EE 230

Lecture 2

Background Materials

Quiz 1

What is the approximate amount of data, in Bytes, that a single platter on a state of the art 3.5 inch hard drive can hold?

And the number is ?

1 3 8

5 4

2 6

9 7

Quiz 1

What is the approximate amount of data, in Bytes, that a single platter on a state of the art 3.5 inch hard drive can hold?

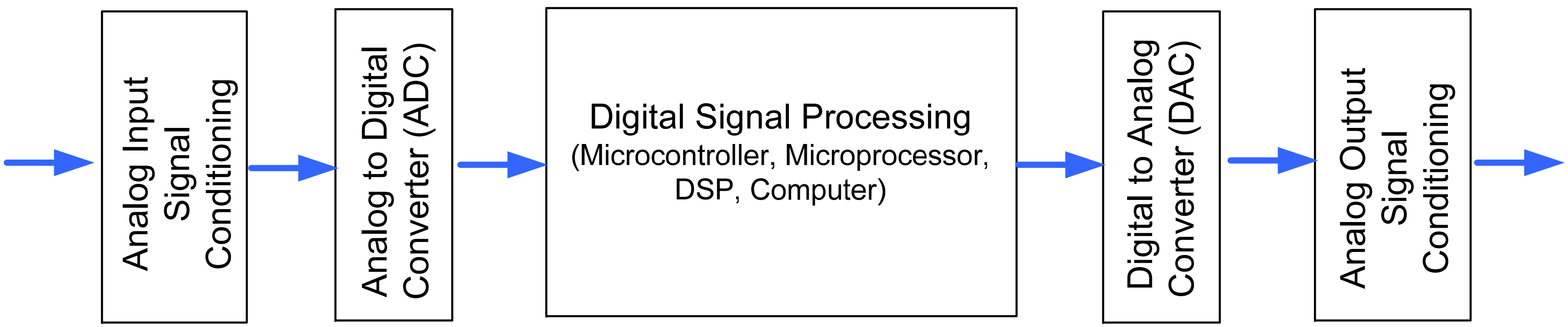
Review from Last Time

The electronics business is one the largest sectors in the world economy

worldwide sales from semiconductors alone projected to be at the $260 Billion level in 2010

Review from Last Time

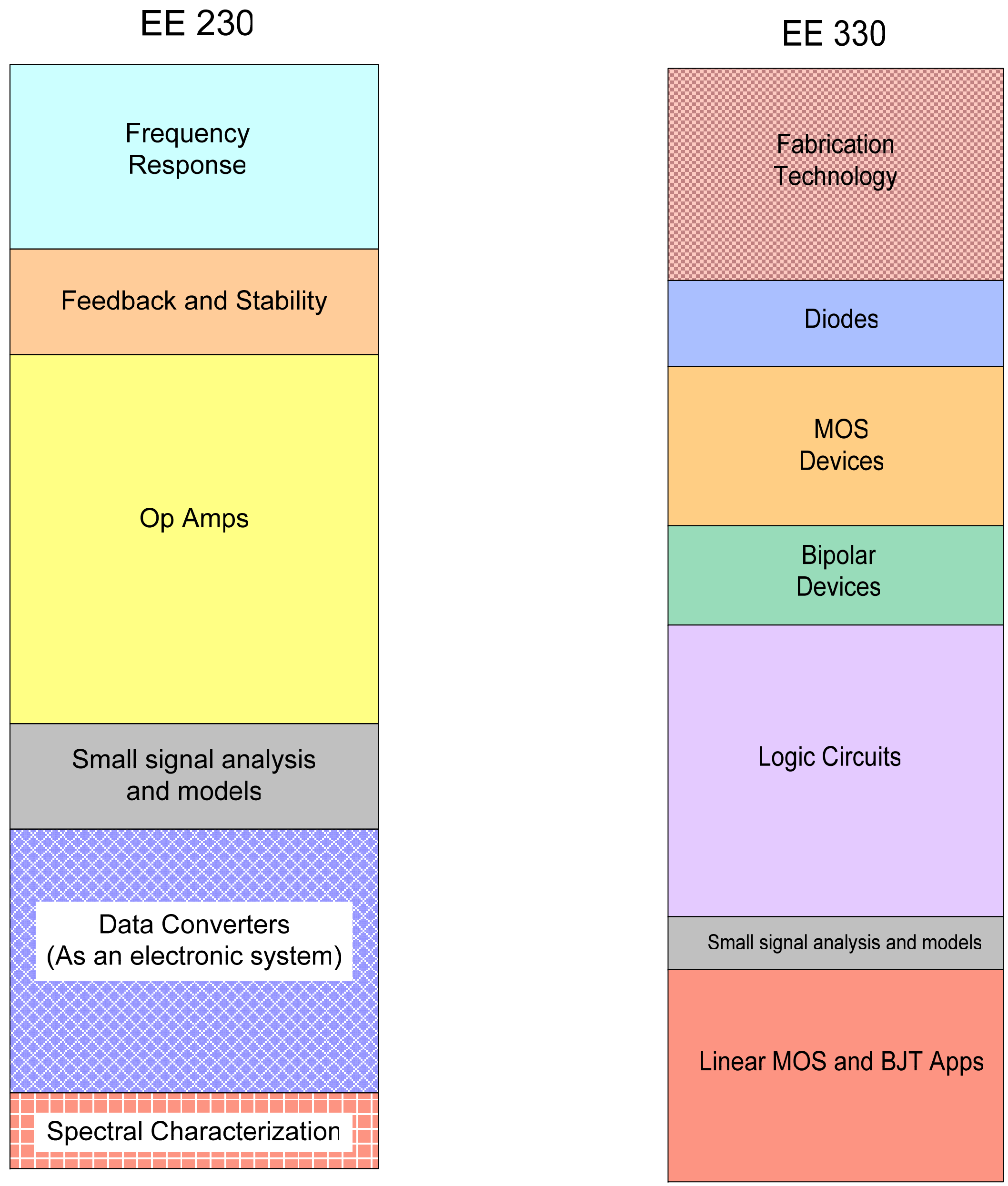
Typical Electronic Part of the System

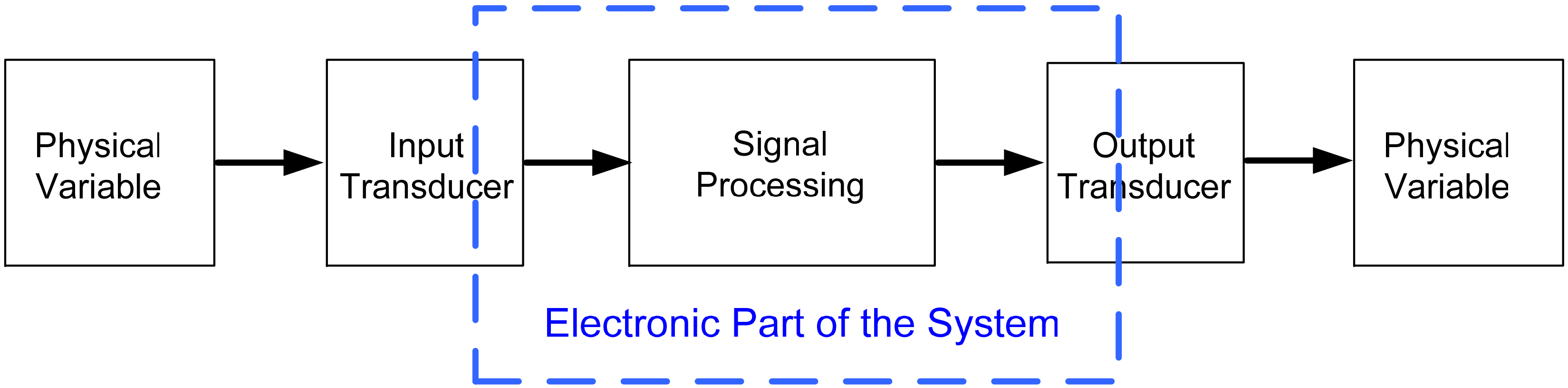


Integrated Circuits and some Passive Components Invariably Used in each of these 5 Blocks

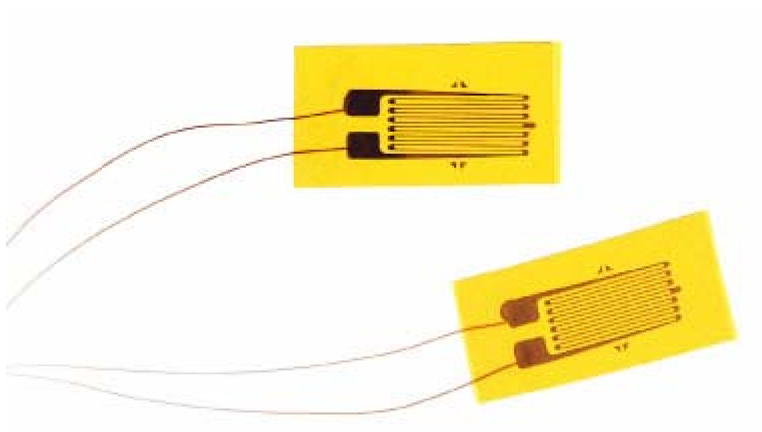
Groups (often very large) of transistors used to build ICs but very limited use of individual transistors external to the integrated circuits

