Introduction to Signals and Systems

Inel 4095
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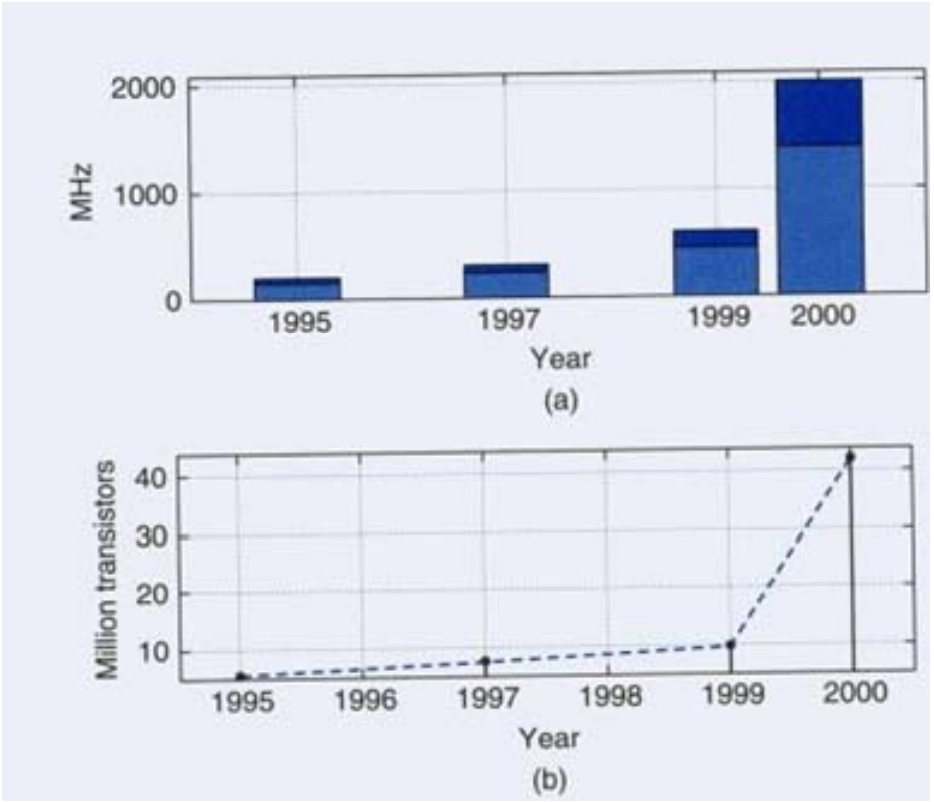


(a) Range of CPU speeds in MHz, (b) Number of transistors in each of the above chips

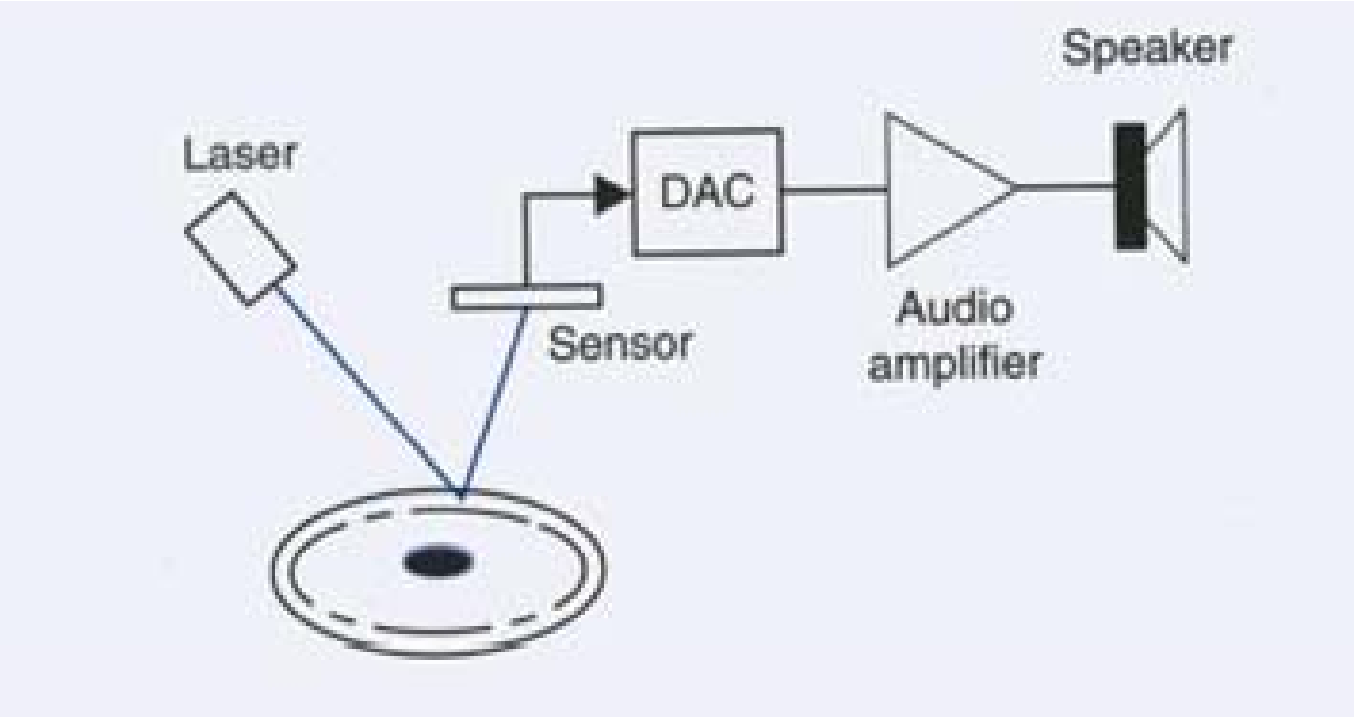
- Advances in digital electronics in computer Engineering results in proliferation of digital technologies
- Digital hardware and software process signals from cell phones, HDTV receivers, radars and sonars
- DSPs and more recently FPGAs are replacing ASICs (Application Specific Integrated Circuits) in industrial, medical and military applciations

