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DSP

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Electrical Engineering

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Outline

✓Continuous Time Signals

✓From Continuous Signal to Digital Signal
- Sampling
- Quantization

✓Continuous Filter vs. Digital Filter

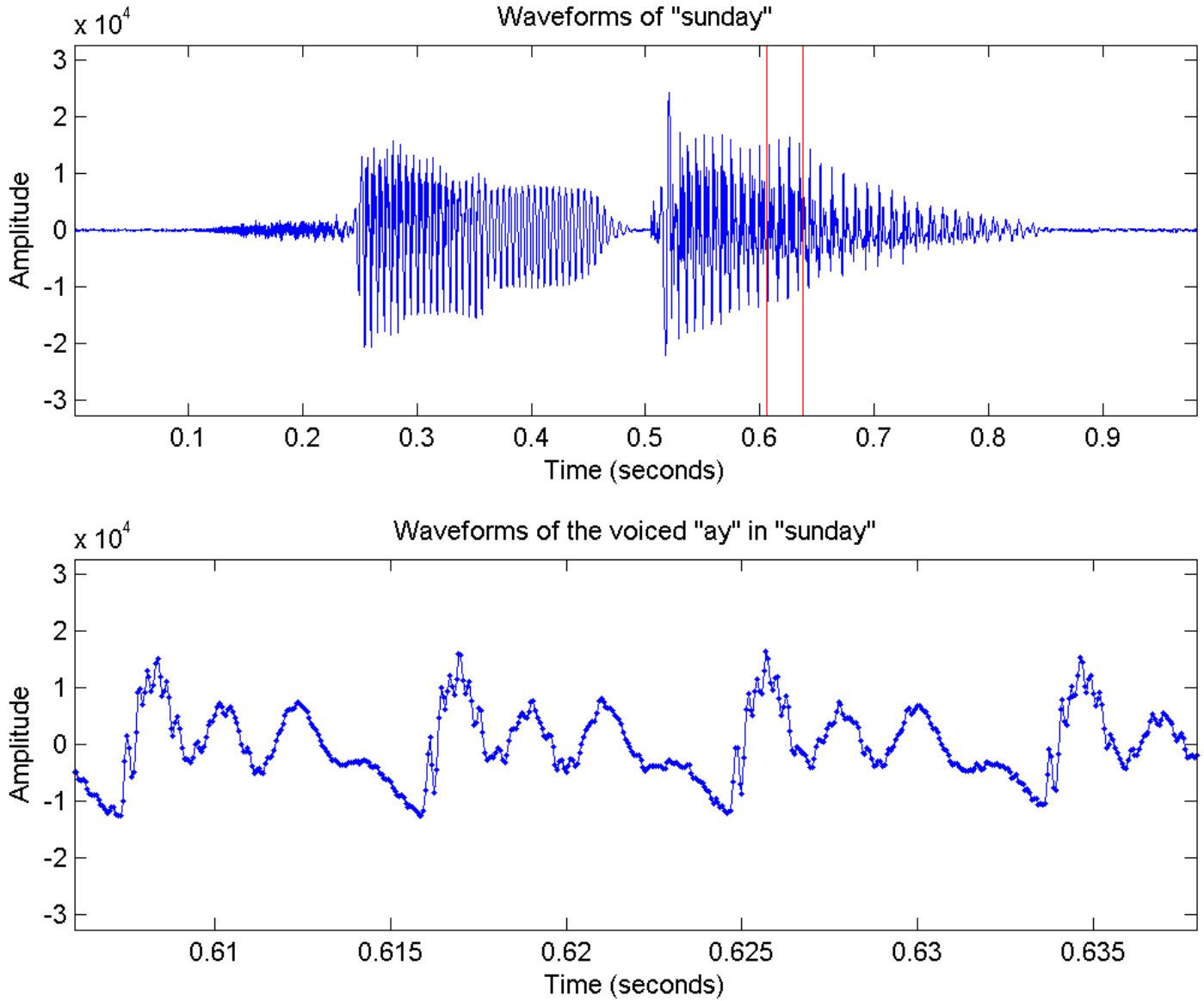
✓DSP Simulation

✓The Aliasing Phenomenon

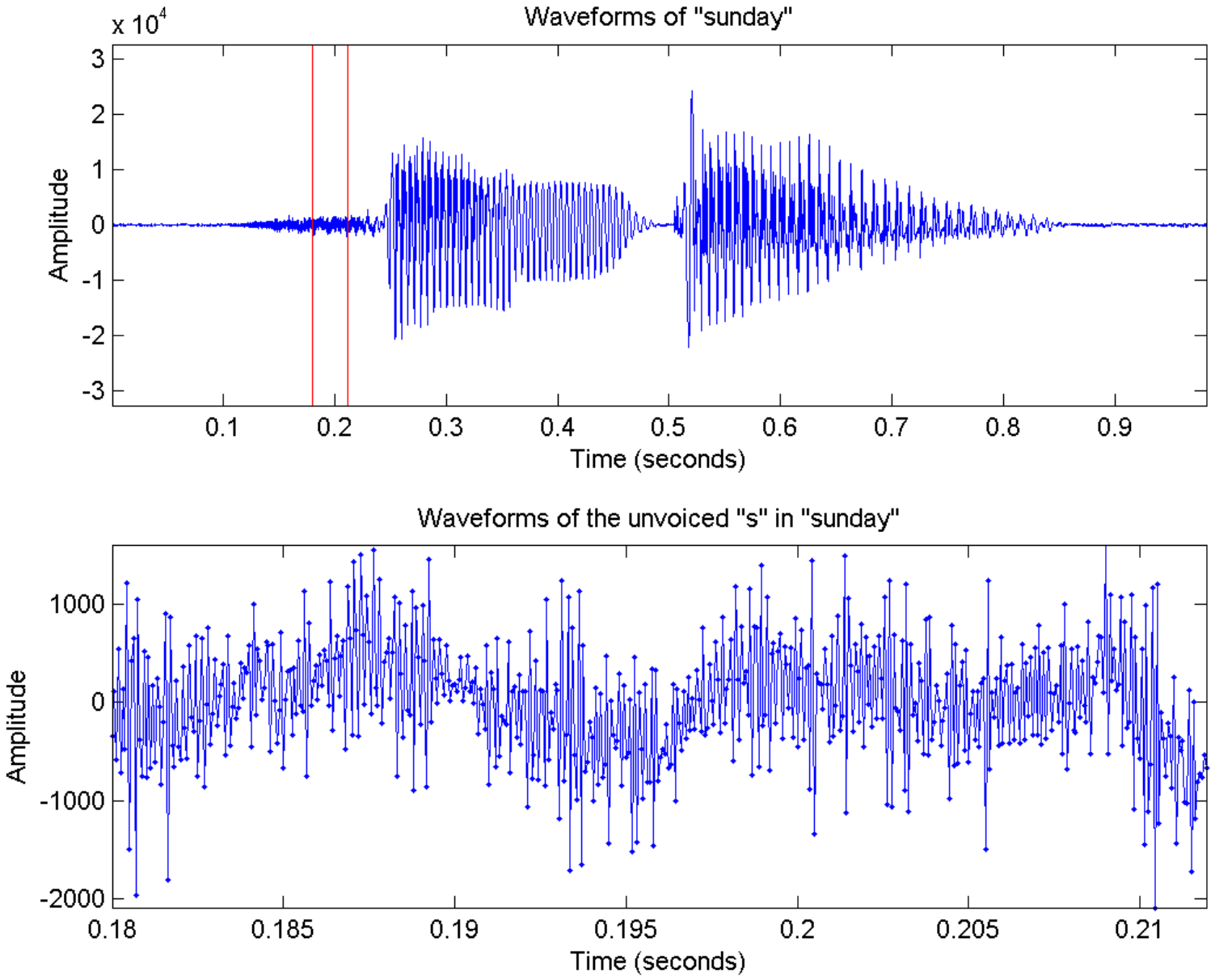
Continuous Time Signals

- Natural Signals
- Output of most sensors
  - Temperature
  - Pressure
  - Position
  - Voice
  - Audio