Material Partitioning in 09-11 Catalog

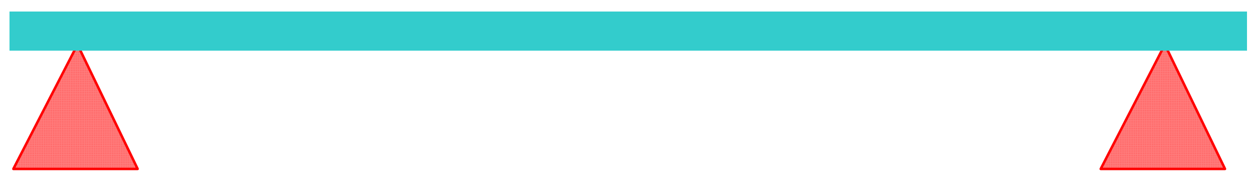




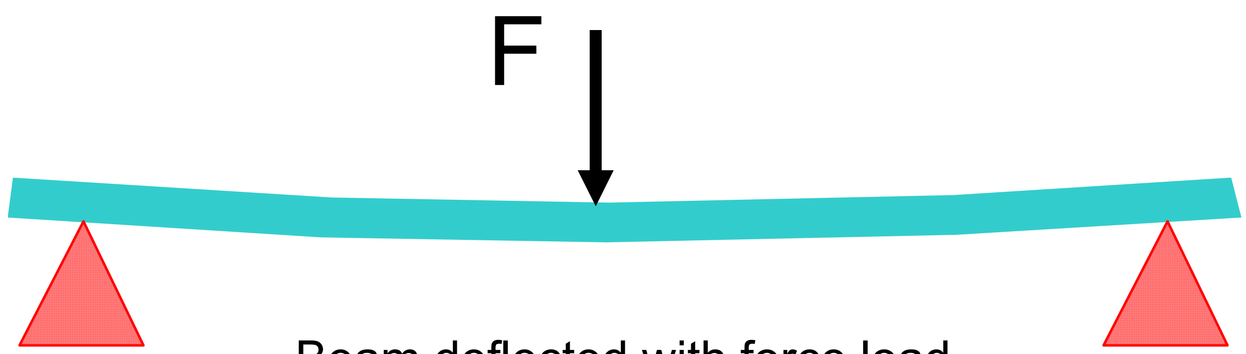
Example of electronic system: Force Measurement with Foil Strain Gauges



Force Measurement with Foil Strain Gauges

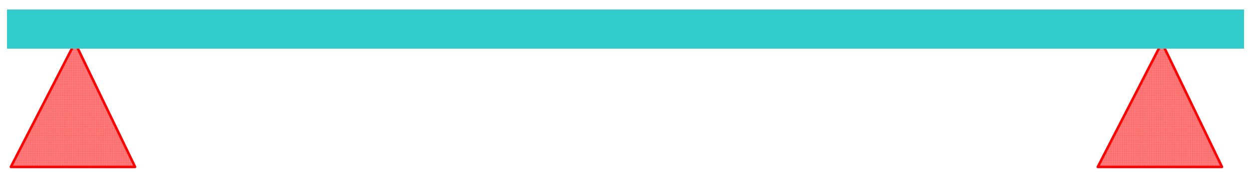


Beam supported at two points

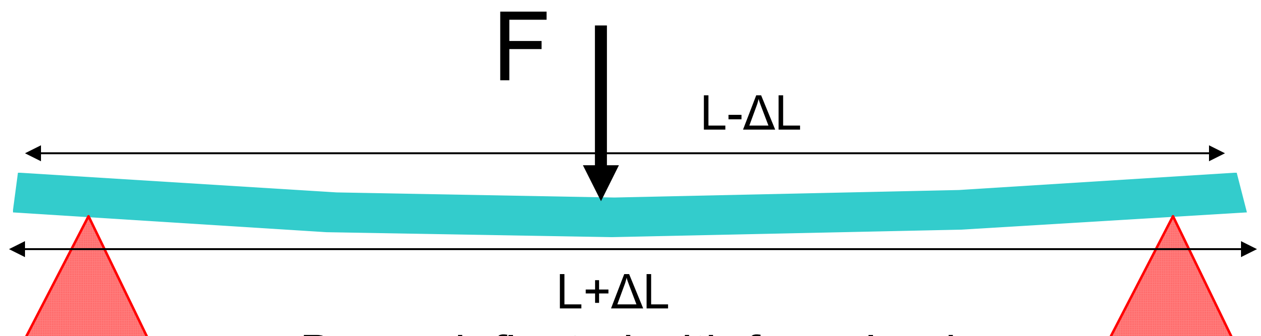


Beam deflected with force load

Force Measurement with Foil Strain Gauges

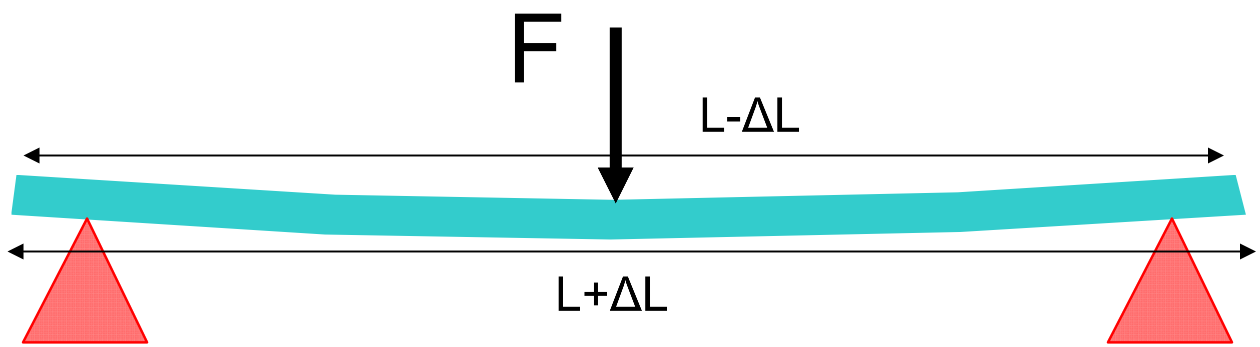


Beam supported at two points



Beam deflected with force load

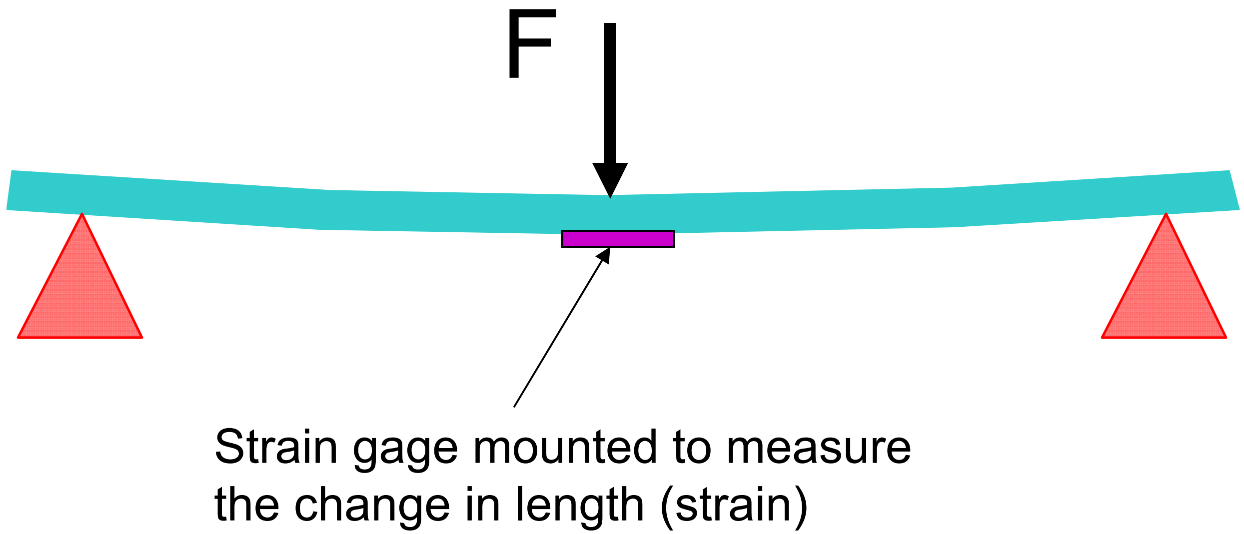
$\Delta L/L$ is often very small



If L=100ft, the thickness of the beam is 1 foot, and the deflection is 0.1ft, it can be shown that ΔL is approximately 4E-3 feet

