Dr. Cahit Karakuş

# ANALOG SİNYALLER

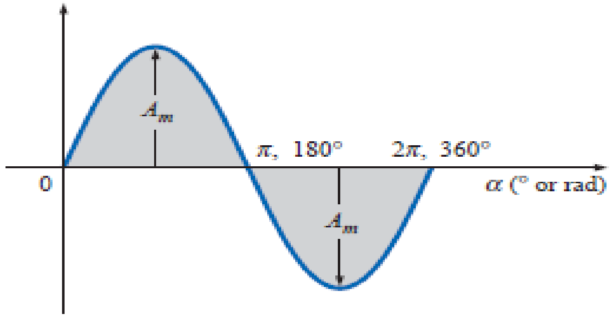
# Sinusoidal Waveform

- Mathematically it is represented as:

The basic mathematical format for the sinusoidal waveform is

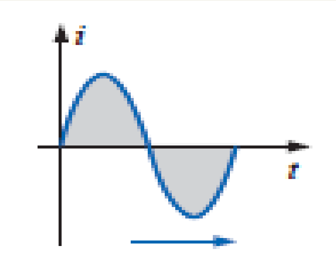
$$A_m \sin \alpha$$

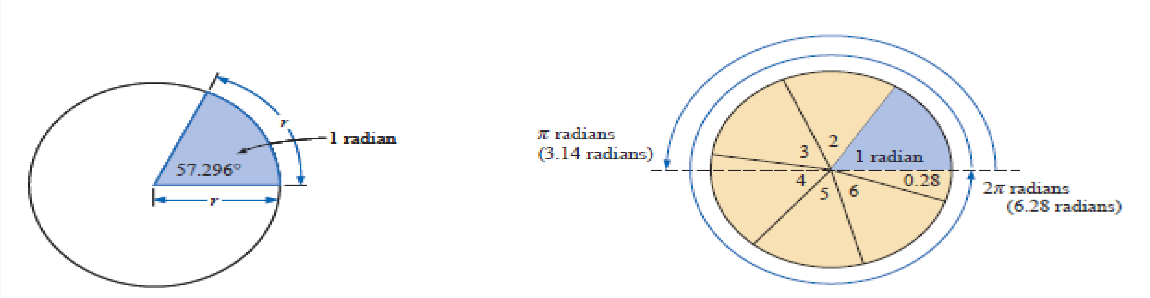
where $A_m$ is the peak value of the waveform and $\alpha$ is the unit of measure for the horizontal axis, as shown in Fig

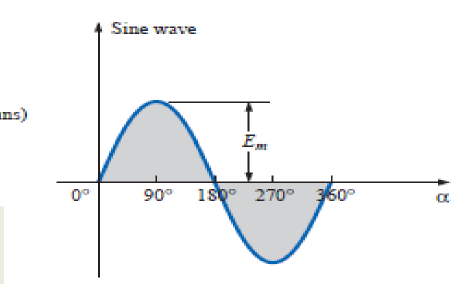


# Sinusoidal Waveform

- Unit of measurement for horizontal axis can be time , degrees or radians.



# Sinusoidal Waveform

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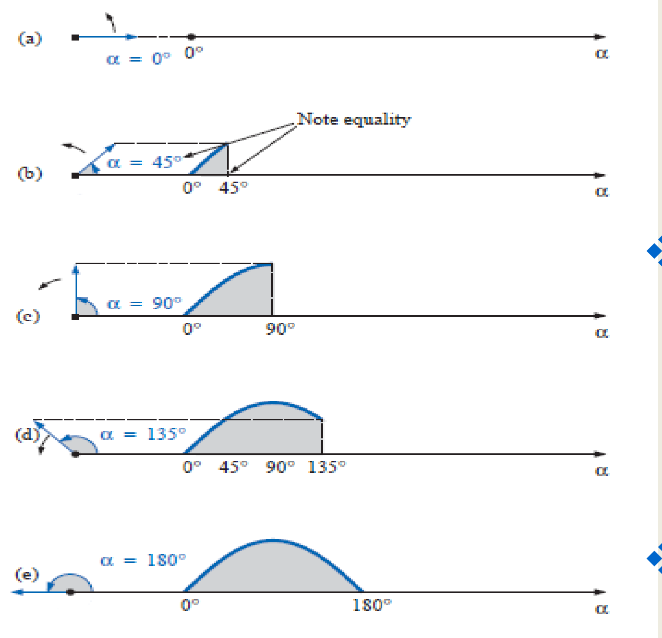



Vertical projection of radius vector rotating in a uniform circular motion about a fixed point

- Angular Velocity

$$\omega = \frac{\alpha}{t}$$

$$\alpha = \omega t$$

- Time required e one revolution is T

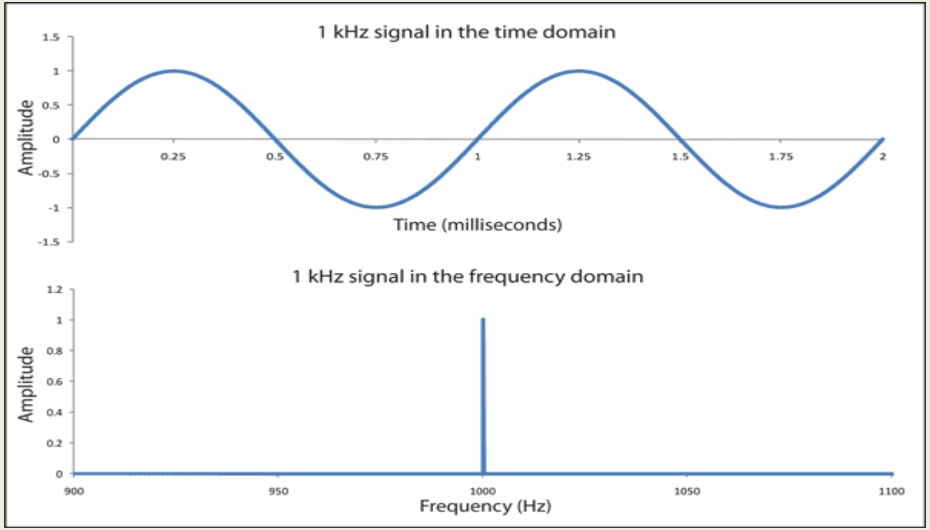
$$\omega = \frac{2\pi}{T}$$

$$\omega = 2\pi f \quad \text{(rad/s)}$$

# Frequency of Sinusoidal

- Every signal can be described both in the time domain and the frequency domain.

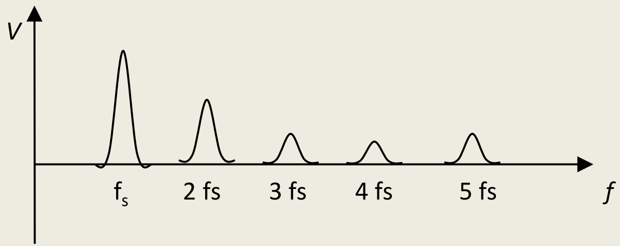
  - Frequency representation of sinusoidal signal is:



# A periodic signal in frequency domain

- Every signal can be described both in the time domain and the frequency domain.