- Digital transmission of voice, data, and video is common and so is computer control
- Abundance of algorithms for processing signals, and presence of DSPs and FPGAs make DSP theory a necessary tool for Engineers and anyone dealing with digital data, soon that will be everybody!!

Examples of signal processing applications

- Compact-Disc Player
- Software defined radio and cognitive radio
- Computer controlled systems

Compact-disc player



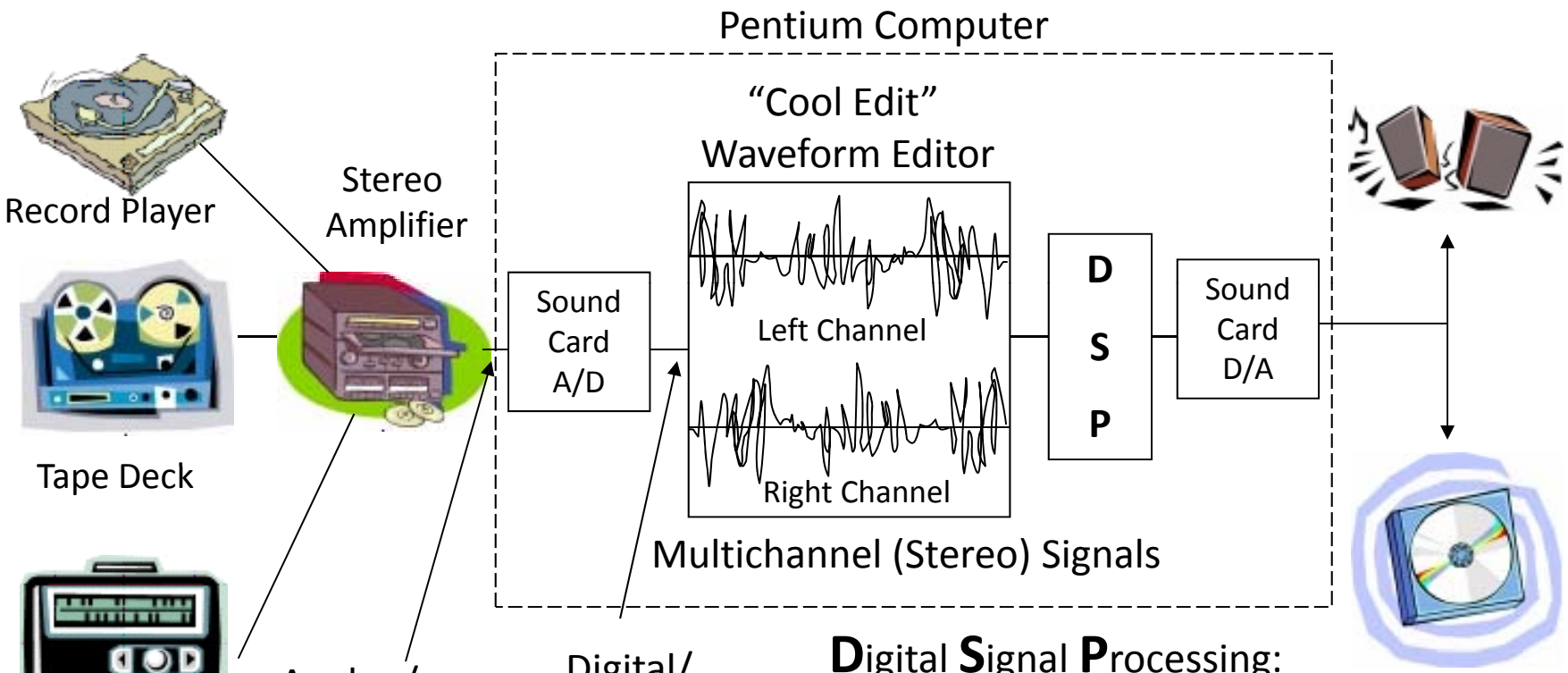
Compact disc player

- Recorded voltage variations over time due to an acoustic sound is called an analog signal given its similarity with the differences in air pressure generated by the sound waves over time
