モノ創りの科学
第3回
アナログ vs. デジタル？

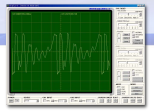
環境情報学部　高汐 一紀

Analog or Digital

- Analog: representation on a scale being proportional to the physical amounts
- Digital: quantized representation of physical quantities
- Physical world consisting of atoms
- Digital world consisting of bits

ex.
- Analog amplifier vs. Digital amplifier
- Books vs. E-books
- Analog thinking vs. ...

Analog..



- Physical quantity in nature
  - Music coming from speakers
  - Temperature, length, electrical voltage, etc.
- Application of electricity..

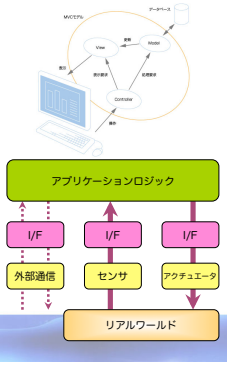
  Microphone:
  Replaces sound pressure wave in nature with homothetic electrical voltage wave..
  - Analog value as sequential waveforms
  - Impossible to measure and represent real value in finite digits
  - Using values in finite digits as approximate quantities

Digital..

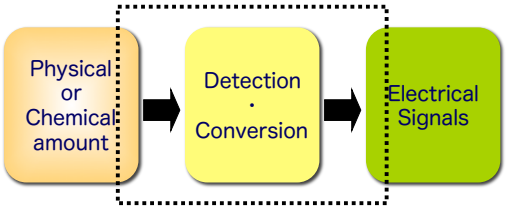
- Contingency in analog values
  - Incompatible with computers
  - Fuzziness of value for true or false
- Digital
  - Derived from the Latin “Digitus”
  - Discrete value with clear threshold
  - Robust over noise and dumping
  - Very compatible with 0/1 world in computers

Artifacts these days..

- Basic construction
  - Application logic
  - Sensors
  - Actuators
  - Communication modules
  - Interfaces for external world
- How to implement them?
  - Hardware?
  - Software?
  - with Analog?
  - with Digital?

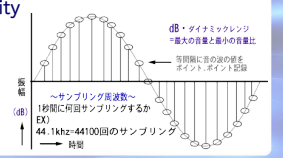


Sensors..



Analog to Digital (A/D Converting)

- Sampling
  - Decide temporal and spatial sampling point, then measure signal intensity
  - Temporally sampling → Sampling Frequency
  - Sampling error
- Quantizing
  - Approximate the signal intensity by finite discrete values
  - Quantization bit rate
  - Quantization error



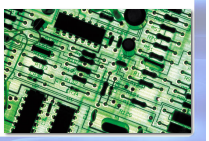
Analog and Digital.. again

- Sensory information (five senses) is analog
  - Light intensity as eyesight
  - Pressure and temperature as touch
  - Chemical amount as taste, etc.
- All information digitally processed must be converted to analog in final phase.. (D/A converting)
  - When?
  - ex. digital amplifier outputs and speakers

Analog and Digital.. again

Microscopic view of digital computers..

- Integration of logic circuits (digital circuits)
- Principles of digital circuits are the application of electronic circuits..
- That is,, the basic is Analog!!



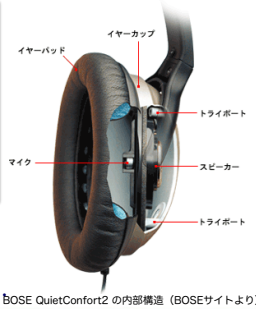
Today's Target..