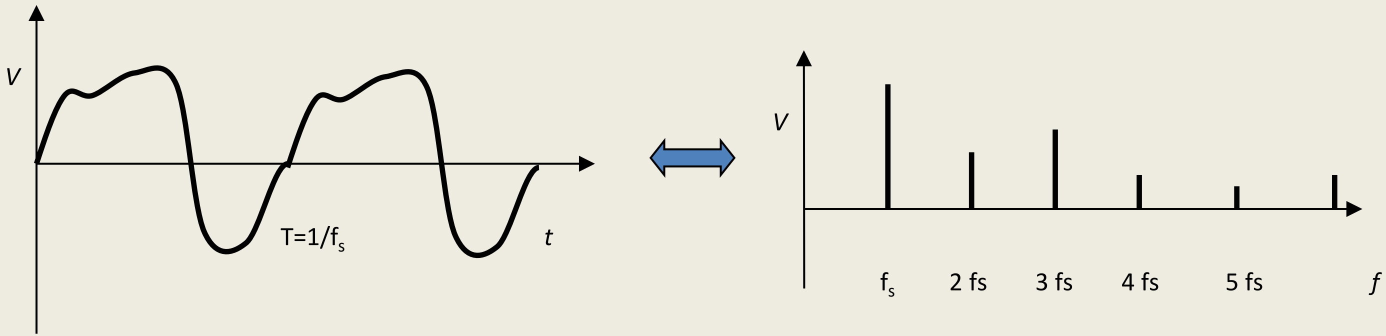
  - A periodic signal is always a sine or cosine or the (weighted) sum of sines and cosines.
  - Frequency representation of periodic signal is:



# A periodic signal in frequency domain

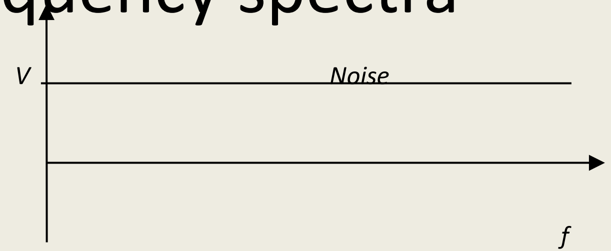
- A periodic signal (in the time domain) can in the frequency domain be represented by:

  - A peak at the fundamental frequency for the signal, $f_s=1/T$
  - And multiples of the fundamental $f_1, f_2, f_3, \ldots = 1^x f_s, 2^x f_s, 2^x f_s$



# Non periodic signal in frequency domain

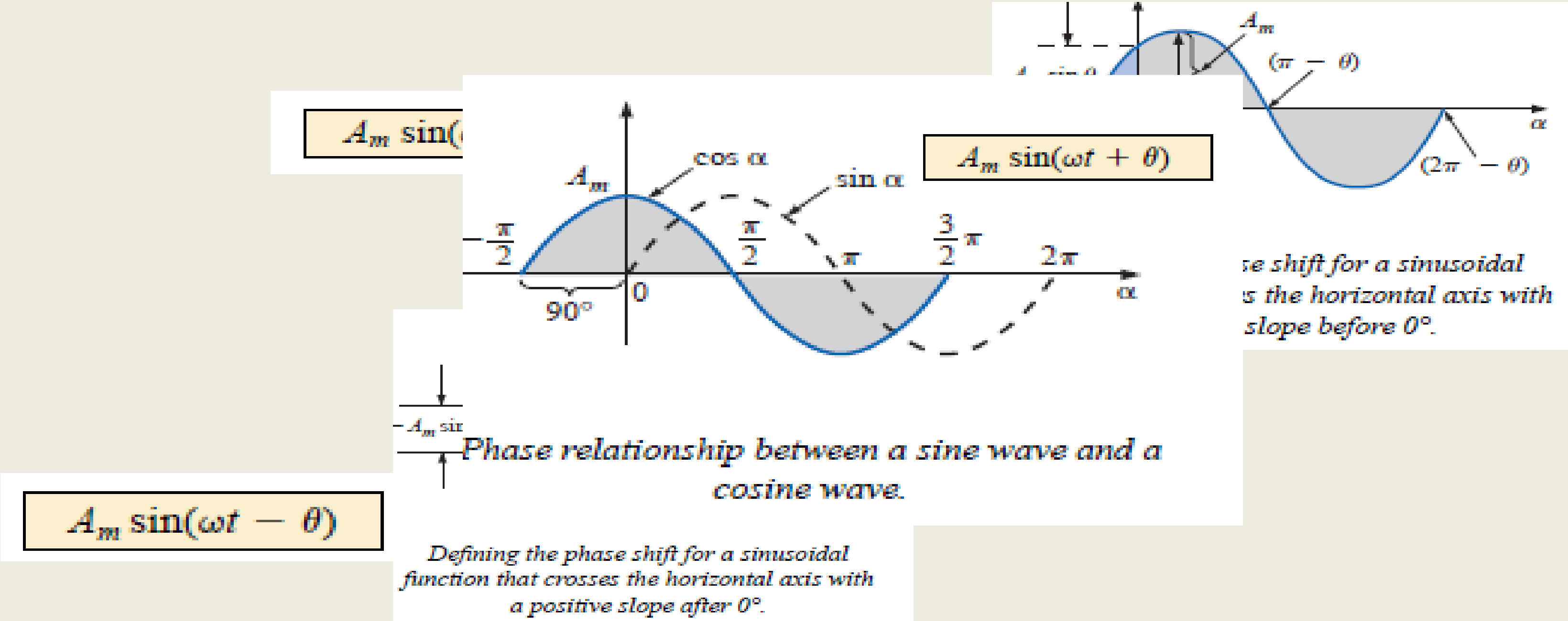
- A non periodic (varying) signal time domain is spread in the frequency domain.
- A completely random signal (white noise) have a uniform frequency spectra



# Phase Relation

❖ The maxima and the minima at pi/2,3pi/2 and 0,2pi can be shifted to some other angle.

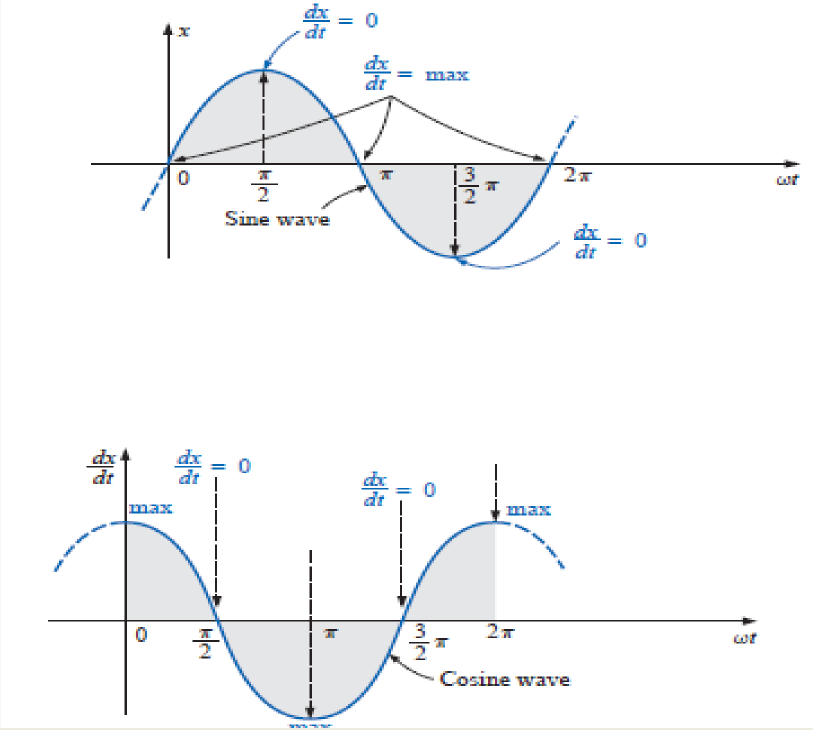
The expression in this case would be:

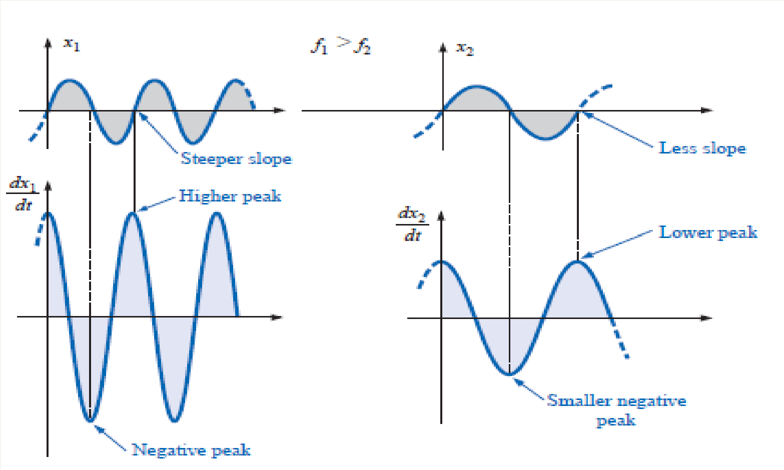



Phase relationship between a sine wave and a cosine wave.

