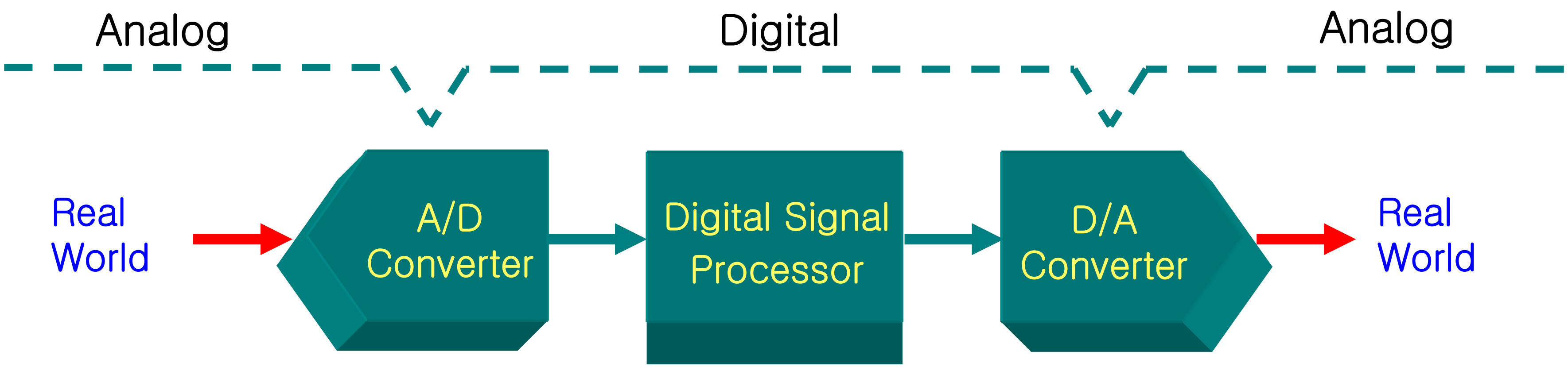
Lect. 24: Data Converters

Data Converters
- ADC: Analog to Digital Converter
- DAC: Digital to Analog Converter

Why data conversion?

Digital Signal Processing is very powerful: DSP is better if possible

Real world is made up of analog signals



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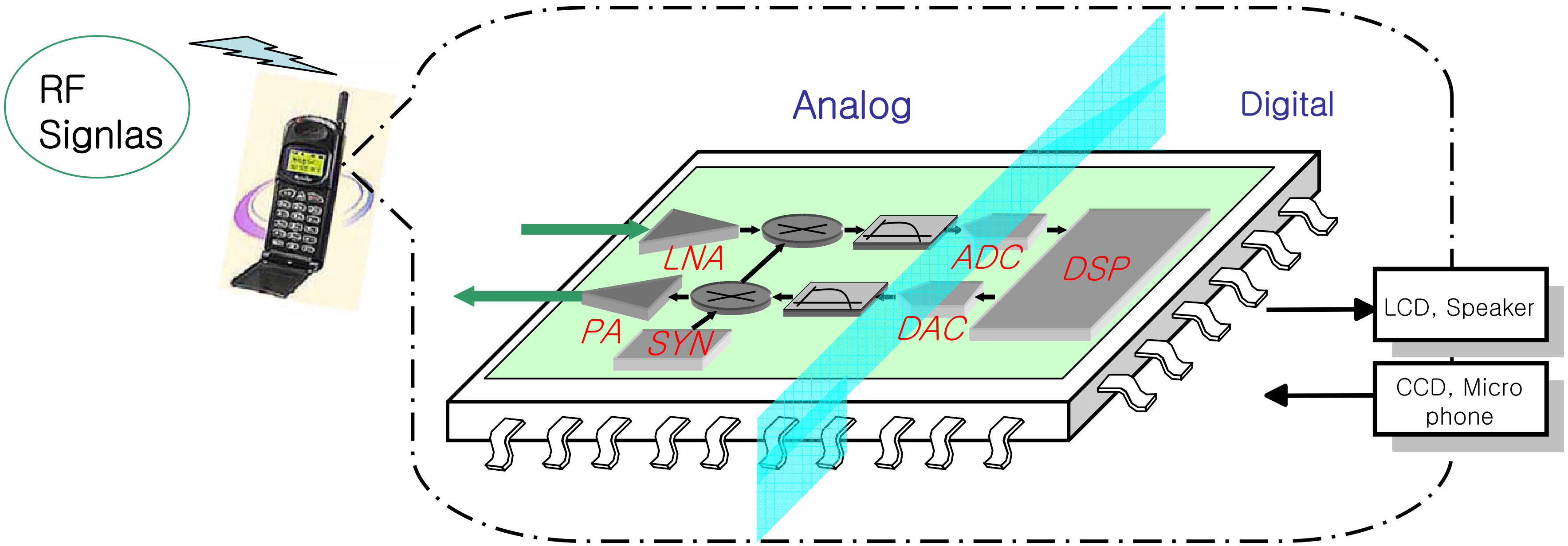