Thus, ΔL/L is approximately 4E-5

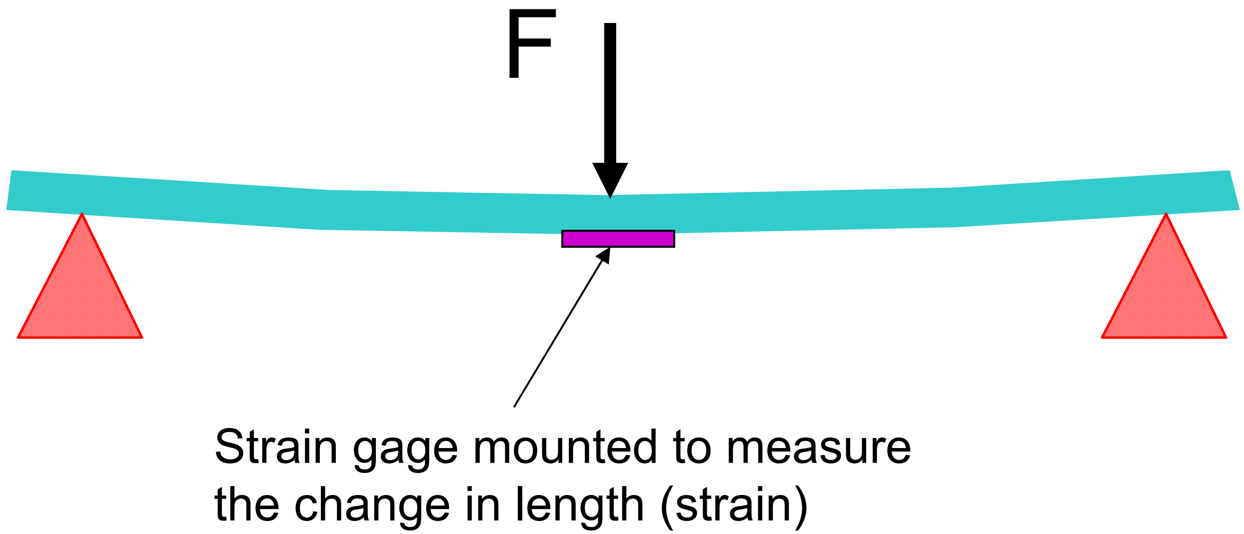
$\varepsilon = \Delta L/L$ is defined to be the strain on the surface



Strain gauge characterization

$$GF = \frac{\Delta R / R}{\Delta L / L} = \frac{\Delta R / R}{\varepsilon}$$

Typical GF for foil strain gauges are around 2

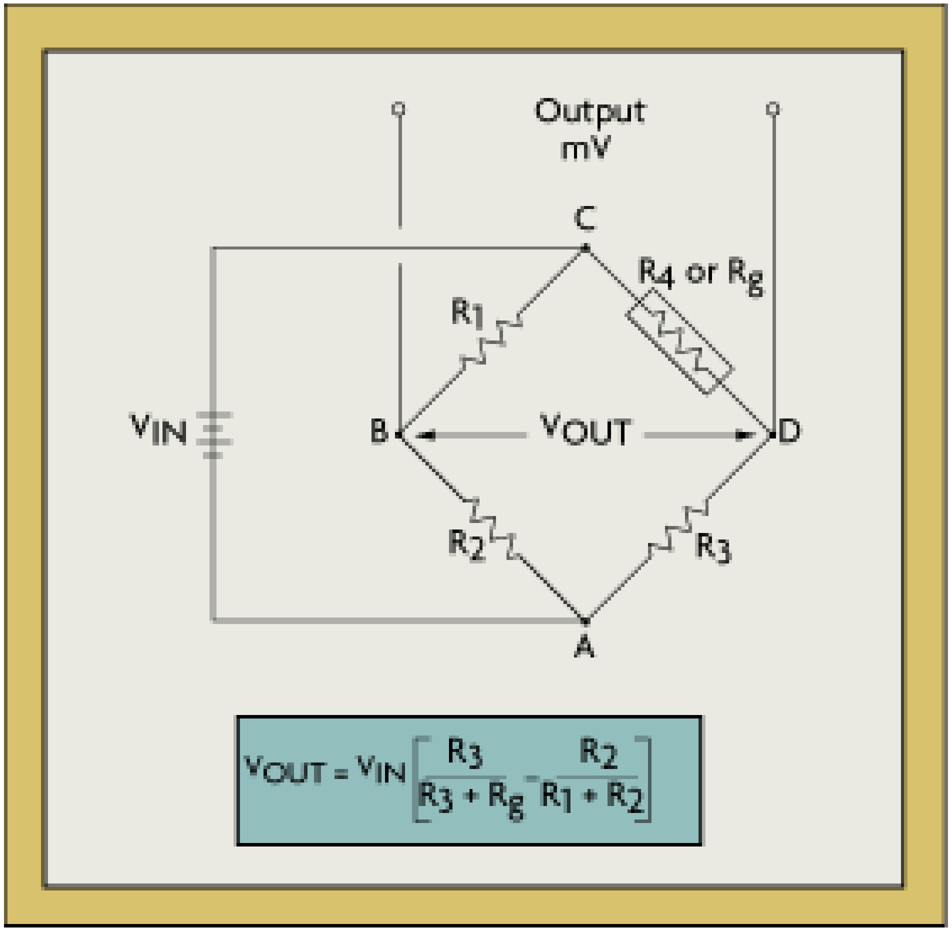


For the sample loaded beam

$$\Delta R / R = \varepsilon \; GF \cong 9E-5$$

Thus, if the unstrained resistor is R=30.0000000Ω,
the strained resistor would be R_{ST}=30.0027Ω

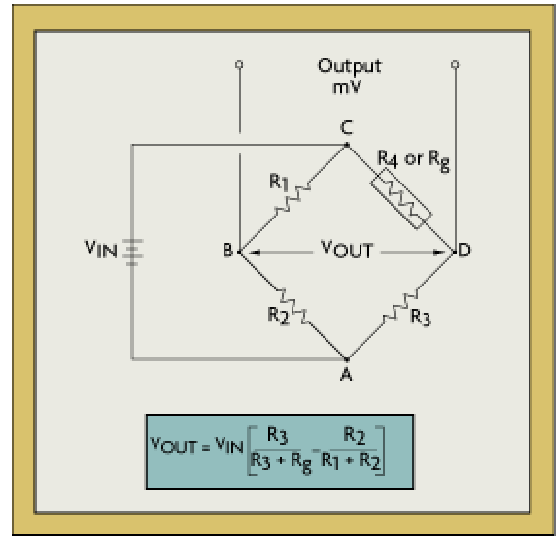
Bridge circuits that is widely used to measure the change in resistance



If R_1=R_2=R_3=30.00000Ω=R_{4N} and V_{IN}=5V, then

V_{OUT}=112.5μV

Bridge circuits that is widely used to measure the change in resistance

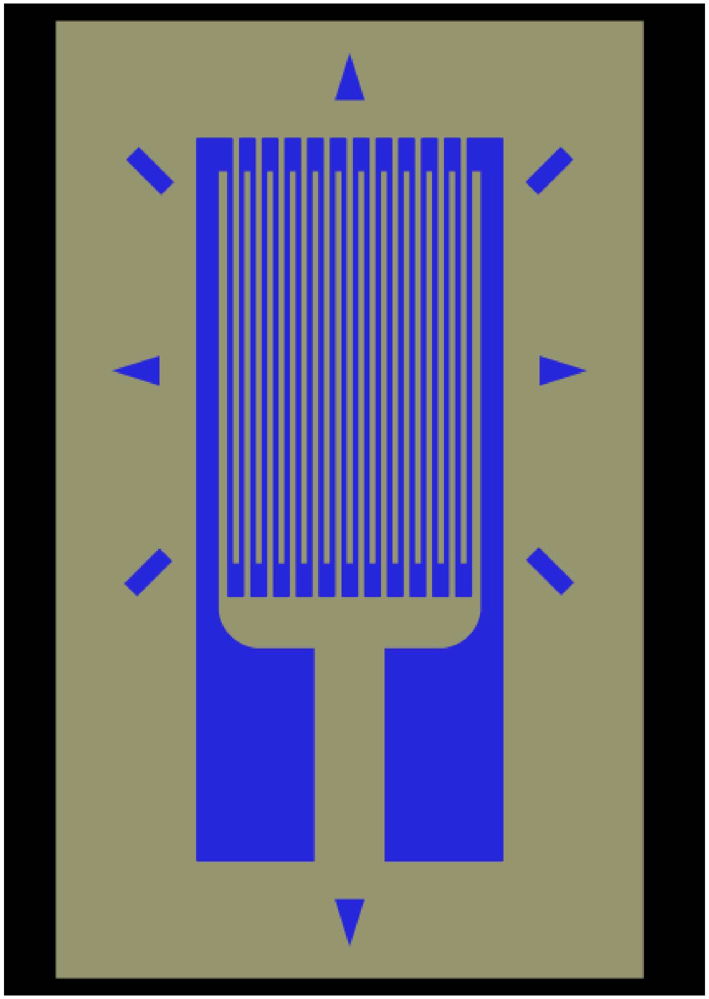


If $R_1=R_2=R_3=30.00000\Omega=R_{4N}$ and $V_{IN}=5V$, then

$$V_{OUT}=112.5\mu V$$

- Often V_{OUT} must be accurately determined (0.01% or better)
- Resistor accuracy is really important
- Temperature or environment can be critically important
- Cost for force (weight) measurement systems can be high