The voiced sound (~ vowel)

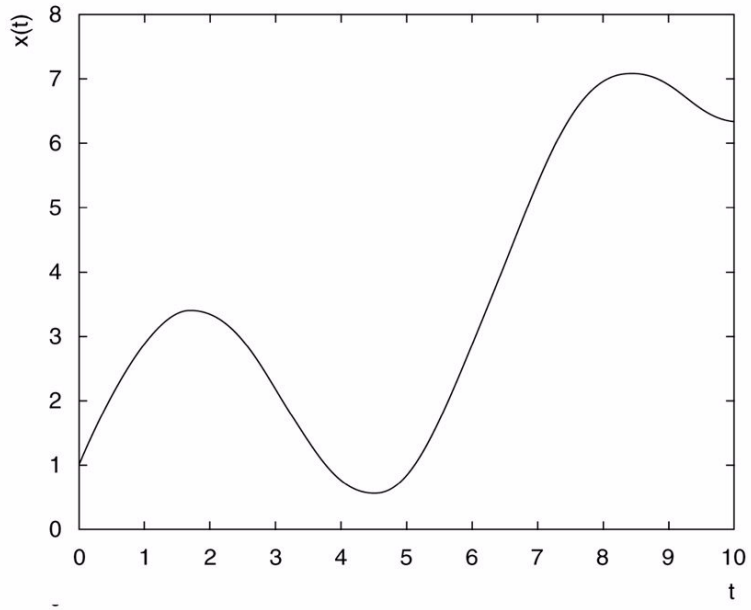


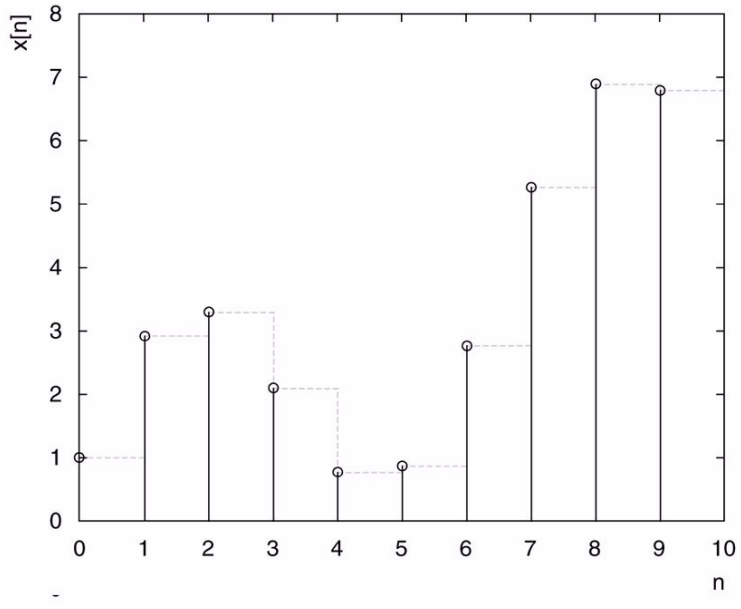
The unvoiced sound (~consonant)