- To store an analog audio signal on a CD the signal is first sampled and convereted into a sequence of binary digits – a digital signal-by an ADC and then especially encoded to compress the information to avoid errors when playing the CD

- The CD player follows the tracks in the disc, focusing a laser on them,
- The laser shines a light that is reflected by the pits and bumps on the surface corresponding to the coded digital signal from an acoustic signal
- A sensor detects the reflected light and converts it into a digital signal, which is then converted into an analog signal by the DAC
- When amplified and fed to the speakers such a signal sounds like the originally recorded acoustic signal

- Audio signals are sampled at 44000 samples / sec, corresponding to a max. frequency of 22kHz for a typical audio signal

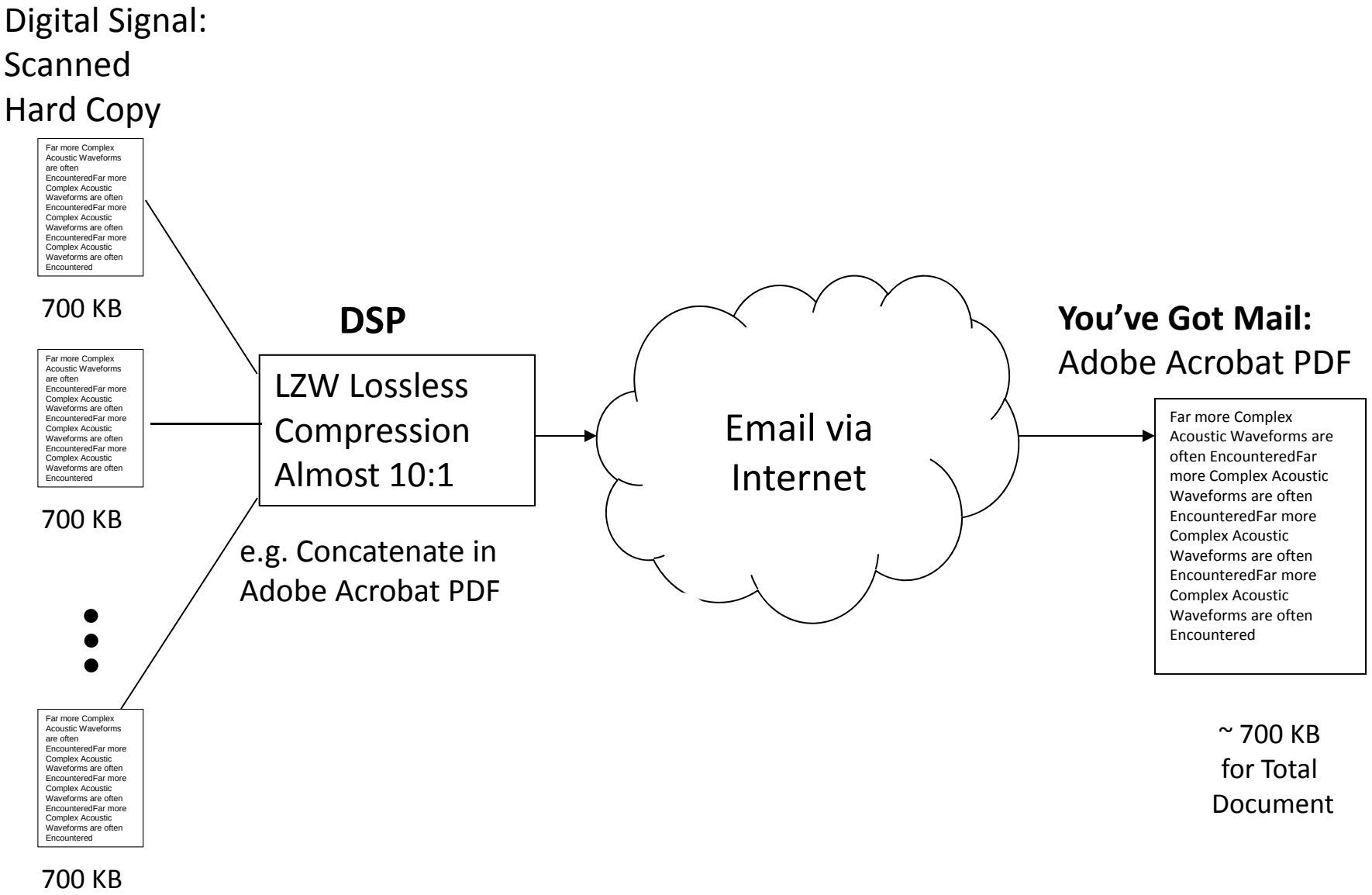
Practical, Inexpensive Signal Processing System