Defining the phase shift for a sinusoidal function that crosses the horizontal axis with a positive slope after 0°.

# Derivative of sinusoidal

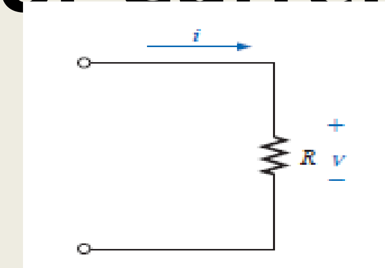


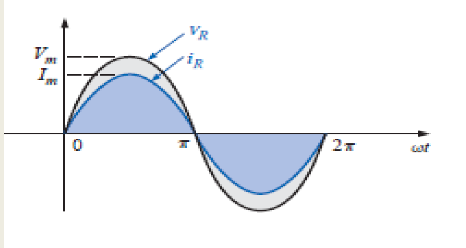



# Response of R to Sinusoidal Voltage or Current

- **Resistor** at a particular frequency

$$I_m = \frac{V_m}{R}$$



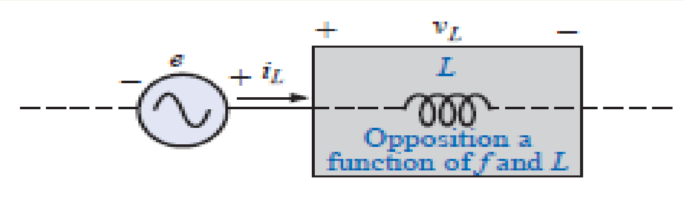



*The voltage and current of a resistive element are in phase.*

$$V_m = I_m R$$

*for a purely resistive element, the voltage across and the current through the element are in phase, with their peak values related by Ohm's law.*

# Response of L to Sinusoidal Voltage or Curre

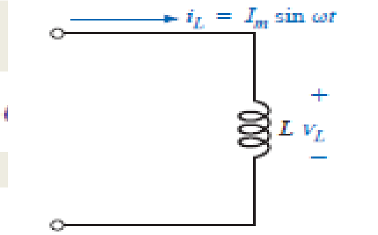



- **Inductor** at a particular frequency

$$v_L = L\frac{di_L}{dt}$$

and, applying differentiation,

*for an inductor, $v_L$ leads $i_L$ by 90°,*

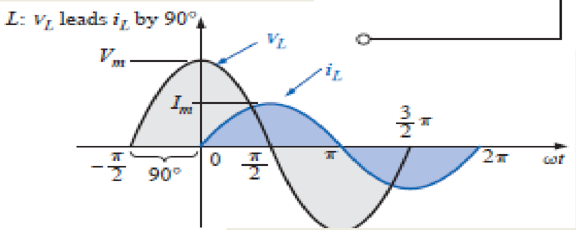



$$\frac{di_L}{dt} = \frac{d}{dt}(I_m \sin \omega t) = \omega I_m \cos \omega t$$

Therefore, $v_L = L\frac{di_L}{dt} = L(\omega I_m \cos \omega t) = \omega L I_m \cos \omega t$

or $v_L = V_m \sin(\omega t + 90°)$

where $V_m = \omega L I_m$

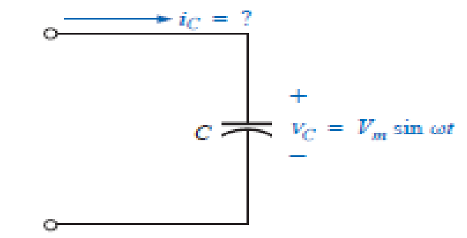



$$\text{Opposition} = \frac{V_m}{I_m} = \frac{\omega L I_m}{I_m} = \omega L$$

$$X_L = \omega L$$

# Response of C to Sinusoidal Voltage or Current

- **Capacitor** at a particular frequency




$$i_C = C\frac{dv_C}{dt}$$

and, applying differentiation,

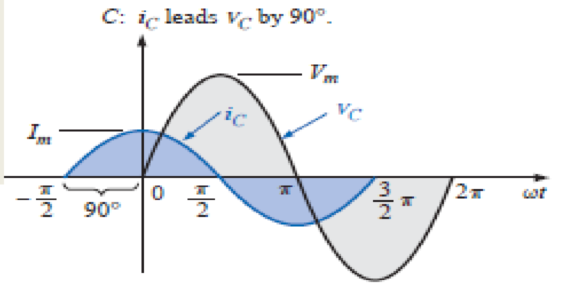
$$\frac{dv_C}{dt} = \frac{d}{dt}(V_m \sin \omega t) = \omega V_m \cos \omega t$$

$$i_C = C\frac{dv_C}{dt} = C(\omega V_m \cos \omega t) = \omega C V_m \cos \omega t$$

$$i_C = I_m \sin(\omega t + 90°)$$

$$I_m = \omega C V_m$$

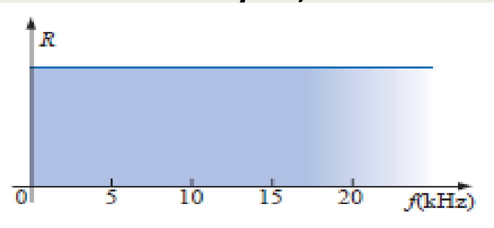
$$X_C = \frac{1}{\omega C}$$

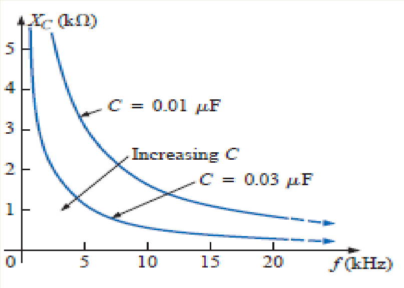



*for a capacitor, $i_C$ leads $v_C$ by 90°, or $v_C$ lags $i_C$ by 90°.**

# Frequency Response of R,L,C

- How varying frequency affects the opposition offered by R,L and C

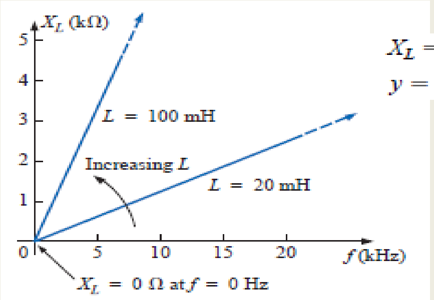



$$X_C = \frac{1}{2\pi f C}$$

$$X_C f = \frac{1}{2\pi C}$$

$$yx = k$$



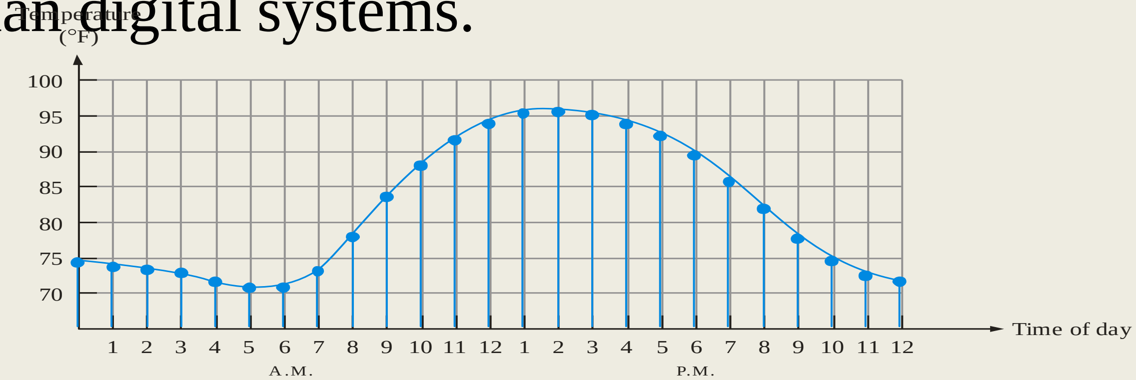

$$X_L = \omega L = 2\pi f L = 2\pi L f$$

$$y = mx + b = (2\pi L)f + 0$$

*In summary, therefore, as the applied frequency increases, the resistance of a resistor remains constant, the reactance of an inductor increases linearly, and the reactance of a capacitor decreases nonlinearly.*