From
Continuous Signal to Digital Signal

Step1: Sampling





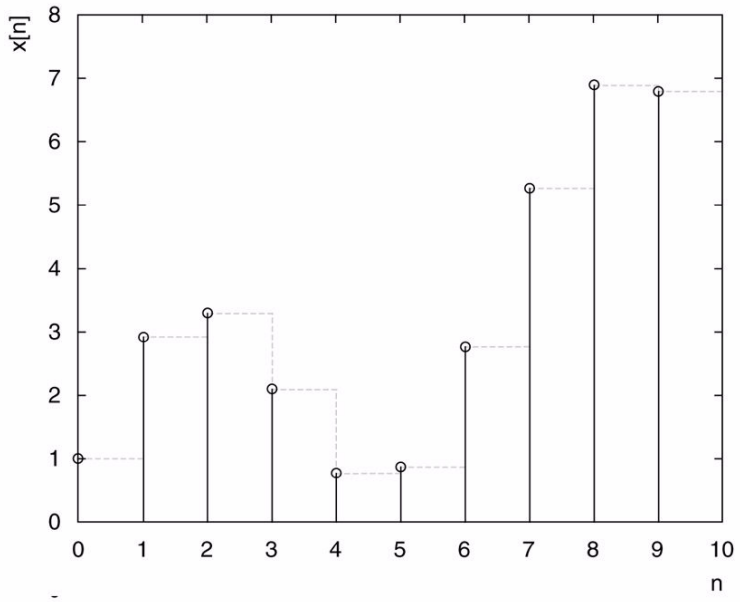
※ The important spec. : fs (sampling frequency)

ex: Digital phone: fs =8kHz (8,000 samples/sec)

CD Quality: fs=44kHz (44,000 samples/ sec)

From
Continuous Signal to Digital Signal

Step2: Quantization



Qx[0]= 0010
Qx[1]= 0110
Qx[2]= 0111
Qx[3]= 0100
Qx[4]= 0001
……

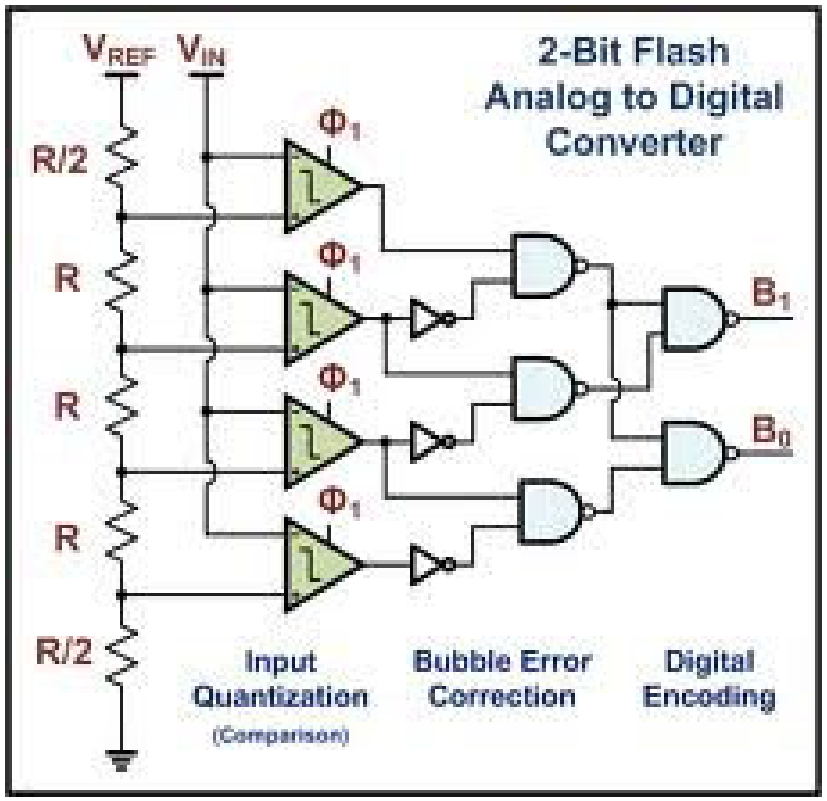
※ The important spec.: Quantization Bit Number N