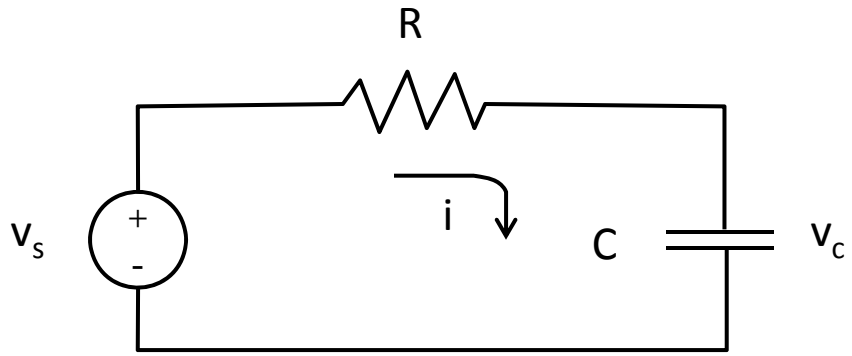
Digital **S**ignal **P**rocessing:

1) **Noise Reduction**
   -Digital Filtering, etc.
2) **Signal Compression**
   -MP3, JPEG/MPEG Image, etc.
3) **Spectral Analysis** (e.g., FFT)

Electronic "Fax" via Portable Document Format



Example: Signals in an Electrical Circuit

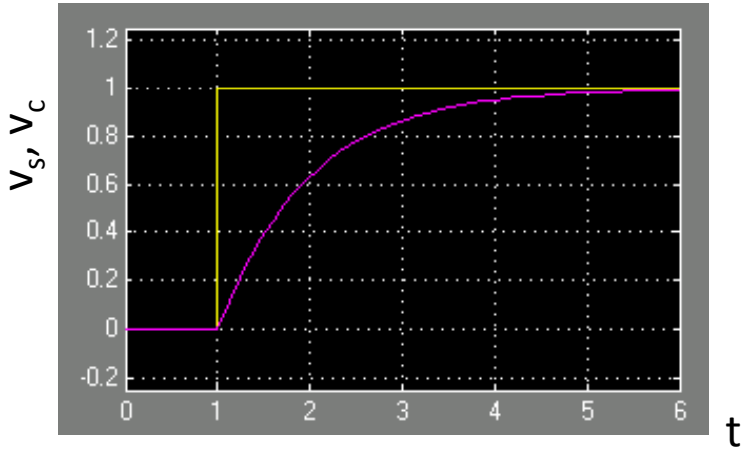


$$i(t) = \frac{v_s(t) - v_c(t)}{R}$$

$$i(t) = C\frac{dv_c(t)}{dt}$$

$$\frac{dv_c(t)}{dt} + \frac{1}{RC}v_c(t) = \frac{1}{RC}v_s(t)$$

- The signals v_c and v_s are patterns of variation over time

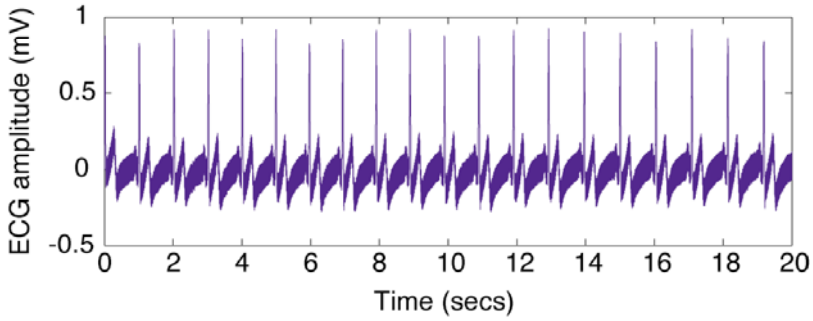


Step (signal) v_s at t=1
RC = 1
First order (exponential) response for v_c

- Note, we could also have considered the voltage across the resistor or the current as signals

Independent Variables

- Time is often the independent variable for a signal. *x*(t) will be used to represent a signal that is a function of time, *t*.
- A temporal signal is defined by the relationship of its amplitude (the dependent variable) to time (the independent variable).



- An independent variable can be 1D (time), 2D (space), 3D (space) or even something more complicated.
- The signal is described as a function of this variable.
- There are many types of functions that can be used to describe signals (continuous, discrete, random are just a few of the concepts we will encounter this semester).