CPE201
Digital Design

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Class 26: ADC and DAC

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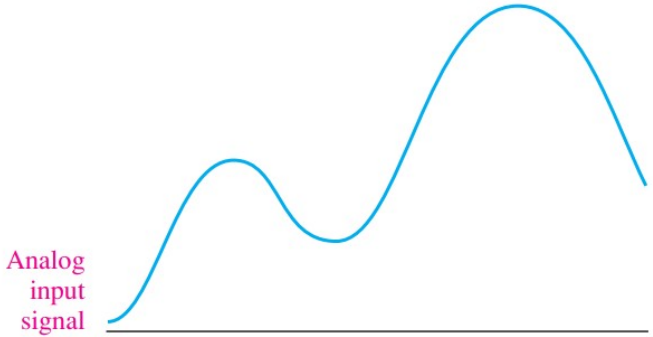
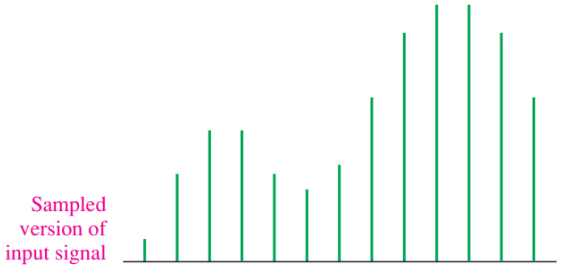
Outline

- Analog to Digital Conversion
- Digital to Analog Conversion

Continuous vs Discrete

- Or Analog vs Digital
- Anything Analog must be converted to Digital





Converters (Sensors)

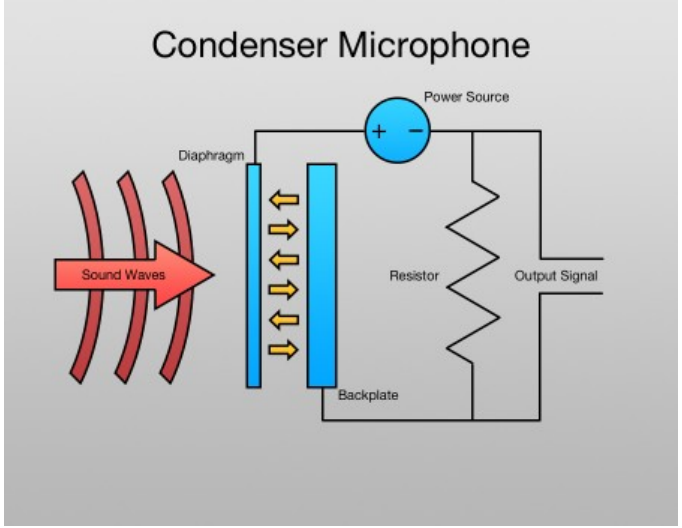
- There are many things that do this already
  - Microphones
  - Speakers
  - Digital thermometers, barometers, accelerometers
  - GPS
  - Cameras

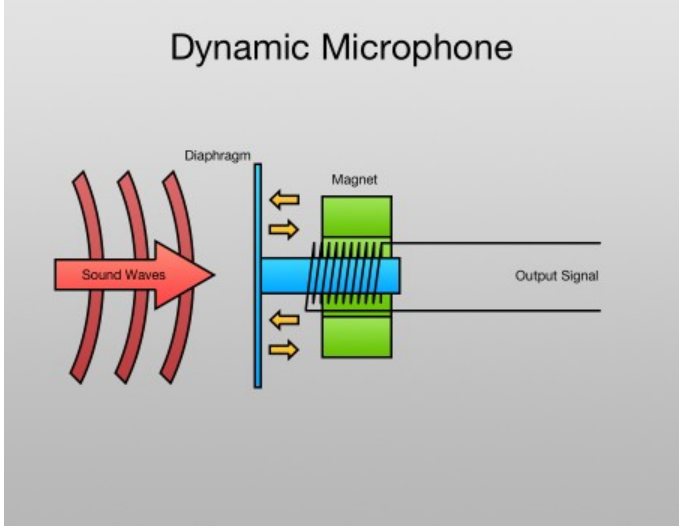
Sensors

- All of these work on the same principles
  - Convert a measurement to a voltage
  - Convert the voltage to a digital signal
  - Capture/store/manipulate the signal