Strain Gauges



Load Cells

Button-Style Compression Load Cells

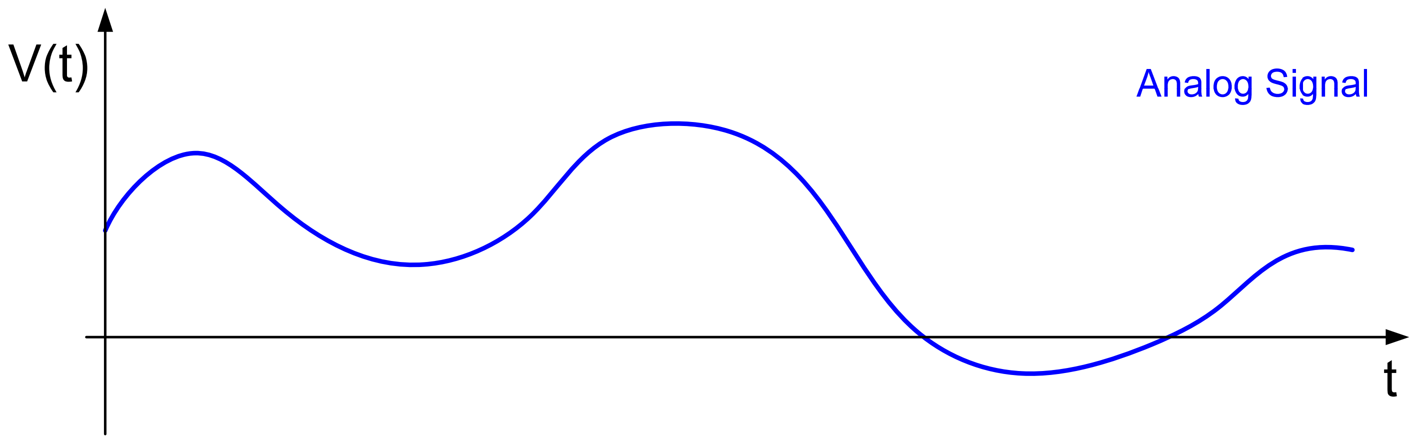
Load Cells

Signal Processing

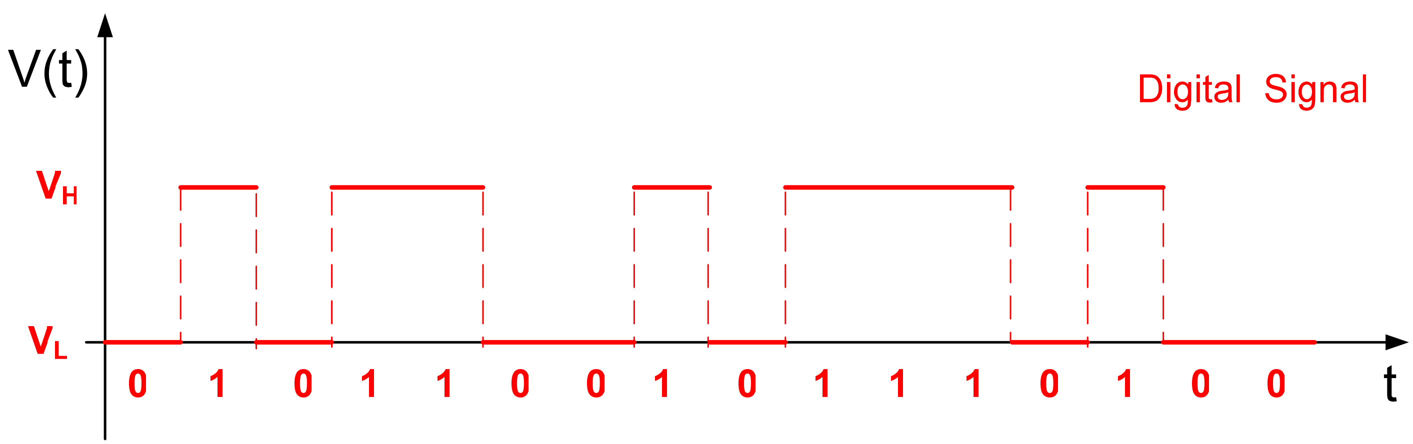
- Often includes a combination of digital and analog circuits
- May contain only digital circuits
- May contain only analog circuits
- Signals can be very small
- Noise often interferes with signals at input or in signal processing circuits

