remarks: what is the information for you?

- Human being is the first.
- Formally, we walked to the computer side, but the computer should come close to human being!
- About Sound
 - Language and Speech : Proof of human being.
 - Music : very important for quality of life.
 - Phone : can you live without it?

Thank you very much for giving me a chance to visit EEPIS and to say hello to all of you.

Terima Kasih.

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