Convert to Voltage

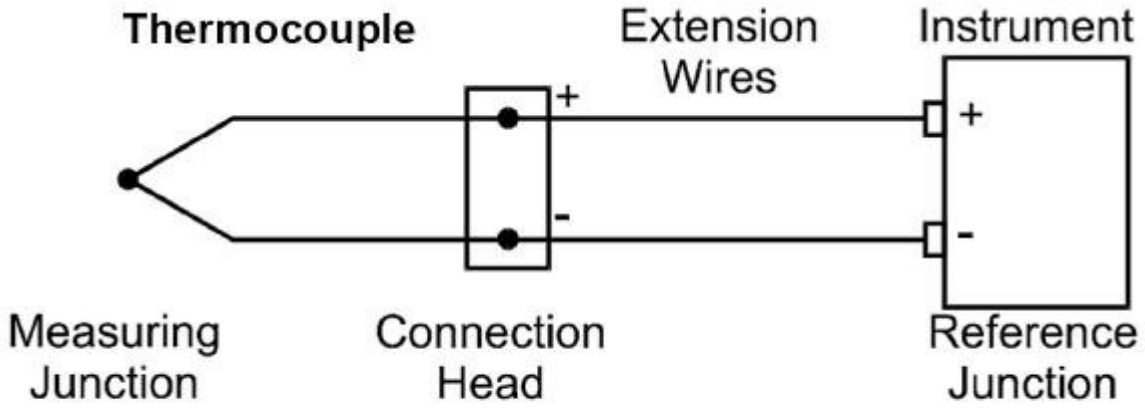
- Microphone





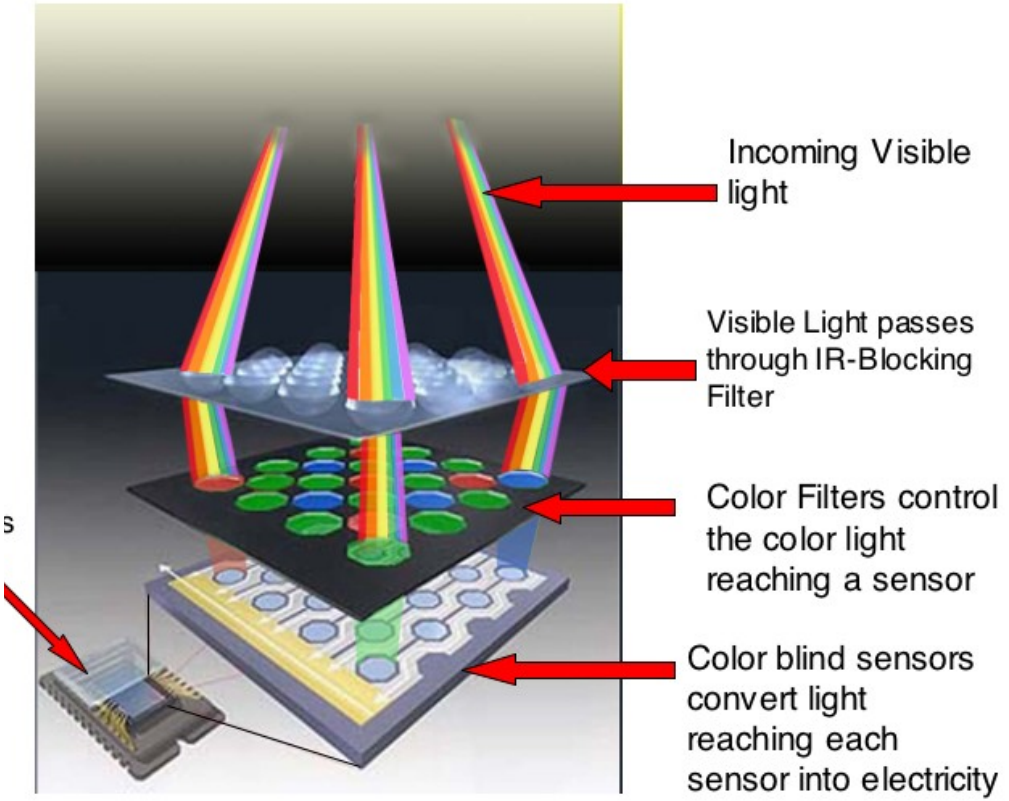
Convert to Voltage

- Thermometer



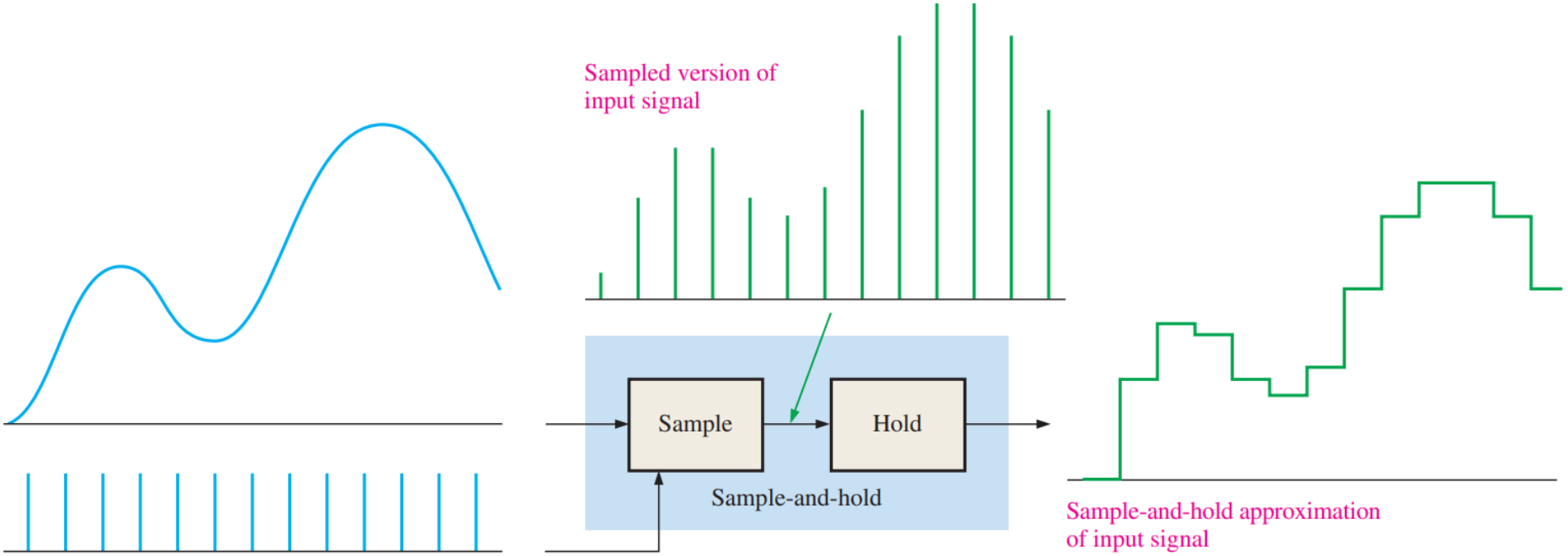
Convert to Voltaqe

- Camera Sensc



Sample the Voltage

- The actual ADC part – usually sample and hold



ADC

- Compares sample to a voltage reference (Vref)
- An ADC has a set number of bits
- Each ADC count is worth Vref/(2^n-1) volts
- Most ADCs have 10-16 bits right now
  - So encoded as a 10-16-bit binary number