# Analog Quantities

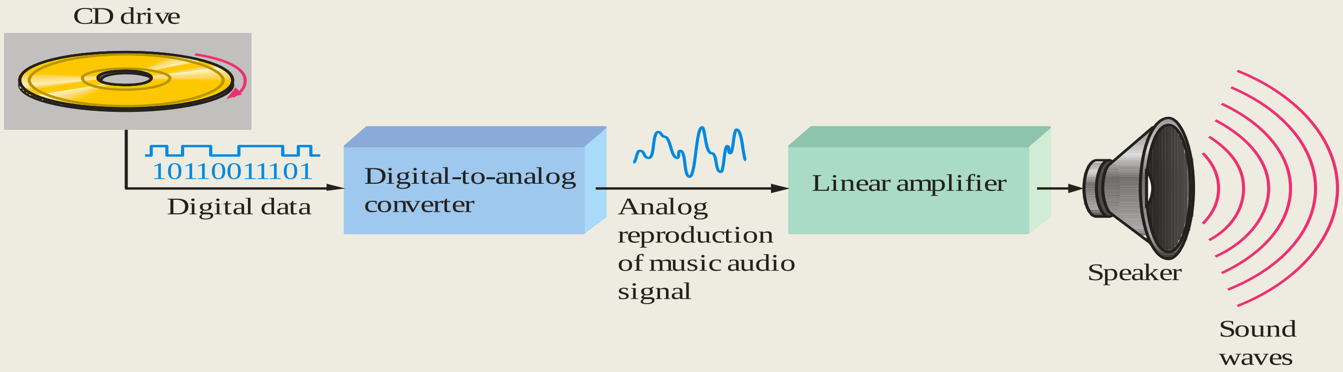
Most natural quantities that we see are **analog** and vary continuously. Analog systems can generally handle higher power than digital systems.




Digital systems can process, store, and transmit data more efficiently but can only assign discrete values to each point.

# Analog and Digital Systems

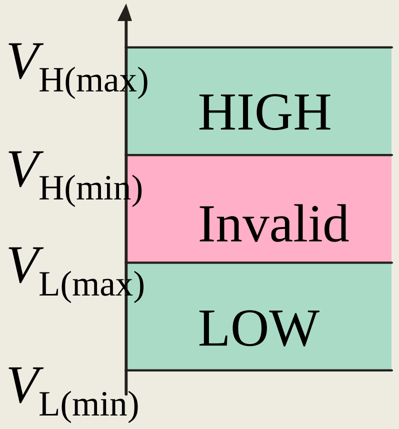
Many systems use a mix of analog and digital electronics to take advantage of each technology. A typical CD player accepts digital data from the CD drive and converts it to an analog signal for amplification.



## Binary Digits and Logic Levels

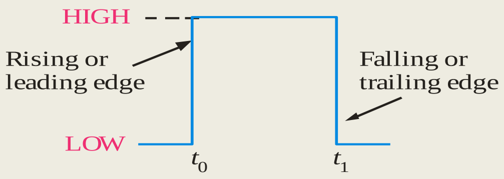
Digital electronics uses circuits that have two states, which are represented by two different voltage levels called HIGH and LOW. The voltages represent numbers in the binary system.

In binary, a single number is called a *bit* (for *b*inary dig*it*). A bit can have the value of either a 0 or a 1, depending on if the voltage is HIGH or LOW.

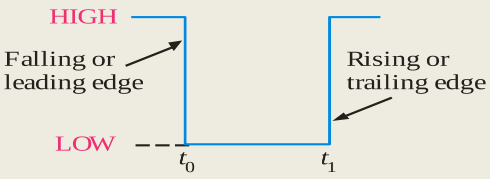


# Digital Waveforms

Digital waveforms change between the LOW and HIGH levels. A positive going pulse is one that goes from a normally LOW logic level to a HIGH level and then back again. Digital waveforms are made up of a series of pulses.



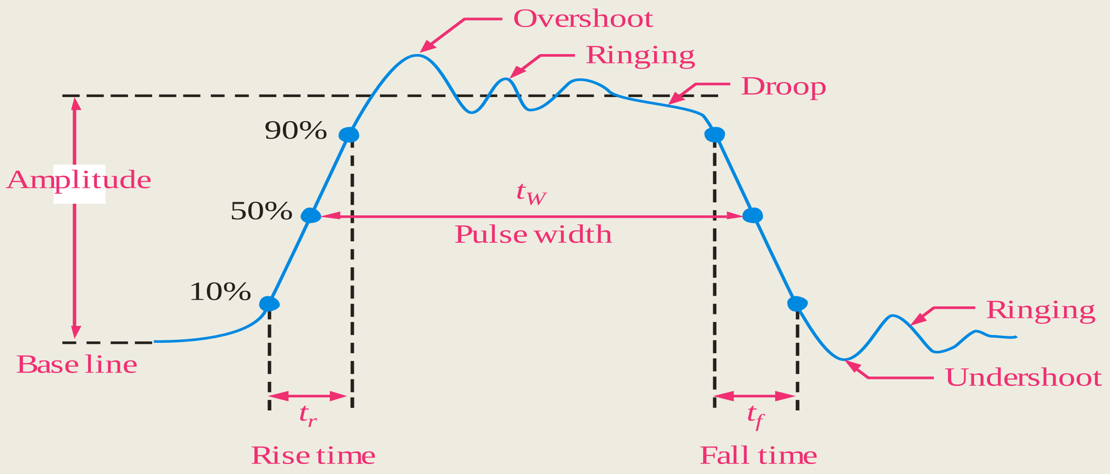

(a) Positive–going pulse




(b) Negative–going pulse

# Pulse Definitions

Actual pulses are not ideal but are described by the rise time, fall time, amplitude, and other characteristics.