- Noise-cancelling headphone

BOSE QuietComfort2

Disassembling..

http://ka10.net/blog/archives/date/2005/02/

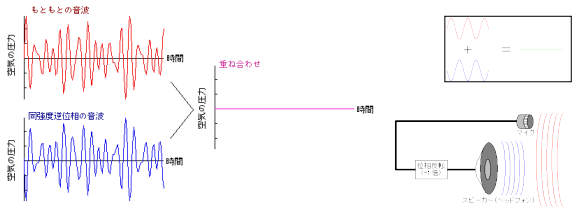


BOSE QuietConfort2 の内部構造（BOSEサイトより）

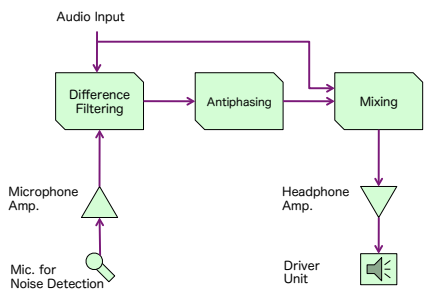
- Active noise-cancelling..
- High-density implementation..

Principles

- Very simple..
  - Sounds are waves..
  - Original waves and antiphase oscillations..



Block Diagram

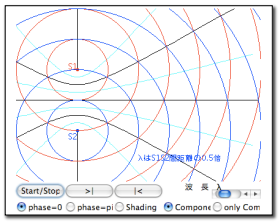


Light Experimentation

- How to verify the principles?
- Tools
  - Sine wave oscillator (PC)
  - Oscilloscope (PC)
  - Speaker x 2 (Active type)
  - Microphone

上手くいきそうだが．．

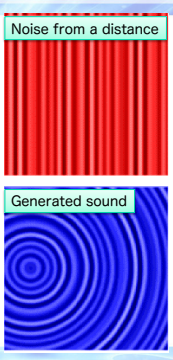
- 音源を離すと明らかに消音効果が薄れる
- なぜ？



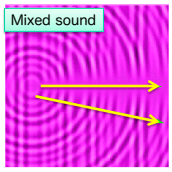
ビジュアル物理：円形波の干渉

http://www.ne.jp/asahi/tokyo/nkgw/gakusyu/hadou/kyumenha/enkeiha-new.html

Results



- Going well where both waves cancel each other.. but,
- Counterproductive in other area..

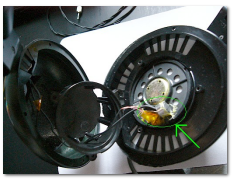


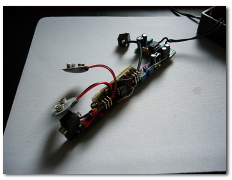
Noise cancelled

Not work well

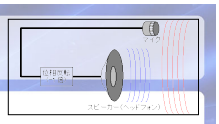
DIY of Noise Cancelling Headphone

- http://assam.cims.hokudai.ac.jp/~josch/workshop/elec/anc/anc.htm
- http://www.headwize.com/projects/noise_prj.htm

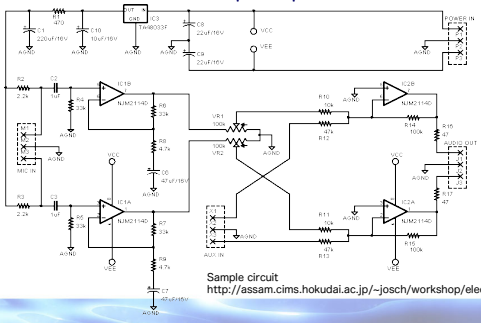




Phase Inverter Circuit



- Phase inversion with Op-Amp



Sample circuit
http://assam.cims.hokudai.ac.jp/~josch/workshop/elec/anc/anc.htm

今日の課題

1. オシロがあったら自然界の何を観察してみたい？
2. ハンディ・オシロスコープもしくは類似のソフトをインストール（オプション）
   - 内蔵のマイクで音を拾ってみる
   - ない場合はヘッドフォンをマイク端子に．．
   - 使ってみた感想（「なんじゃこりゃ？？」もアリ）

- 提出先：SFC-SFS 授業ページ
- 期限：今日中（5/24 23:59）．．