Signals are characterized in several different ways

Signals

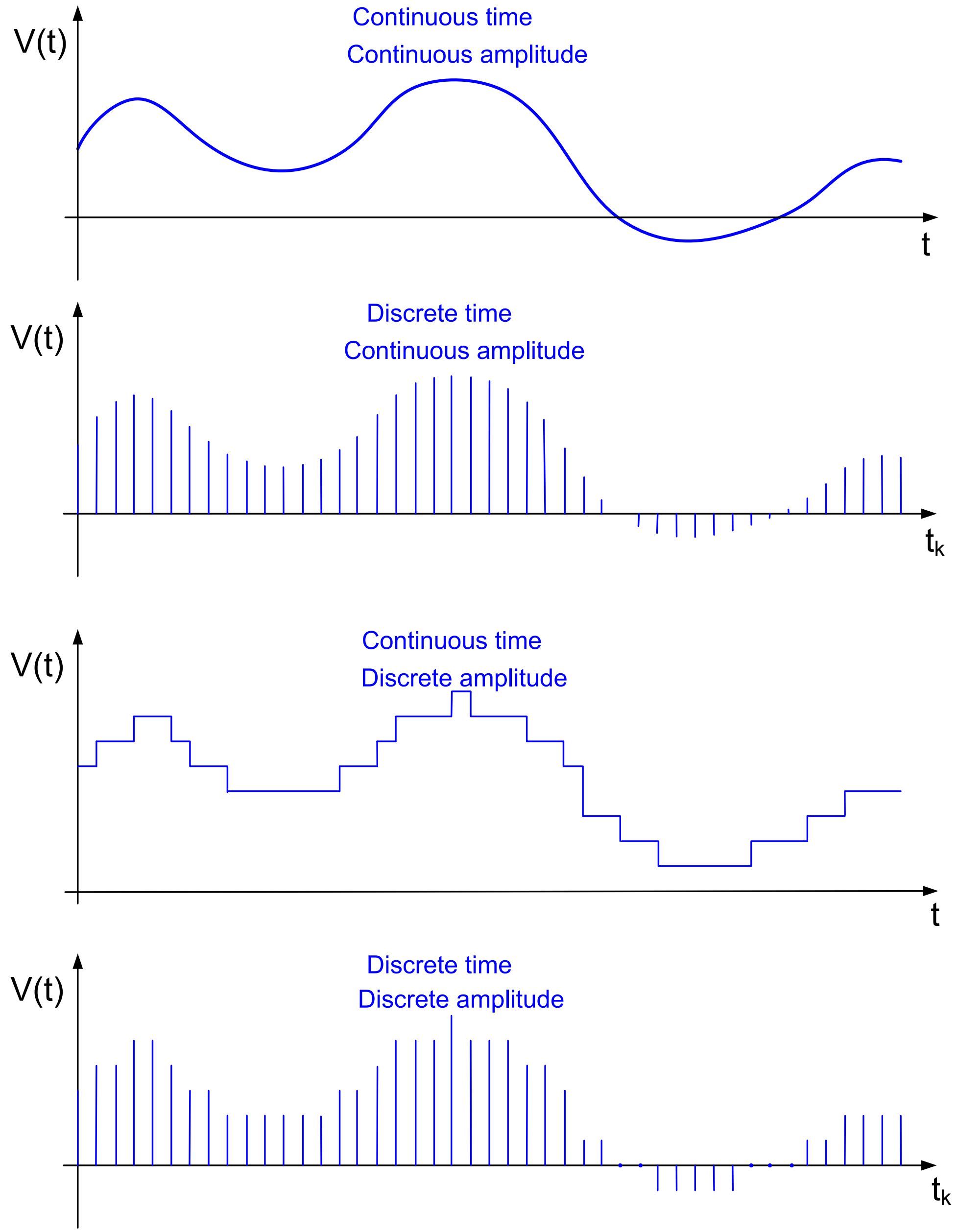


V(t)
Analog Signal
t

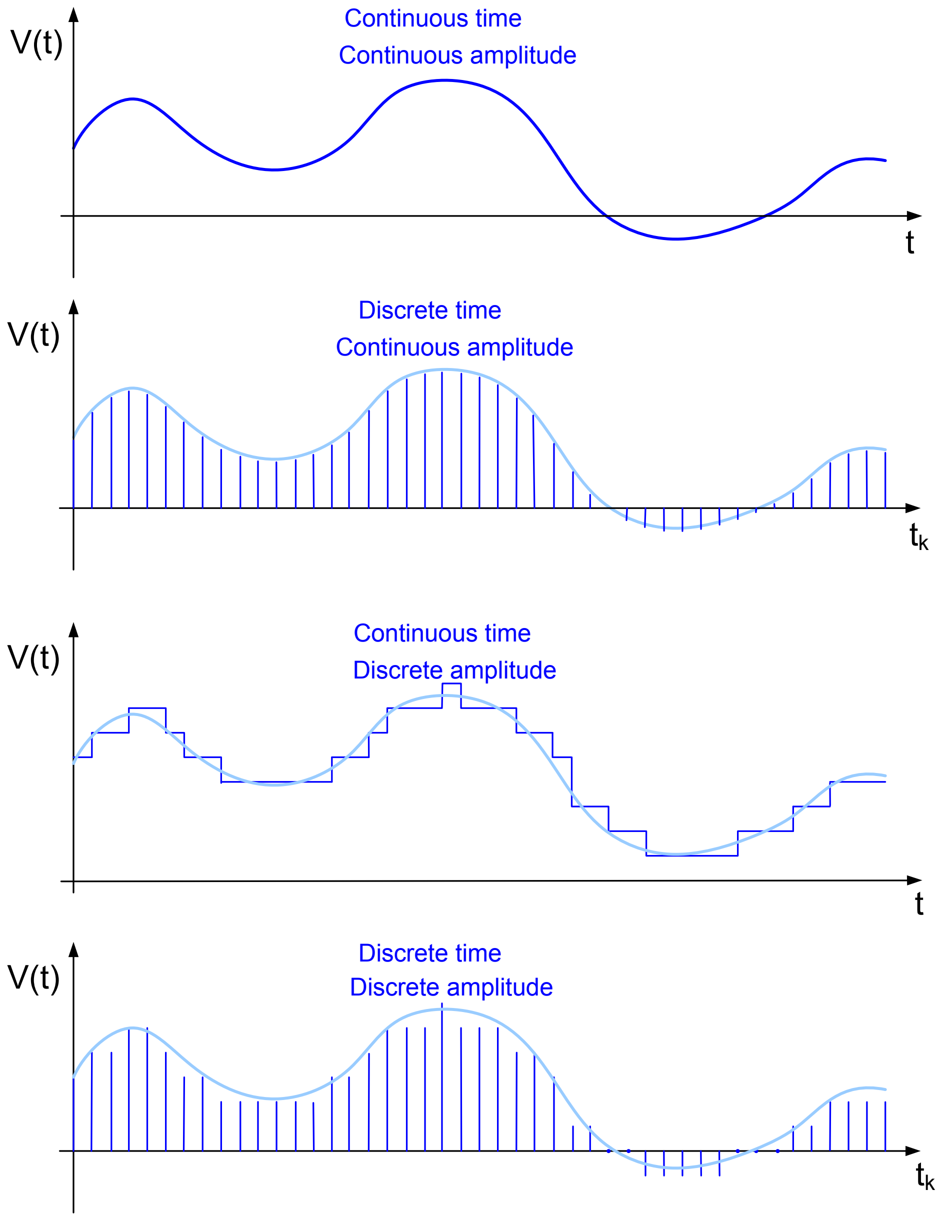


V(t)
Digital Signal
V_H
V_L
0 1 0 1 1 0 0 1 0 1 1 1 0 1 0 0
t

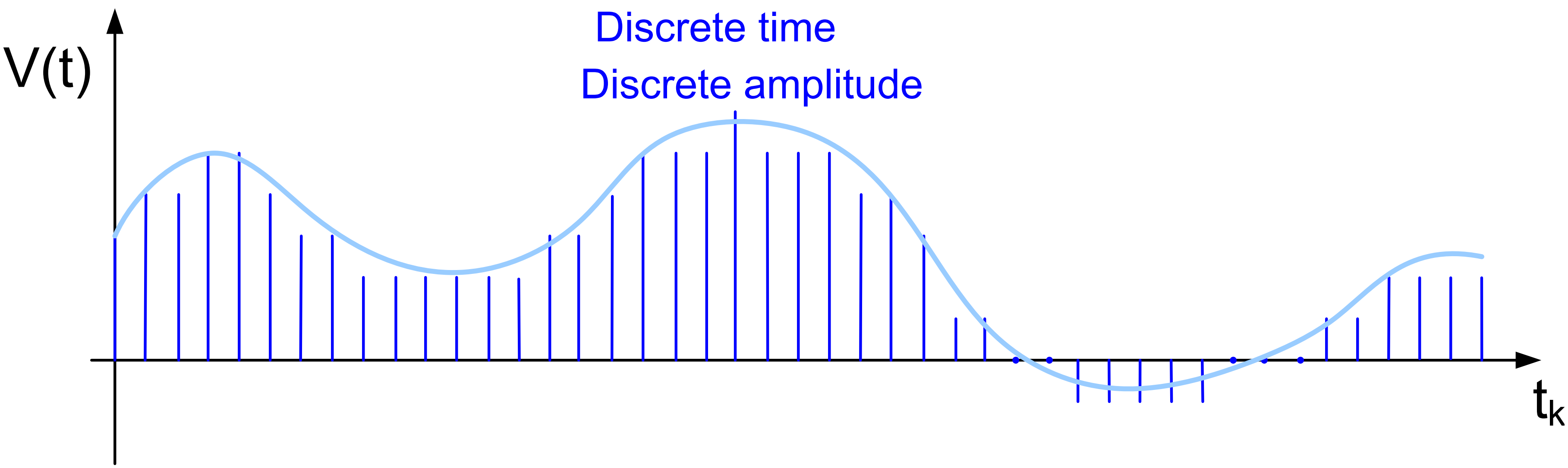
Basic Types of Analog Signals



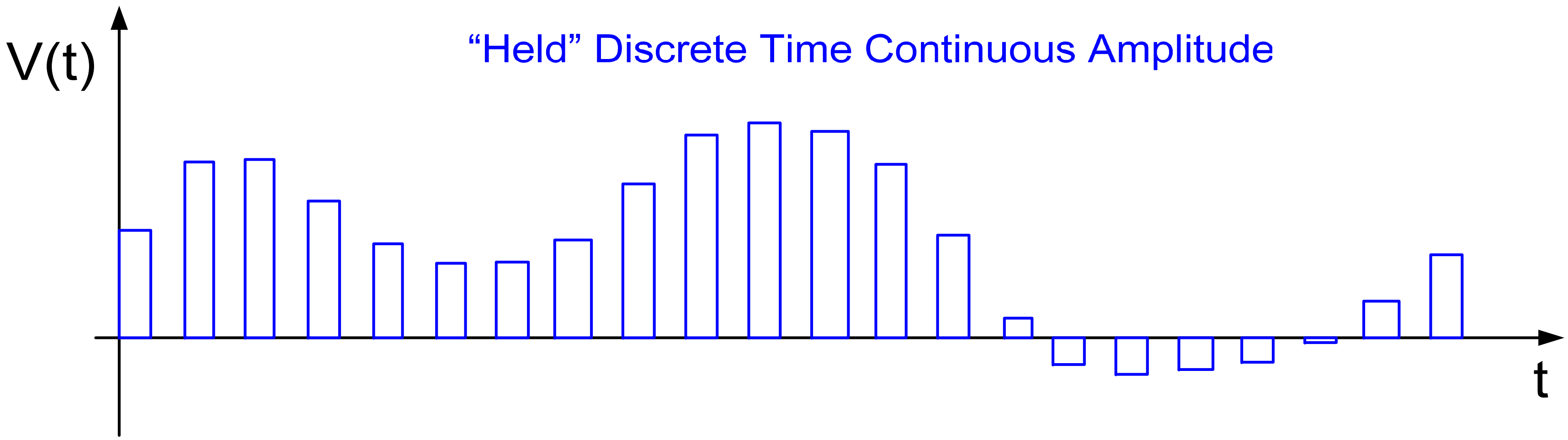
Often but not always represent the same analog CD/CA Analog Signal

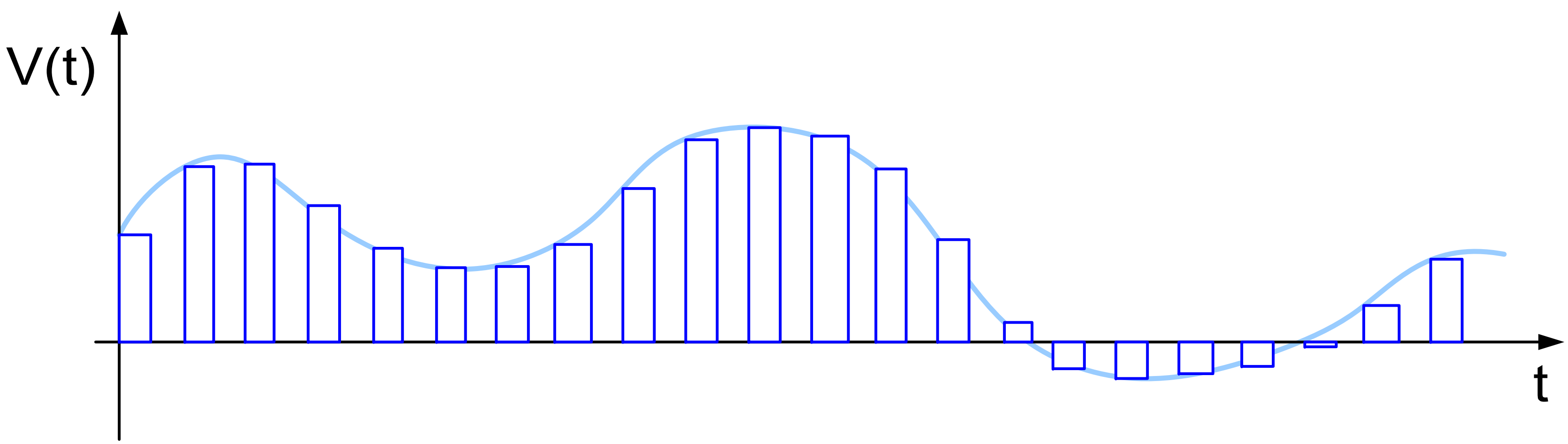


Discrete Time / Discrete Amplitude signals often obtained by sampling a Continuous-Time/Continuous Amplitude signal with an Analog to Digital Converter (ADC)