# Periodic Pulse Waveforms

Periodic pulse waveforms are composed of pulses that repeats in a fixed interval called the **period**. The **frequency** is the rate it repeats and is measured in hertz.

$$f = \frac{1}{T} \qquad\qquad T = \frac{1}{f}$$

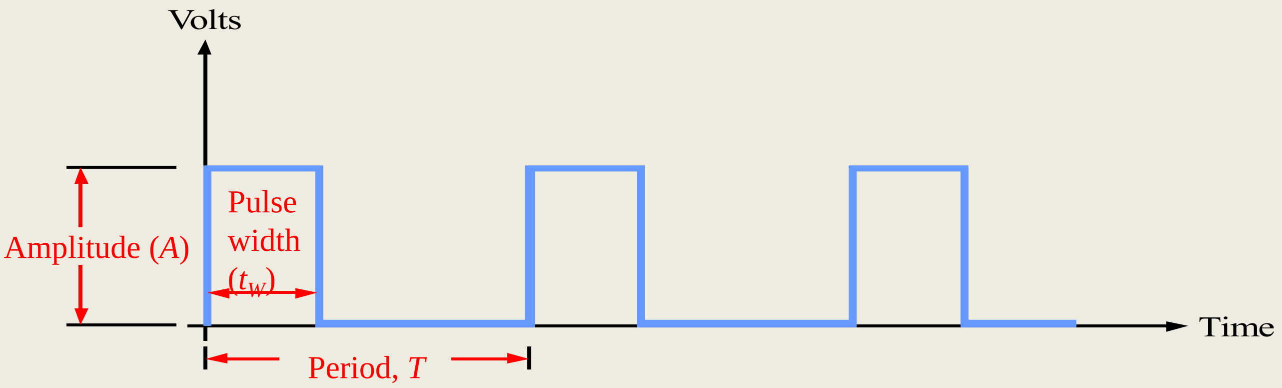
The **clock** is a basic timing signal that is an example of a periodic wave.

What is the period of a repetitive wave if $f$ = 3.2 GHz?

$$T = \frac{1}{f} = \frac{1}{3.2\ \text{GHz}} = \quad 313\ \text{ps}$$

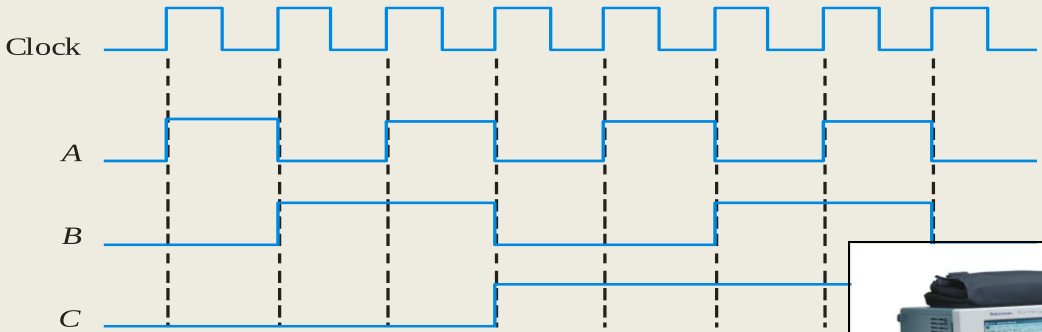
# Pulse Definitions

In addition to frequency and period, repetitive pulse waveforms are described by the amplitude ($A$), pulse width ($t_W$) and duty cycle. Duty cycle is the ratio of $t_W$ to $T$.



# Timing Diagrams

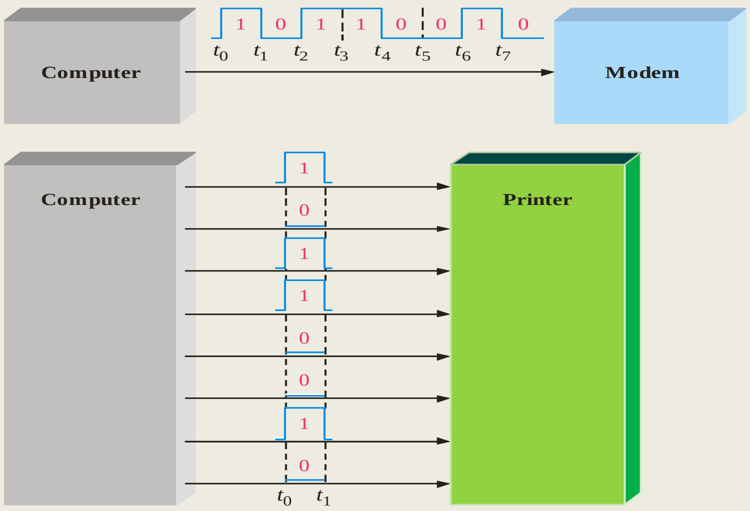
A timing diagram is used to show the relationship between two or more digital waveforms,




A diagram like this can be observed directly on a logic analyzer.

# Serial and Parallel Data

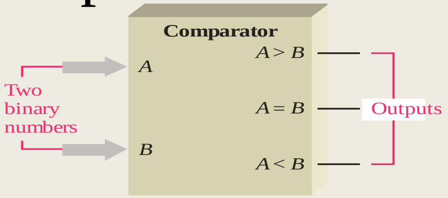
Data can be transmitted by either serial transfer or parallel transfer.



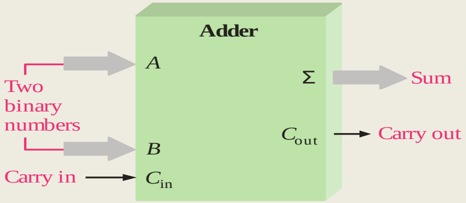
# Basic System Functions

**And**, **or**, and **not** elements can be combined to form various logic functions. A few examples are:

The comparison function

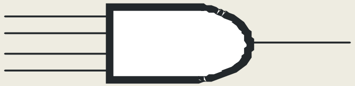



Basic arithmetic functions

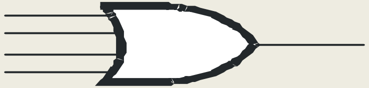


# Basic Logic Functions

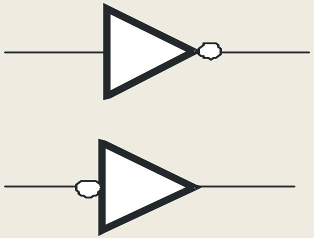
**AND** True only if ***all*** input conditions are true.



**OR** True only if ***one or more*** input conditions are true.



**NOT** Indicates the ***opposite*** condition.



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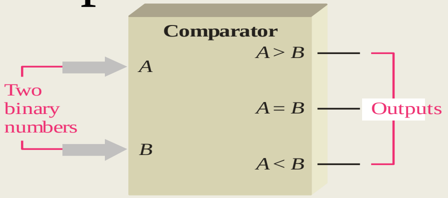
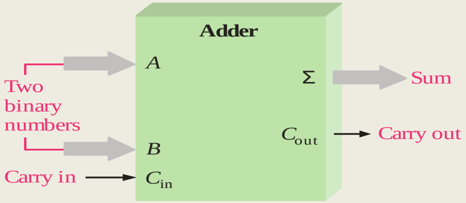
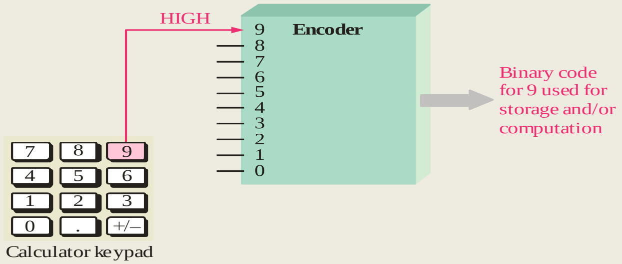