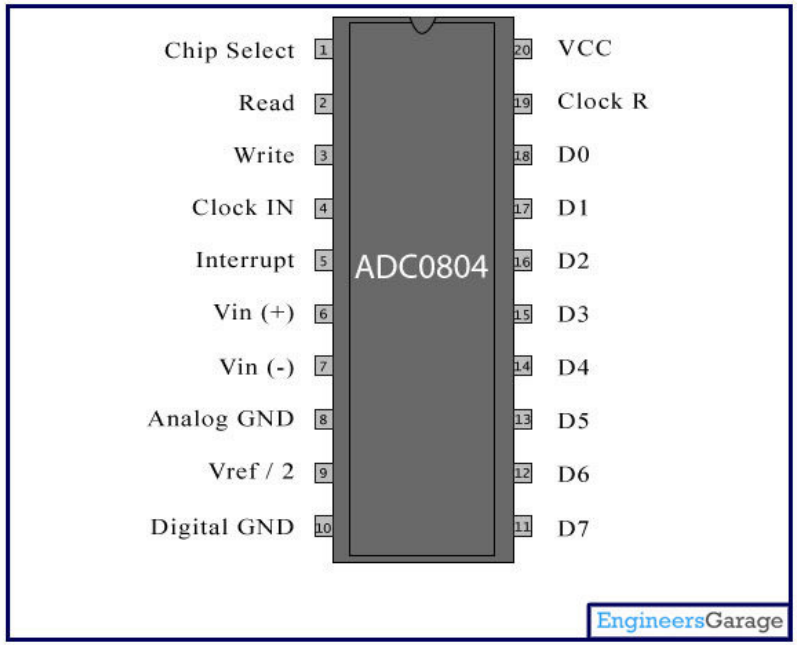
ex: Digital phone: N = 8

CD Quality: N=16

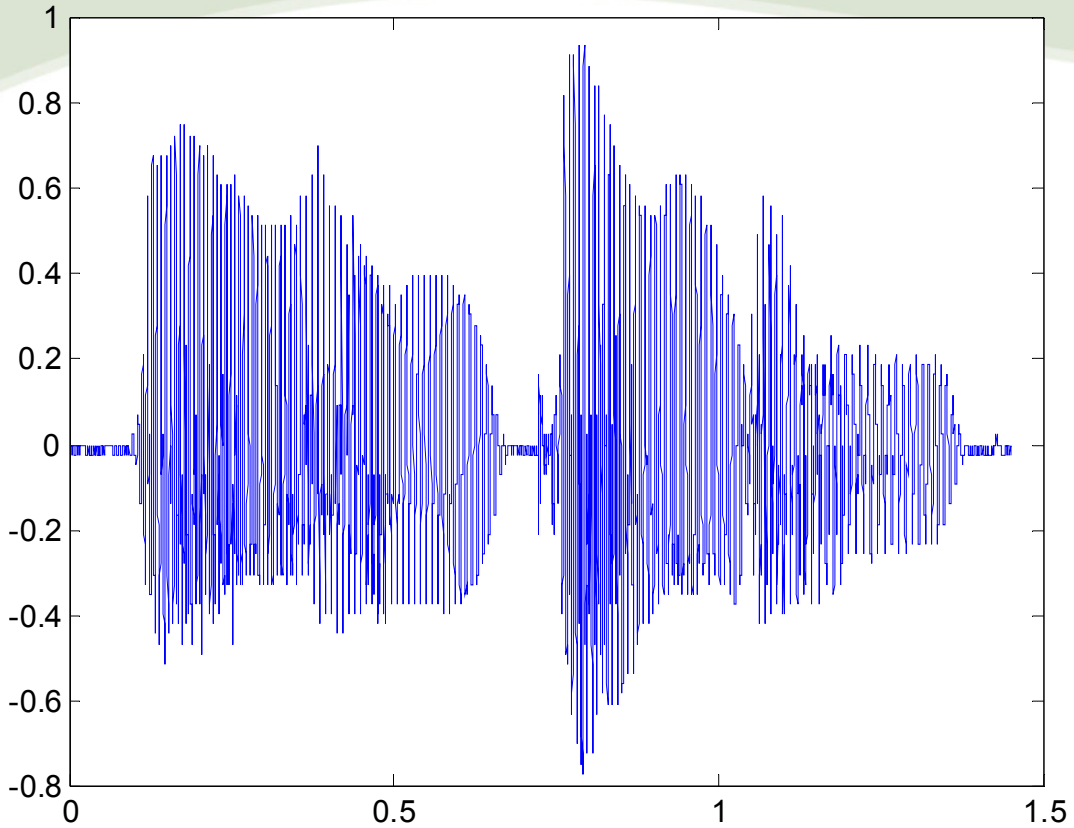
From
Continuous Signal to Digital Signal

Hardware Implementation?