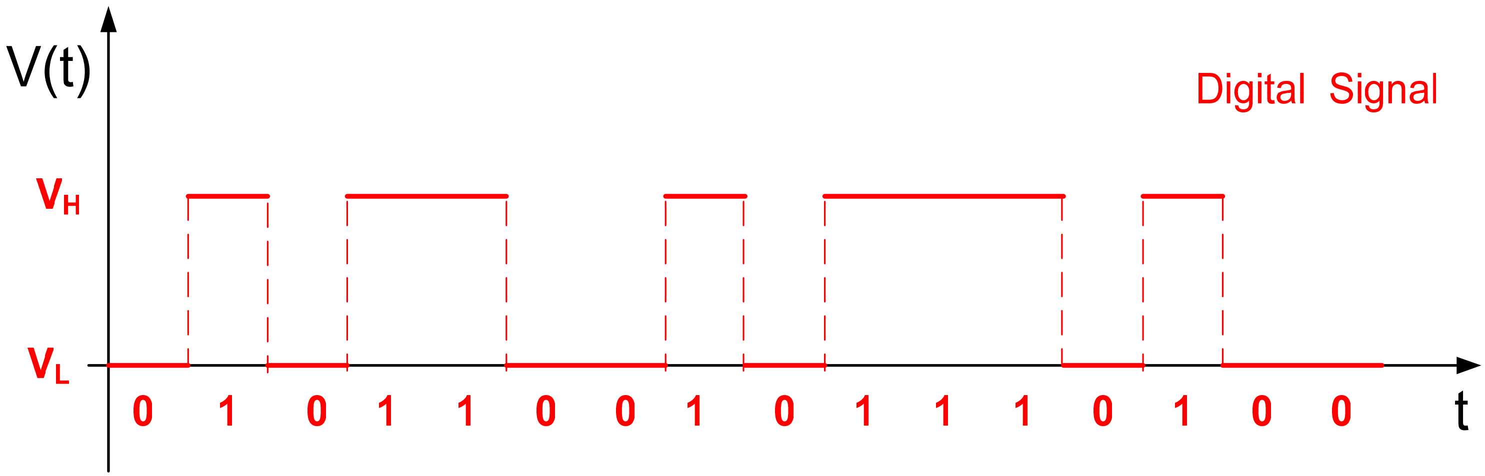


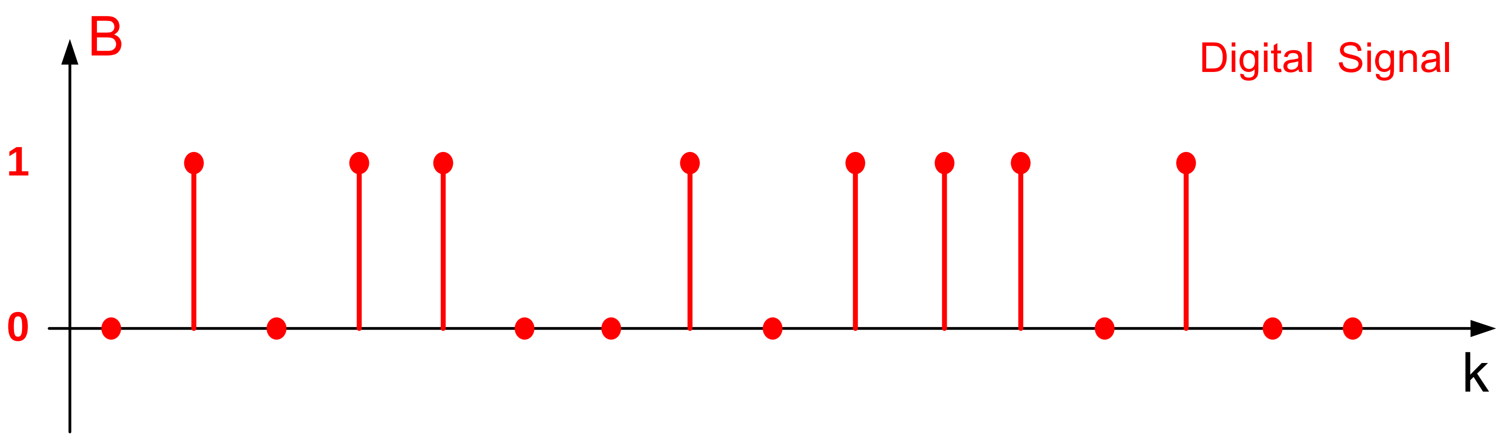
Sometimes the discrete-time analog signal is “held” for a finite interval





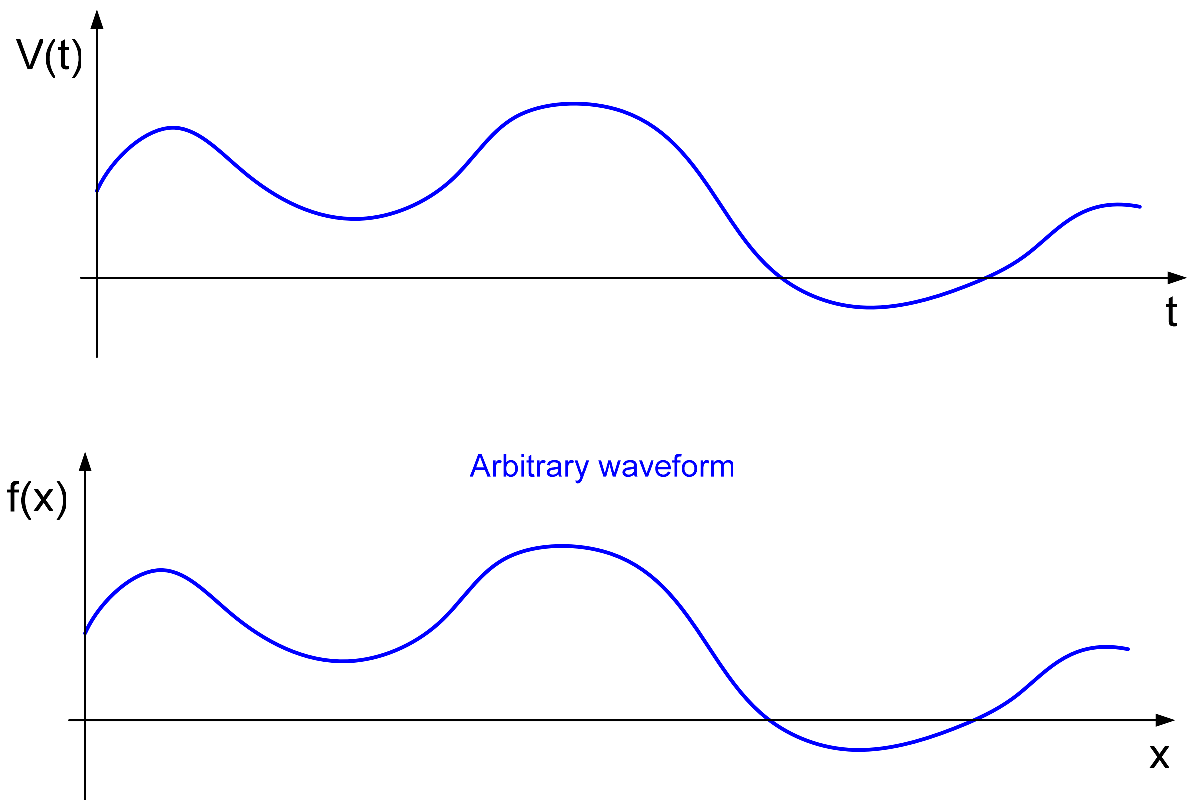
Basic Digital Signals





Often a special case of a Discrete Time Discrete Amplitude analog signal where there are only two amplitude levels

Signal variables



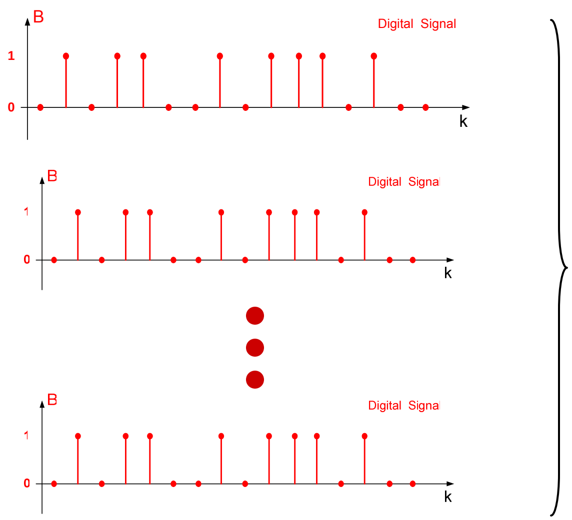
- Signals not necessarily voltage vs time
- Horizontal and vertical axis can have arbitrary dimensions (though horizontal axis is often time)

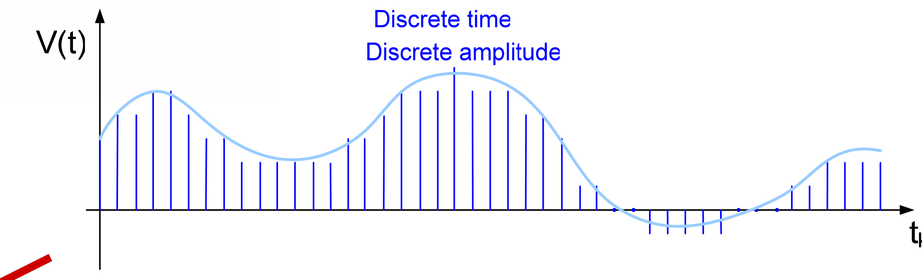
What type of “signals” do you receive when at a concert?