Basic arithmetic functions

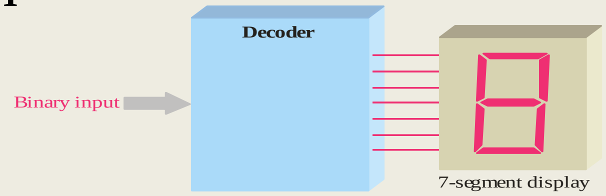


# Basic System Functions

The encoding function

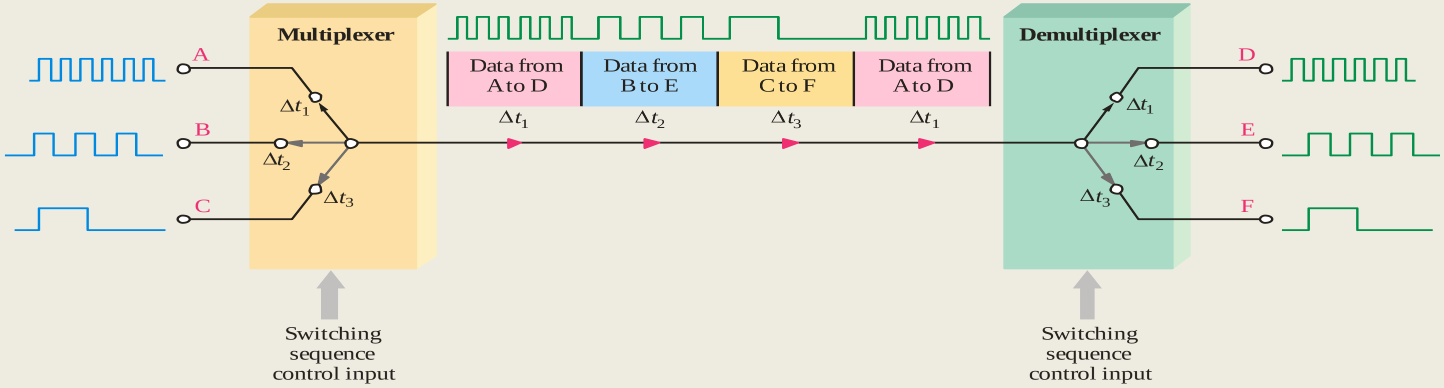



The decoding function



# Basic System Functions

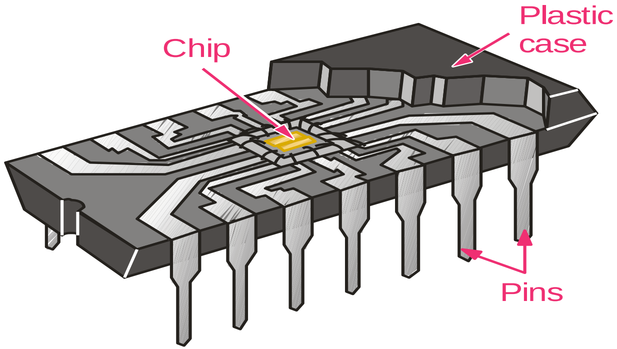
## The data selection function



# Summary

## Integrated Circuits

Cutaway view of DIP (Dual-In-line Pins) chip:

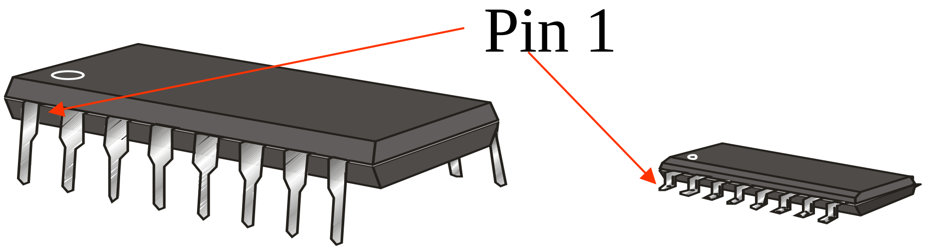



The TTL series, available as DIPs are popular for laboratory experiments with logic.

# Summary

## Integrated Circuits

DIP chips and surface mount chips



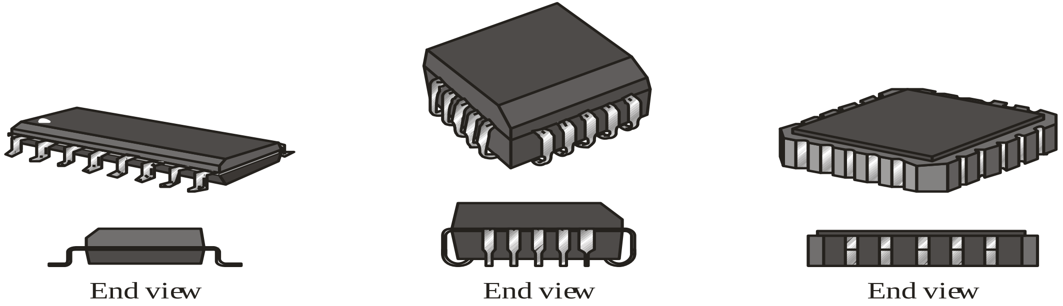

Dual in-line package

Small outline IC (SOIC)

# Summary

## Integrated Circuits

Other surface mount packages:

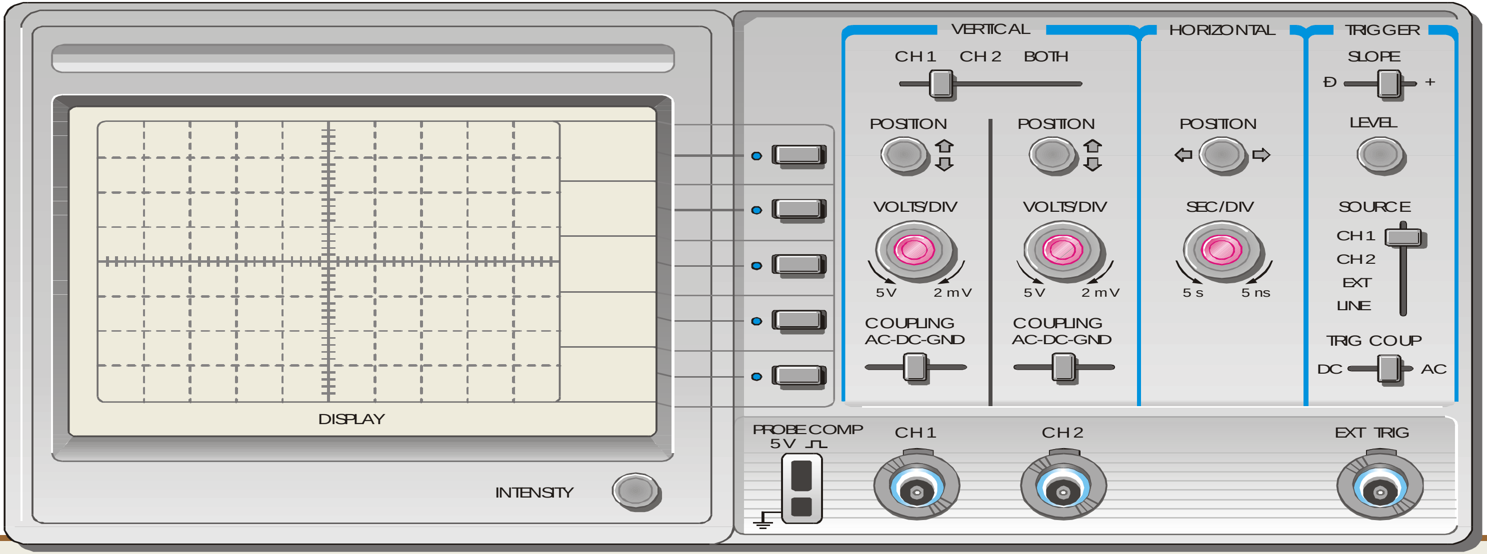



SOIC PLCC LCCC

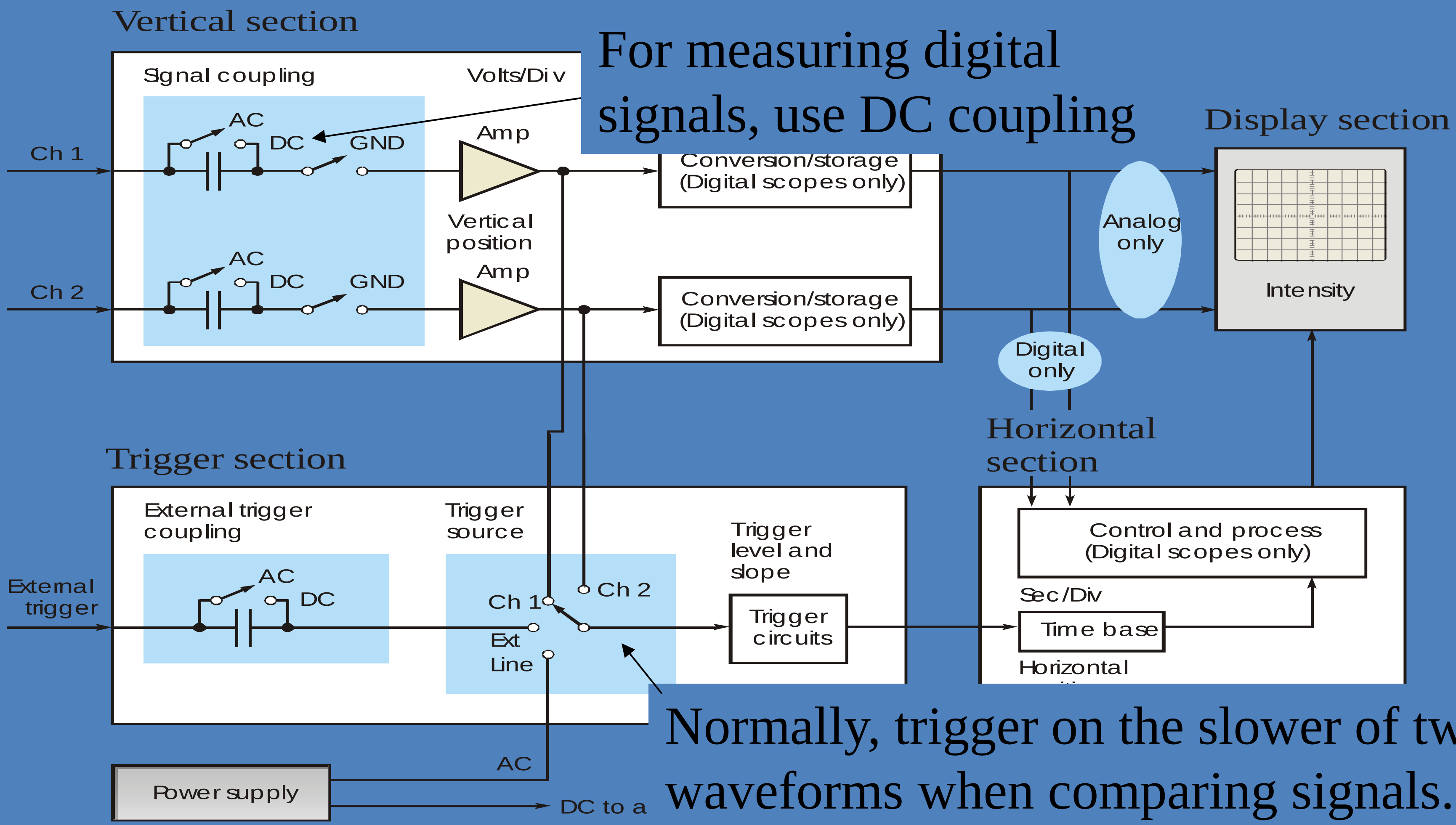
# Summary

## Test and Measurement Instruments

The front panel controls for a general-purpose oscilloscope can be divided into four major groups.



For measuring digital signals, use DC coupling

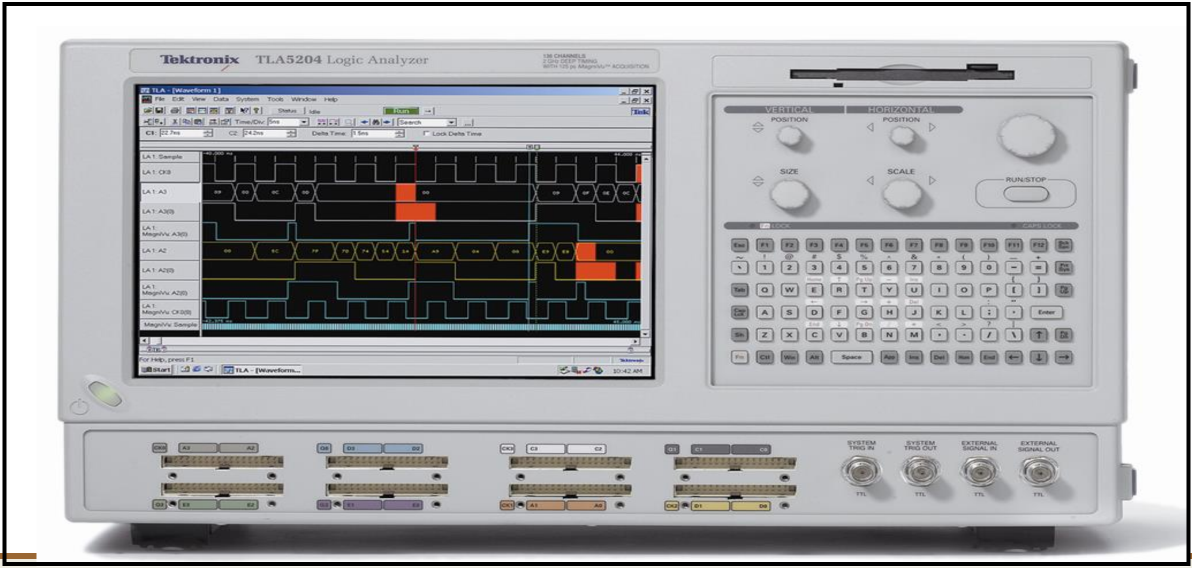



Normally, trigger on the slower of two waveforms when comparing signals.

# Summary

## Test and Measurement Instruments

The logic analyzer can display multiple channels of digital information or show data in tabular form.



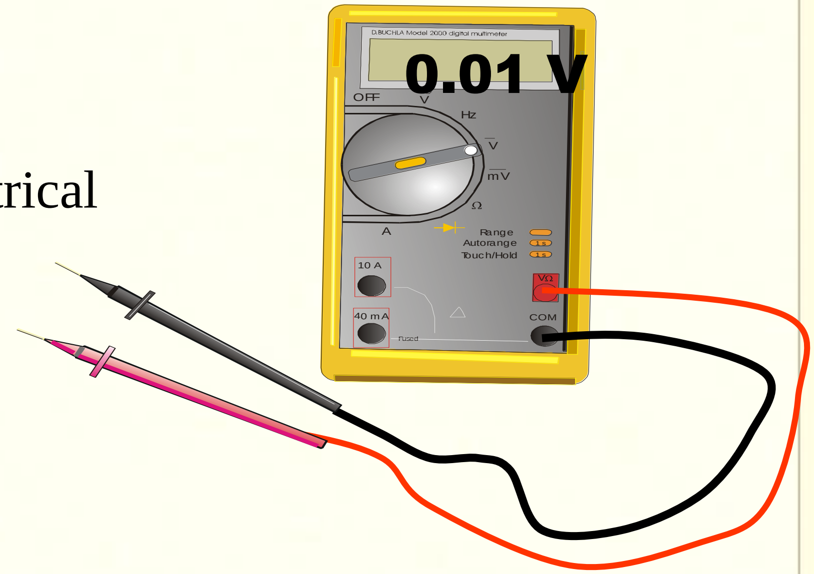
# Test and Measurement Instruments

The DMM can make three basic electrical measurements.

Voltage

Resistance

Current

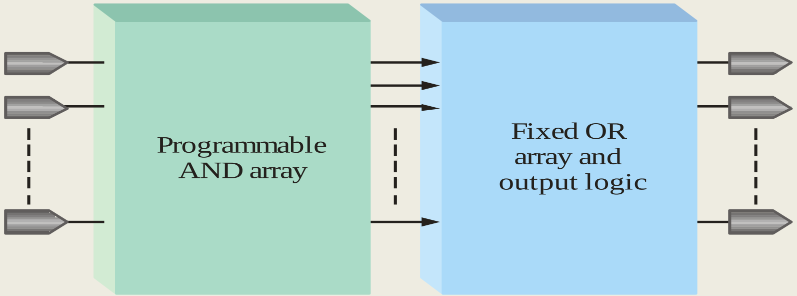



In digital work, DMMs are useful for checking power supply voltages, verifying resistors, testing continuity, and occasionally making other measurements.