DSP Simulation 1



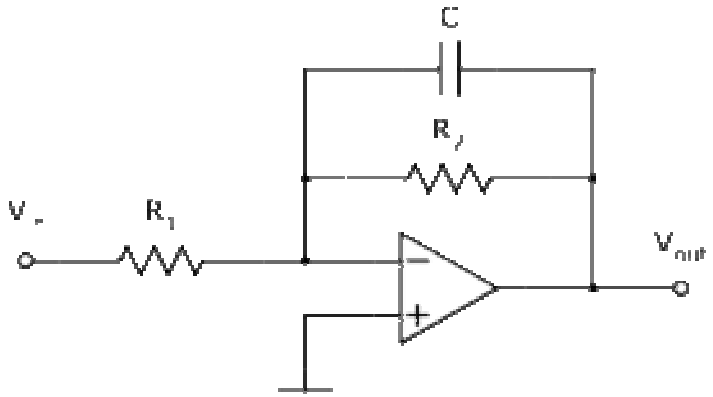
- ✓‘歡迎光臨’ (Welcome)
- ✓Fs=11,025 Hz
- ✓N= 8
- ✓PlayX1

✓Play the audio in different speed:

X0.2 X0.5 X0.8 X1 X1.5 X2

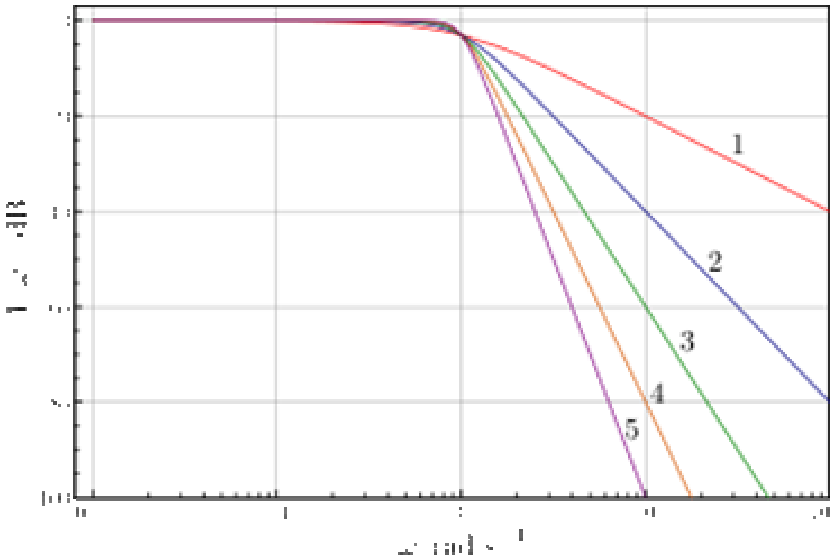
Continuous Filter vs. Digital Filter

Ex. Low Pass Filter Design



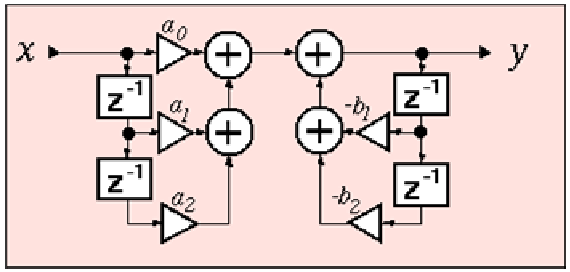
y[n]=x[n]+x[n-1]+x[n-2]

y[n]= x[n]+x[n-1]+ … +x[n-10]



Biquad Filter

Flowgraph:
(Max/MSP-like)