What type of “signals” are recorded for play-back later from a CD?

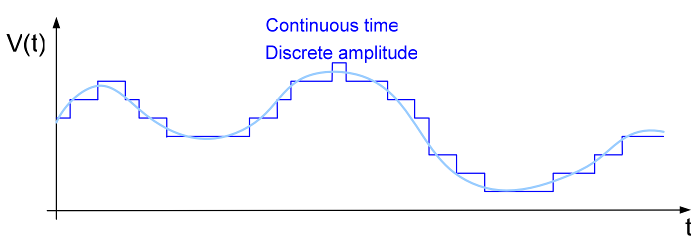
What type of “signals” appear at different parts of an audio playback system?

What type of “signals” a| an audio playback system?

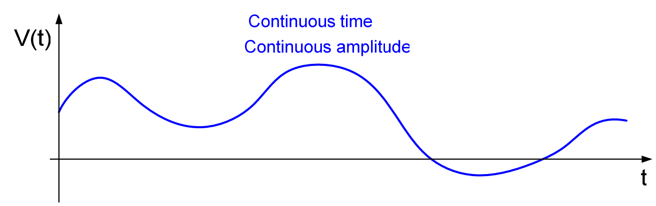




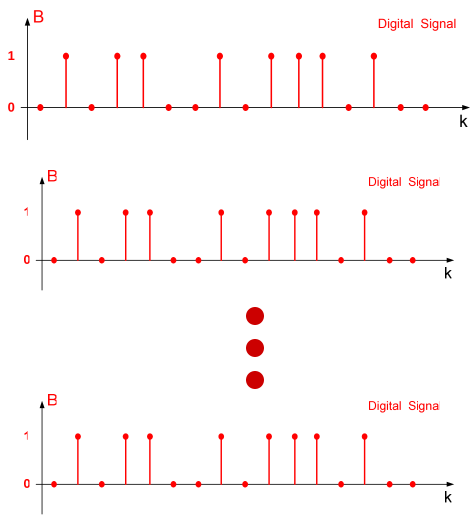
DAC



Filter and Amplifier



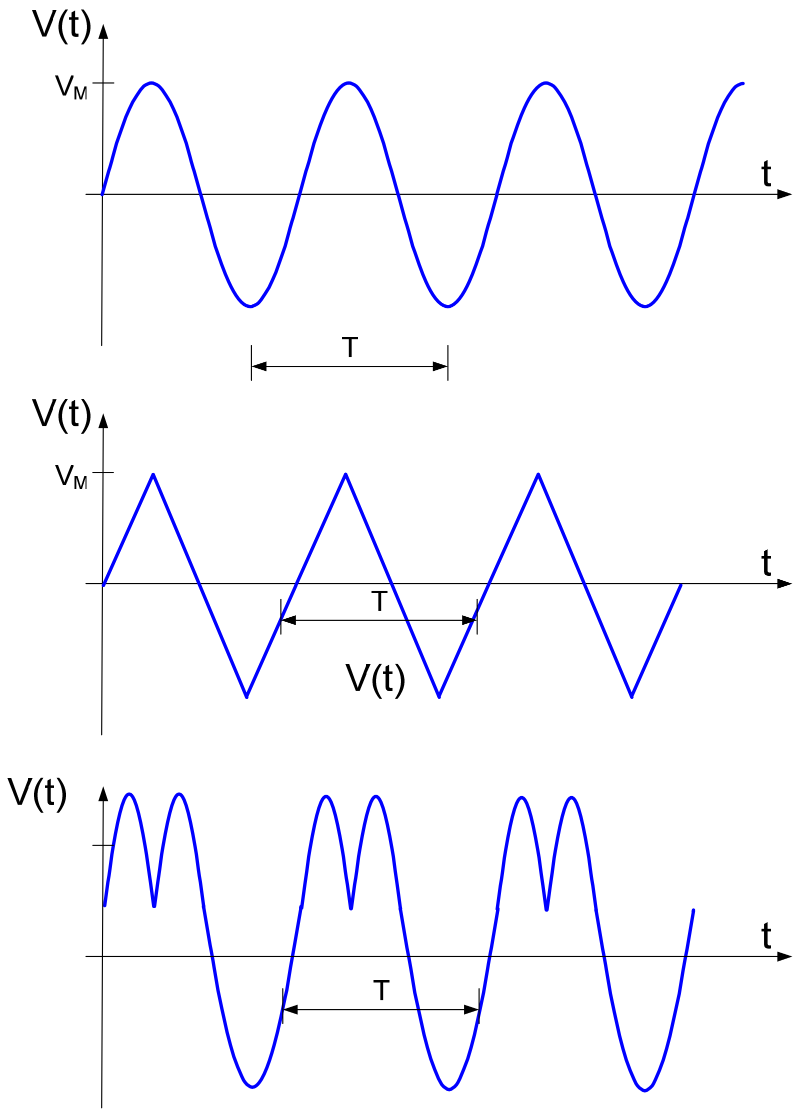
How many levels of audio (characterized by bits of resolution of the ADC/DAC) are used on commercial audio DVDs?



Audio on a DVD-Audio disc can be stored in many different bit depth/sampling rate/channel combinations:

	16-, 20- or 24-bit depth					
	44.1 kHz	48 kHz	88.2 kHz	96 kHz	176.4 kHz	192 kHz
Mono (1.0)	Yes	Yes	Yes	Yes	Yes	Yes
Stereo (2.0)	Yes	Yes	Yes	Yes	Yes	Yes
Stereo (2.1)	Yes	Yes	Yes	Yes	No	No
Stereo + mono surround (3.0 or 3.1)	Yes	Yes	Yes	Yes	No	No
Quad (4.0 or 4.1)	Yes	Yes	Yes	Yes	No	No
3-stereo (3.0 or 3.1)	Yes	Yes	Yes	Yes	No	No
3-stereo + mono surround (4.0 or 4.1)	Yes	Yes	Yes	Yes	No	No
Full surround (5.0 or 5.1)	Yes	Yes	Yes	Yes	No	No

Many useful continuous-time signals are nearly periodic



T is the period

Mathematical relationship for periodic signals

$$V(t+kT)=v(t)$$

Key property of many useful signals:

Theorem: If f(t) is periodic with period T, then f(t) can be expresses as

$$f(t) = \sum_{k=0}^{\infty} A_k \sin(k\omega t + \theta_k)$$

where A_k and θ_k are constants and $\omega = \frac{2\pi}{T} = 2\pi f$

This is termed the Fourier Series Representation of f(t)

$< A_k, \theta_k >_{k=0}^{\infty} = F(\omega)$ termed the frequency spectrum of f(t)

F(ω) is a vector sequence

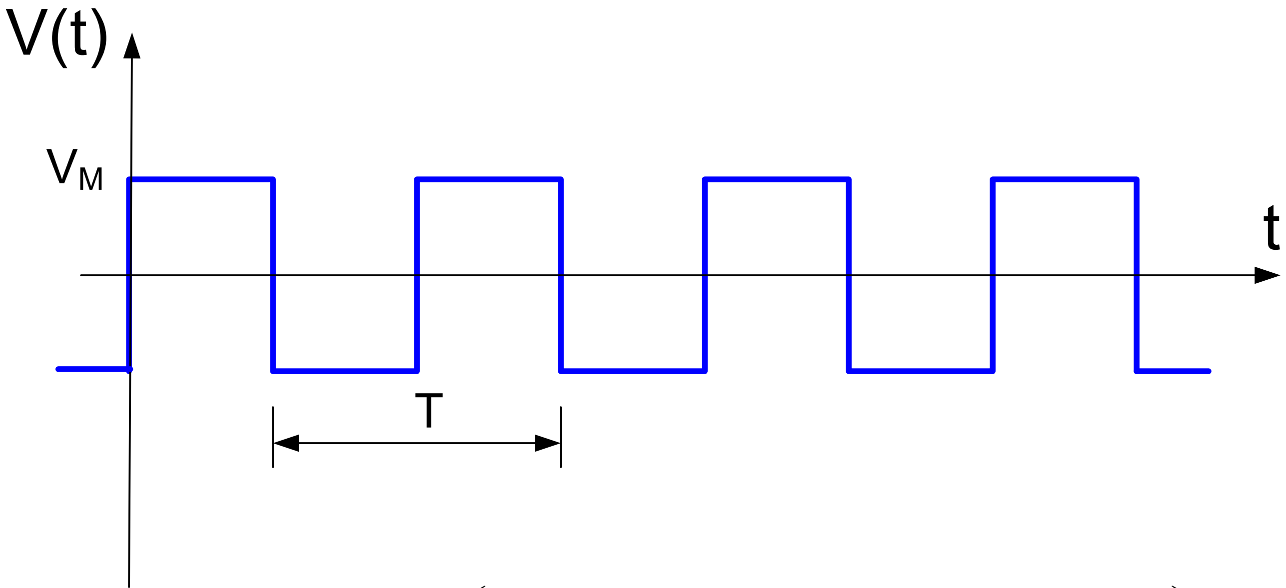
f(t) $\longleftrightarrow$ F(ω) represent a transform pair

$$f\left(t\right)=\sum_{k=0}^{\infty} A_k \sin(k\omega t+\theta_k)$$

A_1 termed the fundamental component of f(t)

for k=1, A_k termed the k^{th} harmonic of f(t)