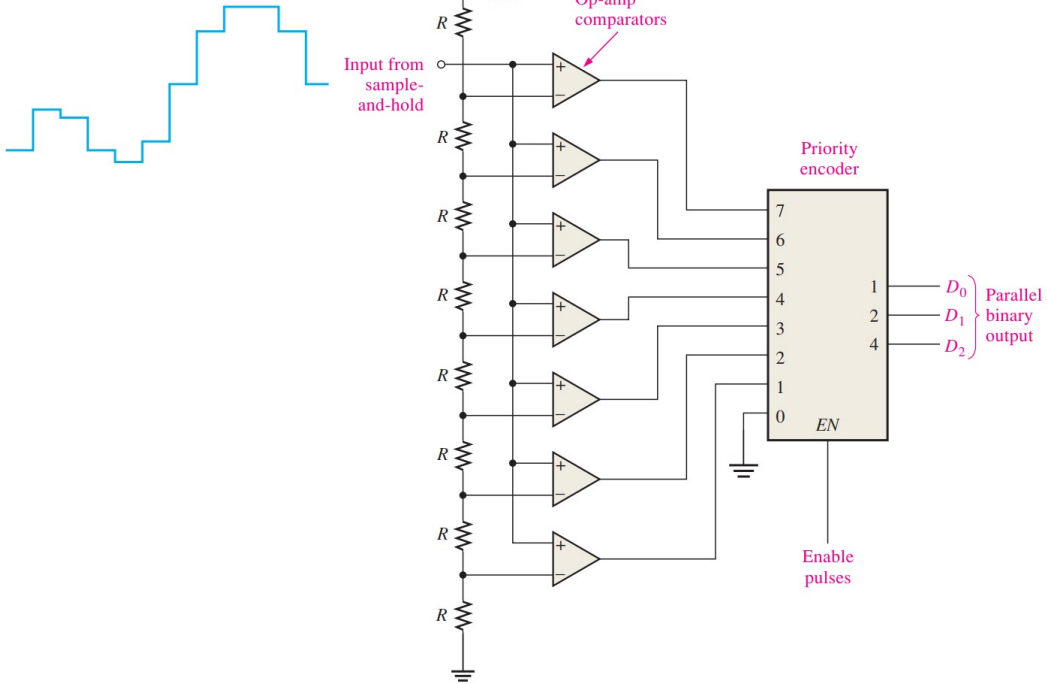
ADC

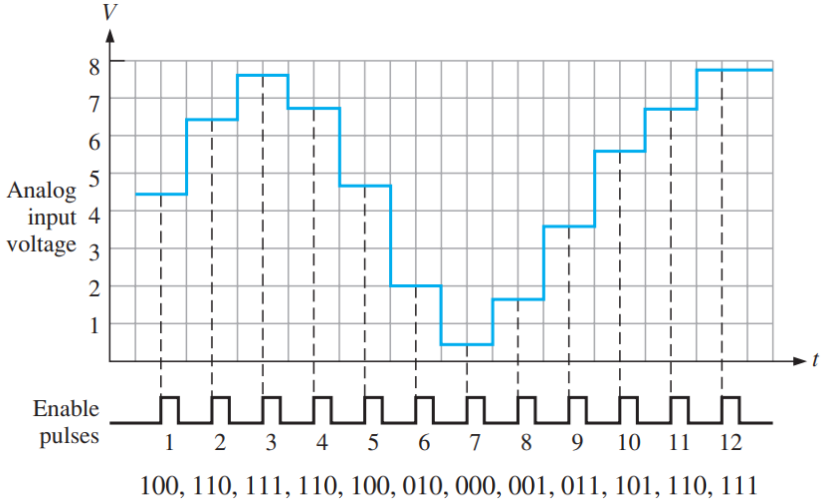
- A 3-bit ADC can give 0-7 counts (2^3-1)
- If Vref is 7V, then each count is 1V

- A 10-bit ADC can give 0-1023 counts
- If Vref=5V, then each count is 4.89mV

Convert the Sample

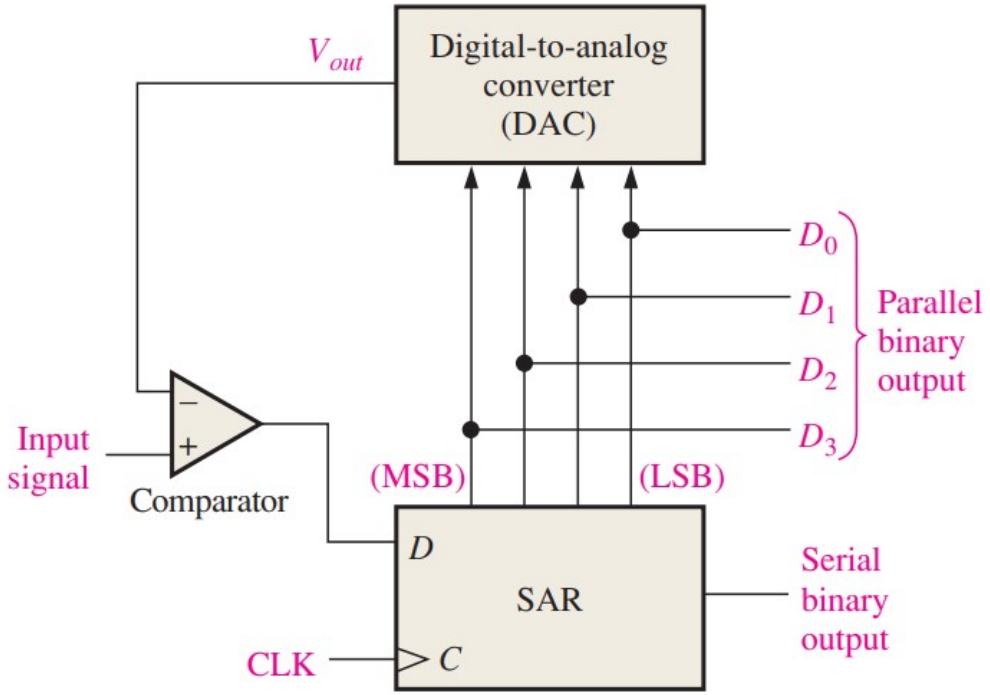
- Flash (Simultaneous) ADC (Vref = 7V)