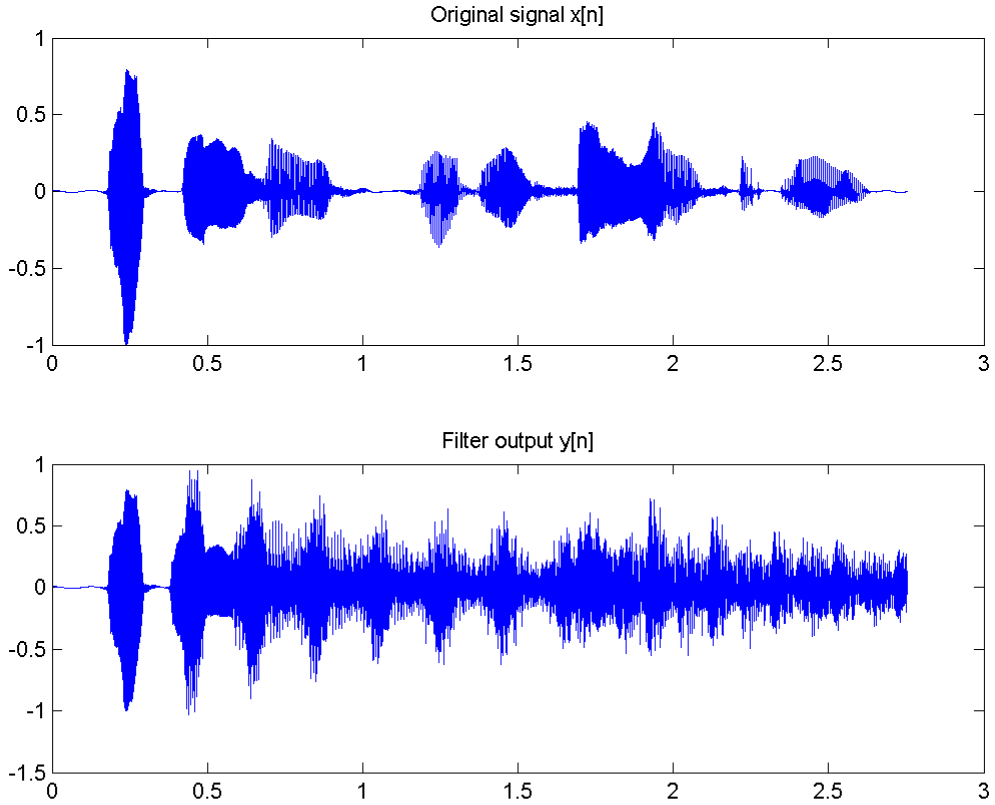
Difference Equation:
(Filter implementation)

```
y[n] = a0*x[n] + a1*x[n-1] + a2*x[n-2]
     - b1*y[n-1] - b2*y[n-2]
```

DSP Simulation 2

- A realistic multiple-fold echo:

$$y[n] = x[n] + 0.8*y[n-3200]$$

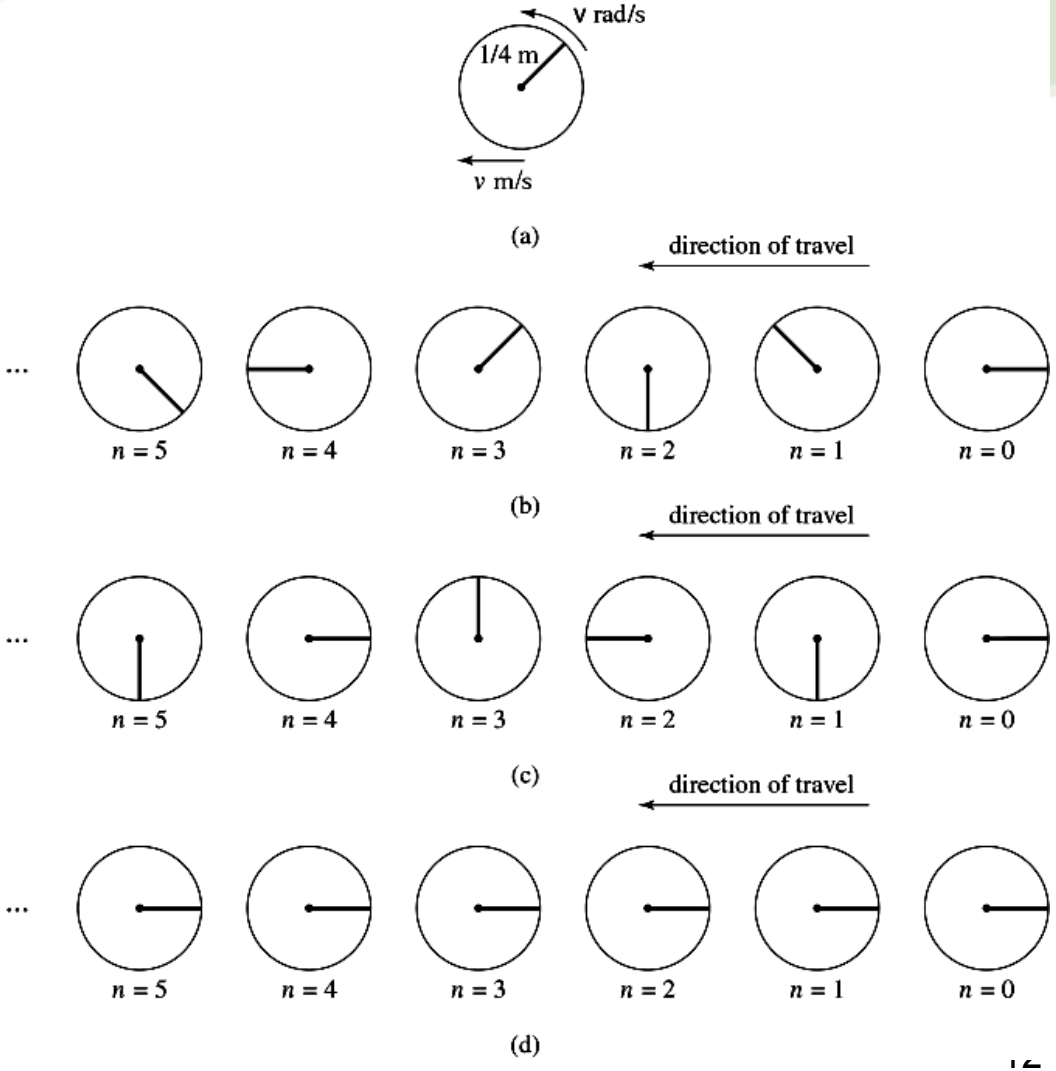


- We can hear the sound clips:

Original signal x[n] 、 Output signal y[n]

The Aliasing Phenomenon -- when fs is not quick enough

- Aliasing movie show
- Movie: 24 ~ 300 FPS
- Persistence of human vision



Buddha's Wisdom

- Adapted from 'The Diamond Sutra' or 'The Vajra Prajna Paramita Sutra'

All conditioned phenomena
Are like dreams, illusions,
bubbles, shadows,

Like dew drops and a
lightning flash:

Contemplate them thus.

若衆生心憶佛念佛
現前當來必定見佛

摘自：《大勢至念佛圓通章》

一切有為法，
如夢、幻、泡、影，
如露亦如電，
應作如是觀。...

Conclusions

✓Implantable antennas (in body antenna)

✓Wireless ECG sensors +on body antenna

✓The sampling frequency should satisfy ‘Sampling Theorem’, or aliasing phenomenon will occur.

✓DSP is a practical technology for computers or IC chips to make your dreams come true.

References

- www.amanogawa.com
- http://www.antenna-theory.com/antennas/aperture/vivaldi.php
- *Discrete-Time Signal Processing*, Alan V. Oppenheim & Ronald W. Schafer, 3rd Edition, Prentice Hall, 2009.
- Jyh-Shing Roger Jang*, "Audio Signal Processing and Recognition,*" available at the links for on-line courses at the author's homepage at http://www.cs.nthu.edu.tw/~jang.


Thank you
for listening!