# Programmable Logic

Programmable logic devices (PLDs) are an alternative to fixed function devices. The logic can be programmed for a specific purpose.  In general, they cost less and use less board space that fixed function devices.

A PAL device is a form of PLD that uses a combination of a programmable AND array and a fixed OR array:



***Analog***

***Digital***

***Binary***

***Bit***

***Pulse***

Being continuous or having continuous values.

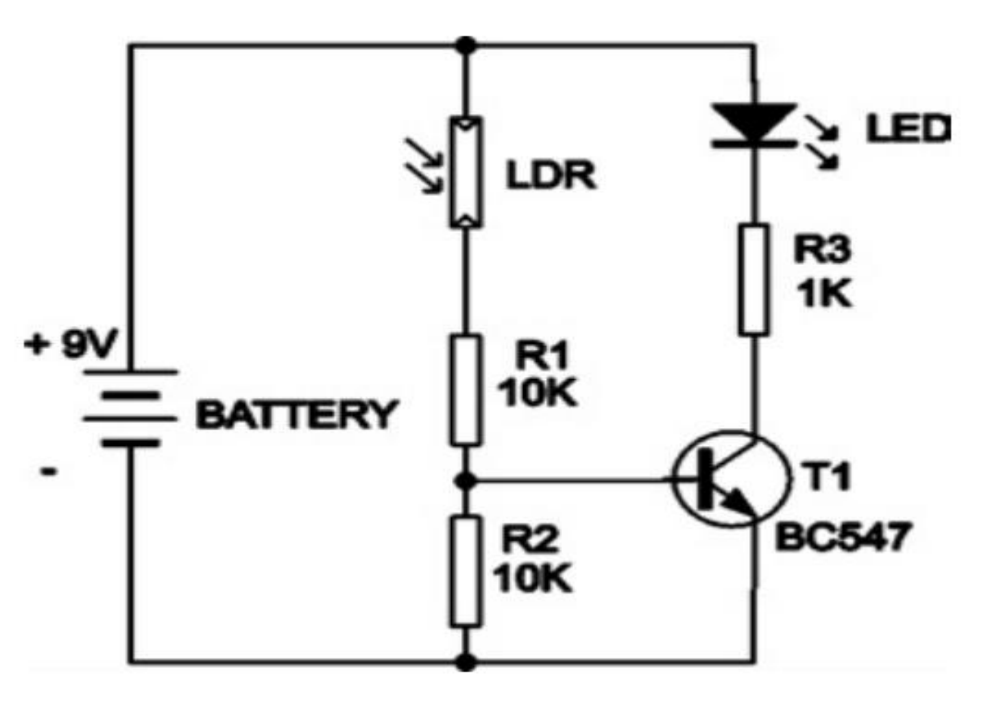
Related to digits or discrete quantities; having a set of discrete values.

Having two values or states; describes a number system that has a base of two and utilizes 1 and 0 as its digits.

A binary digit, which can be a 1 or a 0.

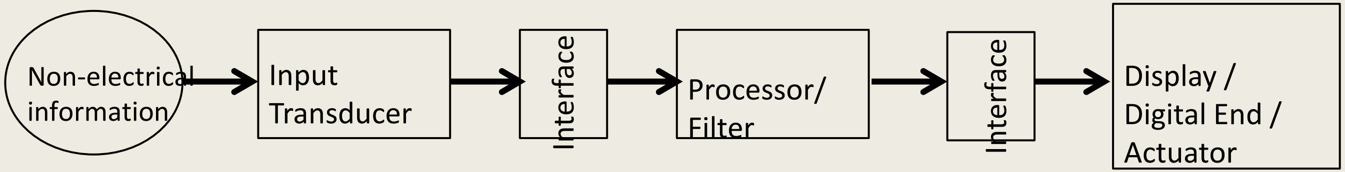
A sudden change from one level to another, followed after a time, called the pulse width, by a sudden change back to the original level.

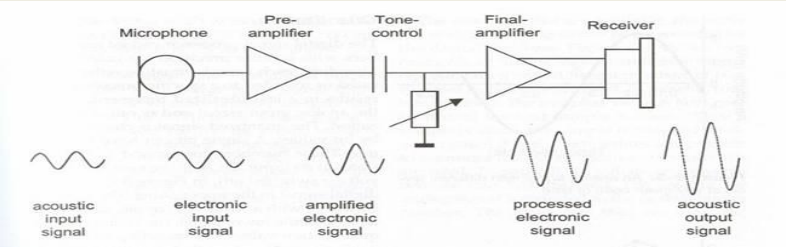
# A Light Sensitive lighting system



# Analog Electronics Systems

- Block diagram of an analog electronic system.



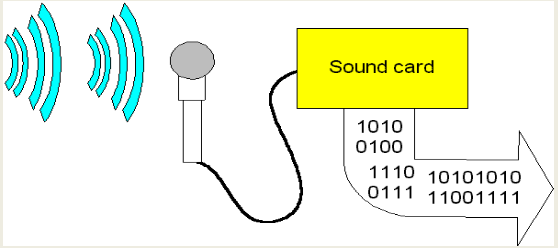

A Loud Speaker system.

# Typical block chain in an Electronic System

- Sensor/Transducer: converts the real-world signal into an analog electrical signal.
- Filters: The analog signal is often weak and noisy, so filters are required to remove noise.
- Amplifiers: are needed to strengthen the signal.
- A/D converters: if digital processing is required.

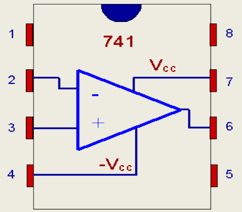
# Typical block chain in an Electronic System

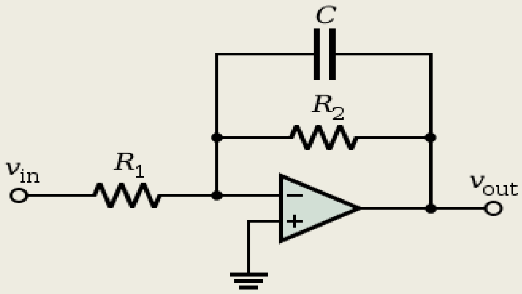
- An analog-to-digital converter transforms the analog signal into a stream of 0‘s and 1's.
- The digital data is processed by a CPU, such as a DSP, a microprocessor, or a microcontroller.
- Digital-to-analog conversion (DAC) is necessary to convert the stream of 0's and 1's back into analog form.



# Op-Amps in electronic system

- An important building block used for amplification and filtering is : Operational Amplifier.

# DC Circuit analysis

- **Circuit analysis** is the process of finding the voltages across, and the currents through, every component in the circuit.

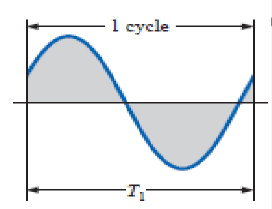
- For *dc* circuits the components are resistive only and analysis is simpler.

  - Ohm Law,
  - Series, Parallel circuits,
  - Kirchhoff's voltage and current laws,
  - Current, Voltage divider rules,
  - Thevenin, Norton's theorems.

# DC and AC Circuit analysis

- For *dc* circuits the components are resistive as the capacitor and inductor show their complete characteristics only with varying voltage or current.

- One form of alternating waveform is sinusoidal waveform where the amplitude alternates periodically between two peaks.

- 

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