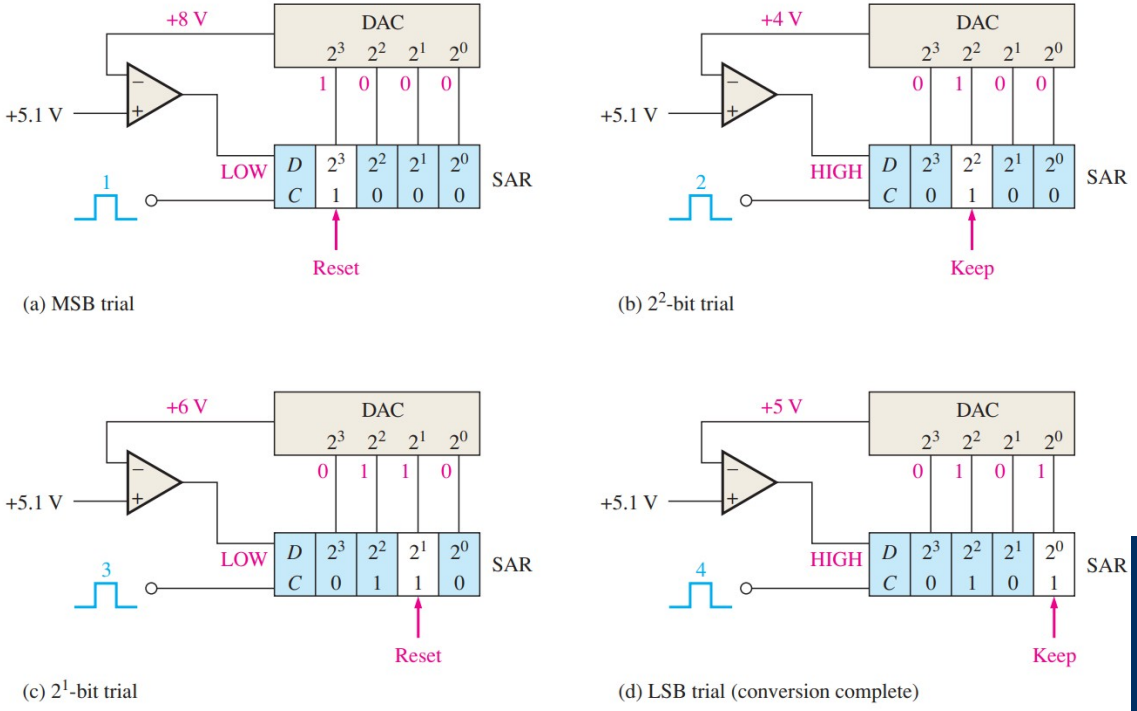
Convert the Sample

- Successive-Approximation ADC



Example

- Vref = 15V



Other Types

- There are plenty

- Flash ADC is more expensive (more hardware) but fast
- SAR ADC is cheaper, but slower

DAC

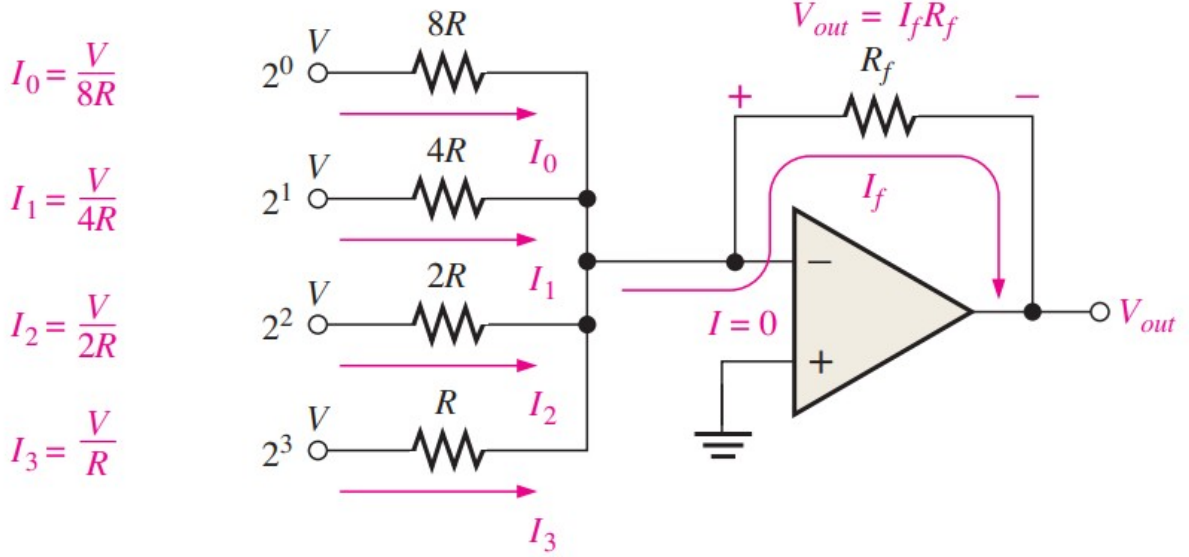
- Converting voltages back to analog
  - For anything where on/off is not great
    - Dimming lights
    - Amount of gas/brake in a car
    - Audio