LNA: Low Noise Amplifier
PA: Power Amplifier
SYN: Frequency Synthesizer

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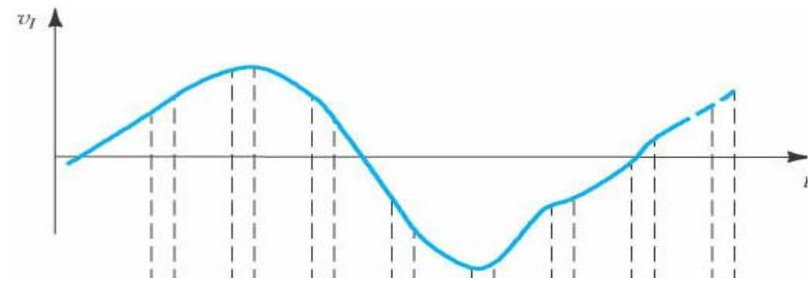
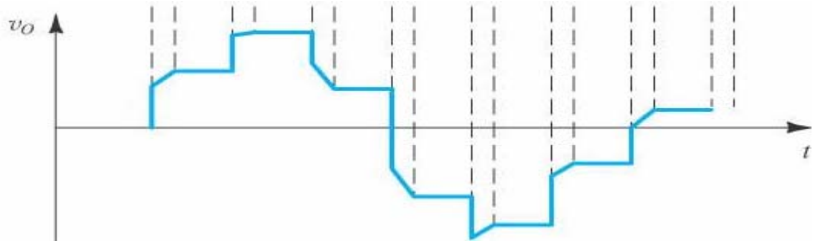
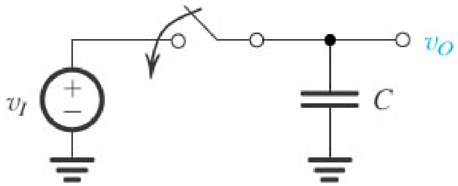
A/D Process



Input analog signal



Sampled signal



(a)

Sample and Hold Circuit

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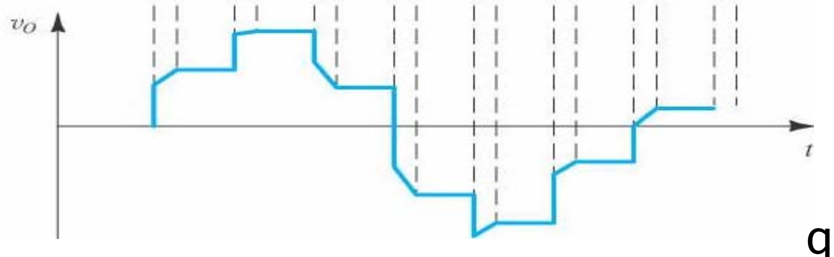
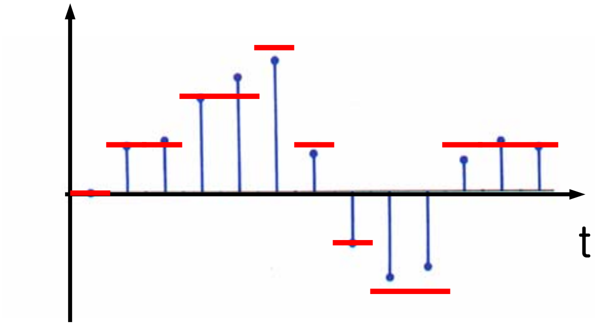
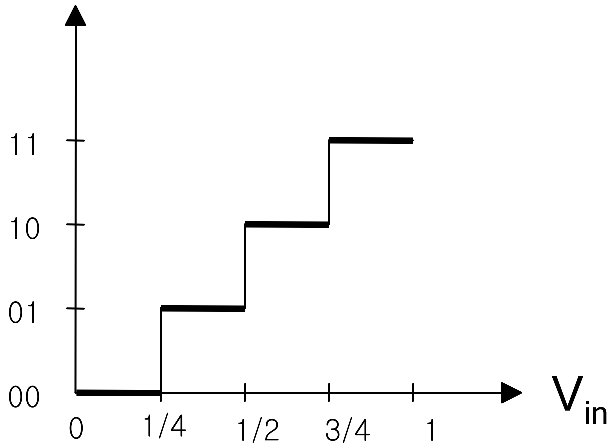


quantization



Output Code



digital coding

… 01011 ….