Example: Consider a square wave

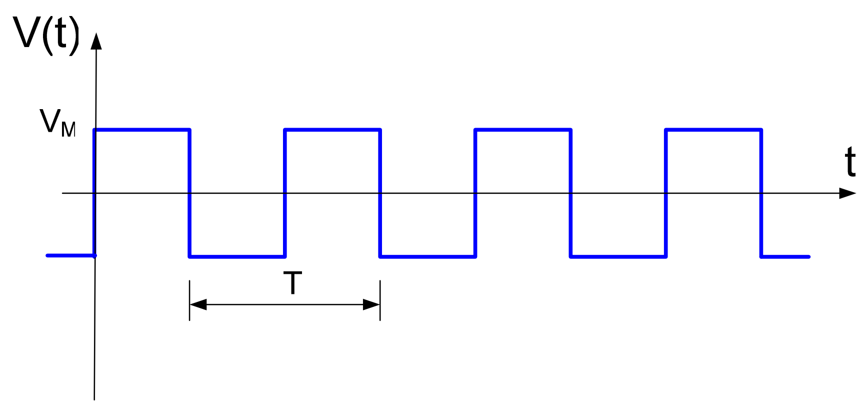


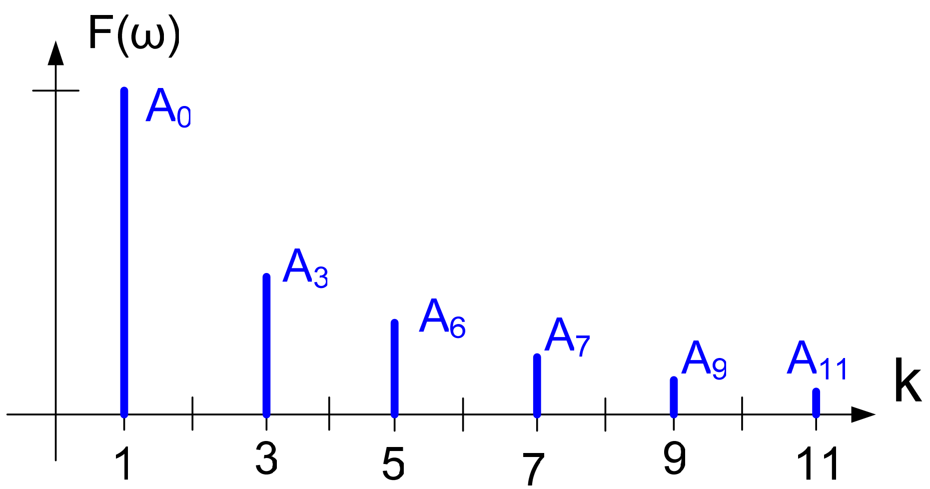
$$V_{SQ}(t) = \frac{4}{\pi} V_x \left(\sin \omega t + \frac{1}{3} \sin 3\omega t + \frac{1}{5} \sin 5\omega t + \ldots\ldots \right)$$

$$V_{SQ}(t) = \frac{4}{\pi} V_x \sum_{\substack{k=1 \\ k\ odd}}^{\infty} \frac{\sin k\omega t}{k}$$

where $\omega = \frac{2\pi}{T}$

Example: Consider a square wave



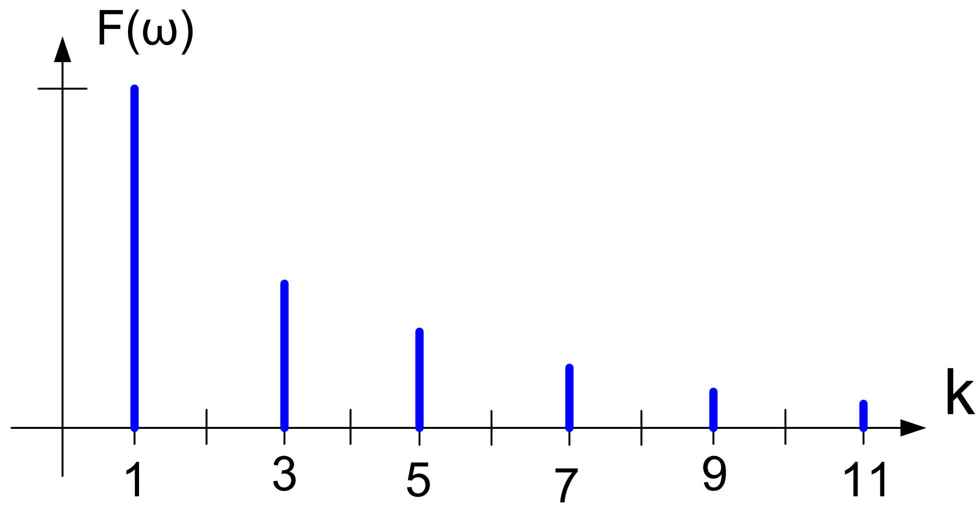


$$V_{SQ}(t) = \frac{4}{\pi} V_M \sum_{\substack{k=1 \\ k\ odd}}^{\infty} \frac{\sin k\omega t}{k}$$

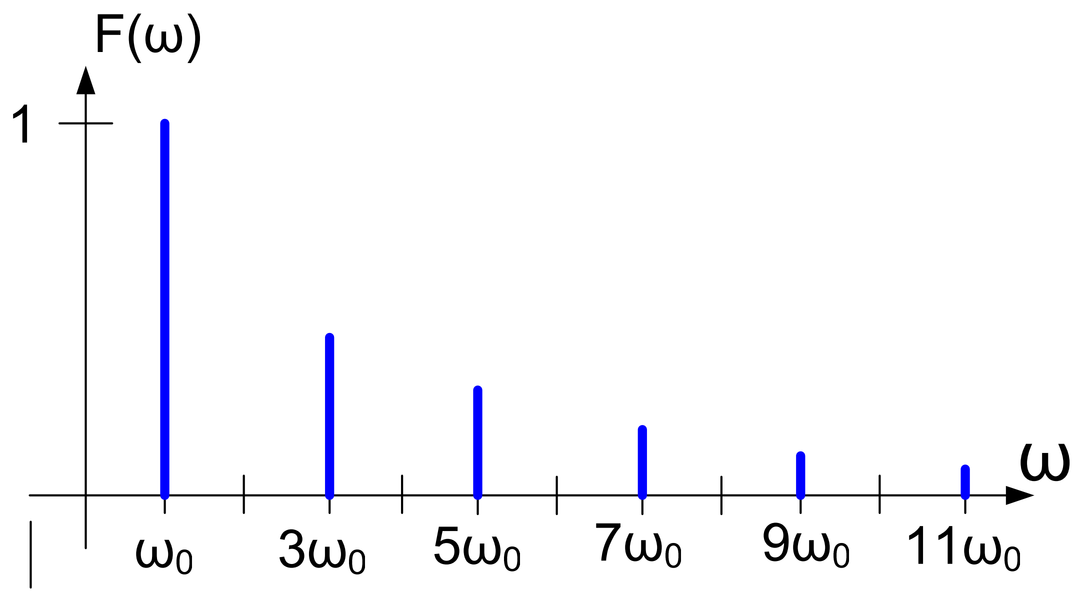
$$\omega = \frac{2\pi}{T}$$

$$A_k = \frac{4}{k\pi} V_M$$

Example: Consider a square wave



Often index axis is labeled in units of frequency



Other characteristics of signals

- Nonperiodic signals can also be represented in the frequency domain
- Fourier Transform used for this purpose
- Discrete Time Signals can also be represented in the frequenc domain
- Discrete Fourier Transoorm (DFT)) used for this purpose

Reason for interest in signals in an electronics course

- Often interested in knowing how nearly periodic signals propagate through a system
- Can be shown that this can be determined if know how sinusoidal signals propagate through a system
- Often design circuits so that sinusoidal signals will propagate through the circuit in a predetermined way
- This is the major reason a strong emphasis on analyzing circuits with sinusoidal excitations was made in EE 201