https://www.youtube.com/watch?v=xNWv7htg7_c

Binary-Weighted-Input DAC

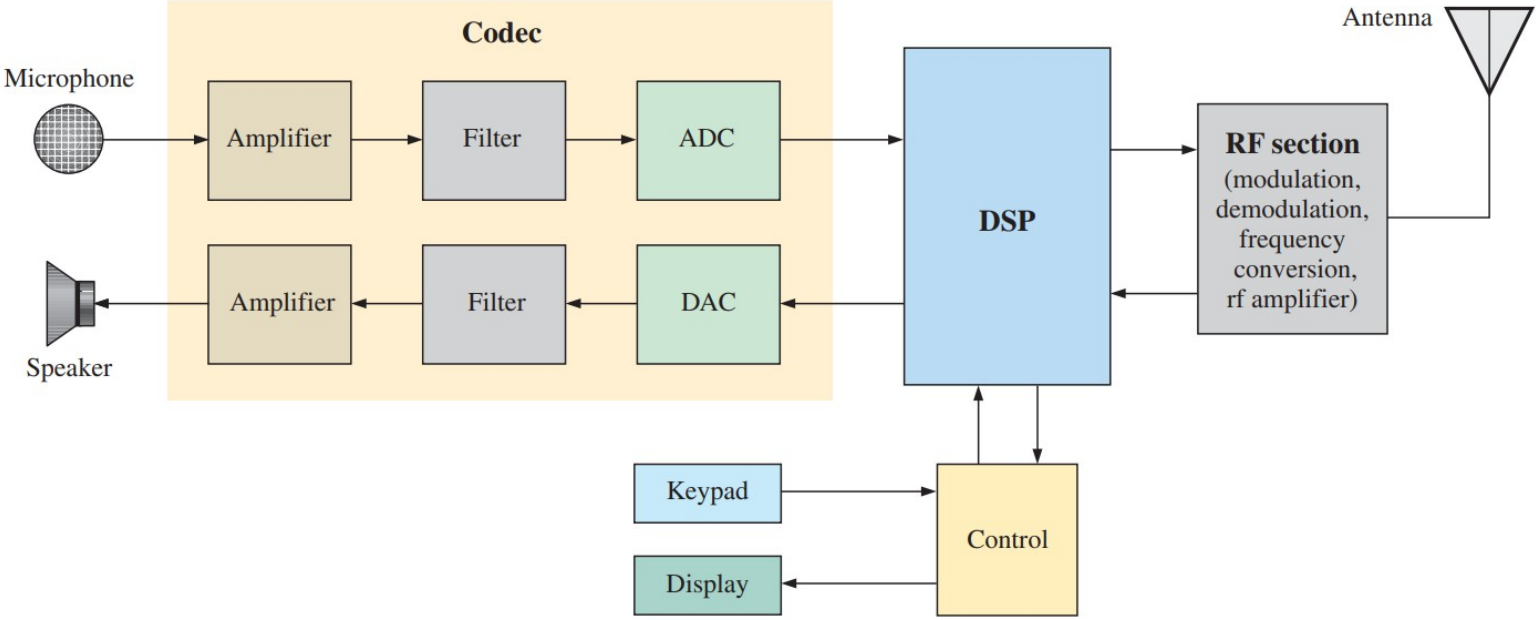
- Op-amp in summing mode
  - Resistors scaled like ADC, MSB = half of voltage
  - Gives 15

output levels



ADC & DAC

- Common in most systems today



Simplified block diagram of a digital cellular phone.

Reading

- This lecture
  - Sections 12.1-12.3
- Next lecture
  - Sections 13.6-13.9