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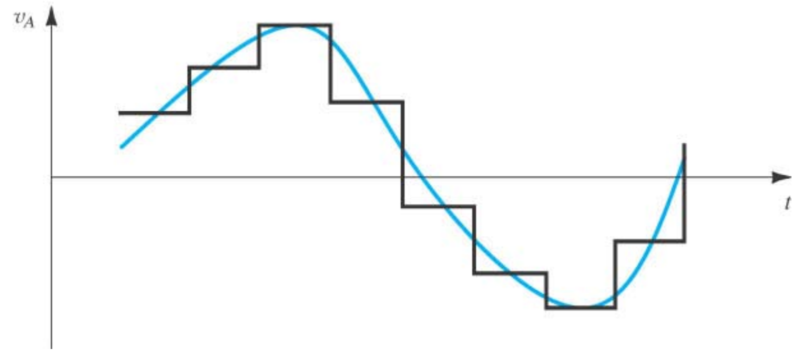
D/A Process

Digital input: ...01011 ....

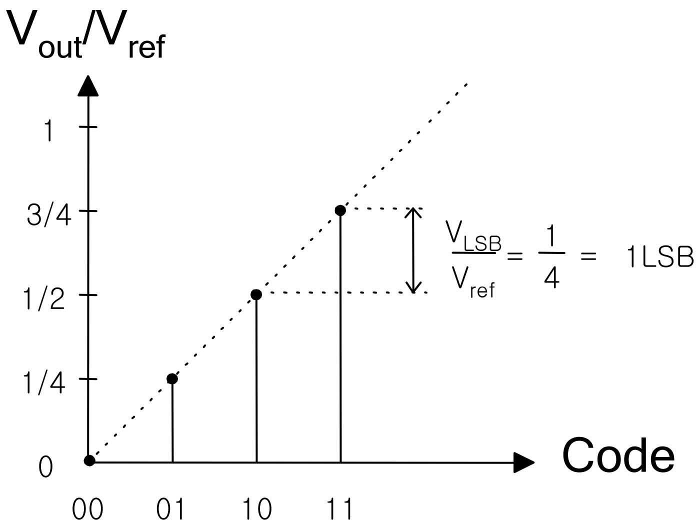


Key parameters: Resolution and bandwidth

Hardware implementation of D/A Converter

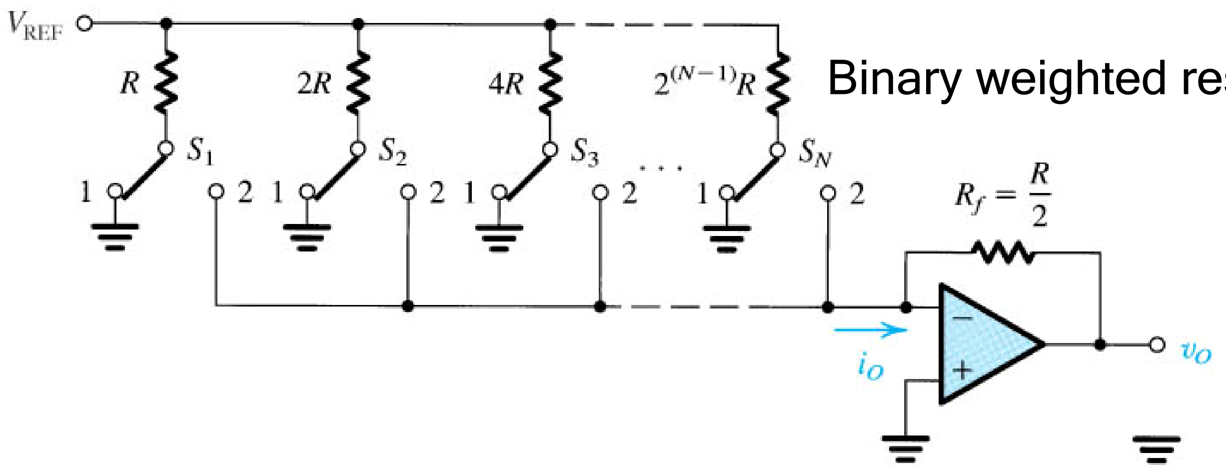
Input: $b_1b_2b_3 \ldots b_N$ (b_N: Least significant bit)

$$D = \frac{b_1}{2^1} + \frac{b_2}{2^2} + \cdot\cdot\cdot + \frac{b_N}{2^N}$$



Lect. 24: Data Converters

N-bit D/A Converter
$$D = \frac{b_1}{2^1} + \frac{b_2}{2^2} + \cdot \cdot \cdot + \frac{b_N}{2^N}$$



Binary weighted resistors

$$i_O = \frac{V_{REF}}{R} b_1 + \frac{V_{REF}}{2R} b_2 + \cdot \cdot \cdot + \frac{V_{REF}}{2^{N-1}R} b_N = \frac{2V_{REF}}{R}\left(\frac{b_1}{2^1} + \frac{b_2}{2^2} + \cdot \cdot \cdot + \frac{b_N}{2^N}\right) = \frac{2V_{REF}}{R} D$$

$$v_o = -V_{REF} D$$

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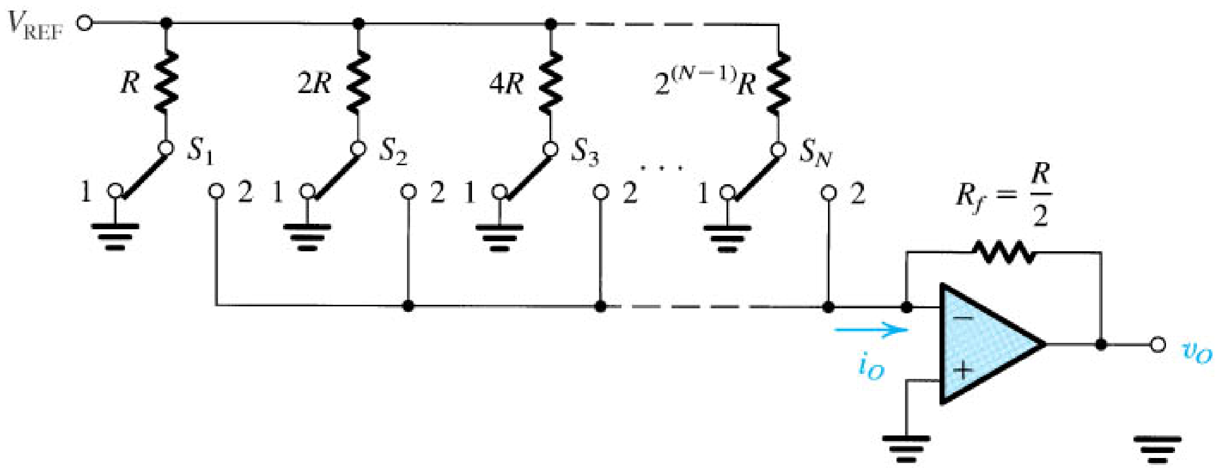
N-bit D/A Converter



Accuracy of DAC: V_{REF}, precision of binary resistors, switch performance

➔ With binary weighted resistors, big differences in R

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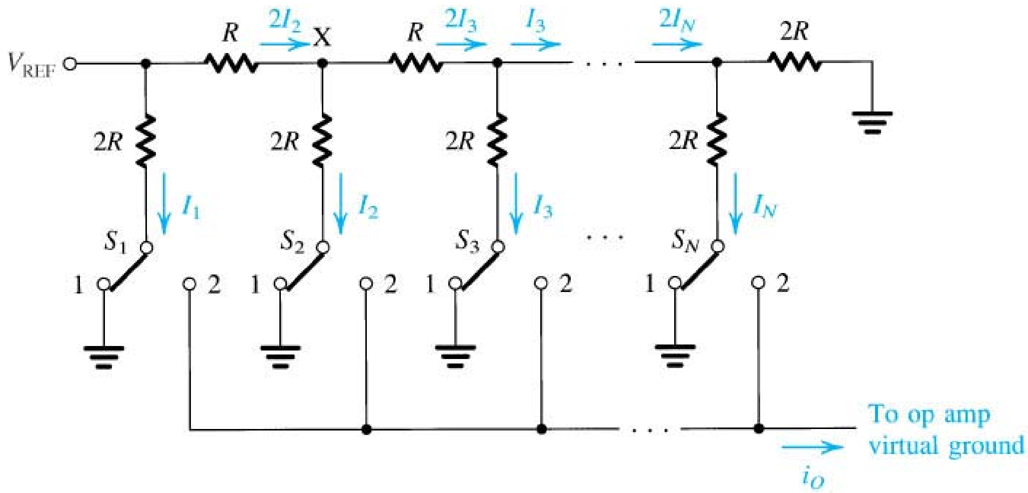
D/A Converter: R-2R Ladder



$$I_1 = 2I_2 = 4I_3 = \cdots = 2^{N-1} I_N$$

$$I_1 = \frac{V_{REF}}{2R}, I_2 = \frac{V_{REF}}{4R} \; \ldots \; I_N = \frac{V_{REF}}{2^N R}$$

$$i_O = \frac{V_{REF}}{R}\left(\frac{b_1}{2} + \frac{b_2}{2^2} + \; \ldots + \frac{b_N}{2^N}\right) = \frac{V_{REF}}{R} D$$

Many other techniques available.
➔ Active research area:
Resolution, power, manufacturability