

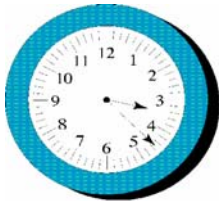
Signals

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Outline

- Analog and Digital
- Periodic and Aperiodic signals
- Analog Signals
- Digital Signals

Analog and Digital



a. Analog

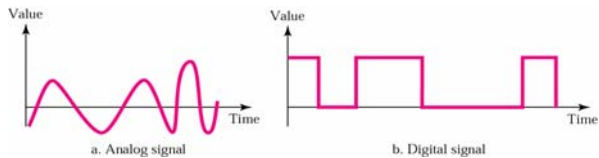


b. Digital

Analog and Digital

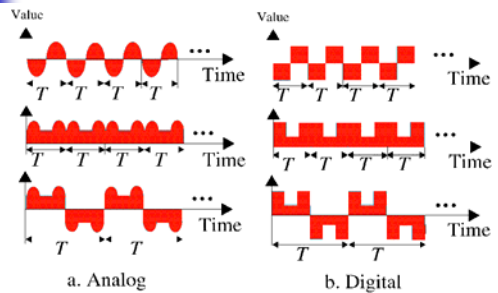
- Definition
 - Analog – continuous
 - Digital – discrete
- Data
 - Analog Data – voice
 - Digital Data – 010101
- Signals
 - Analog Signal – Wave form changes over time
 - Digital Signal – Limited value (e.g., 0 and 1)

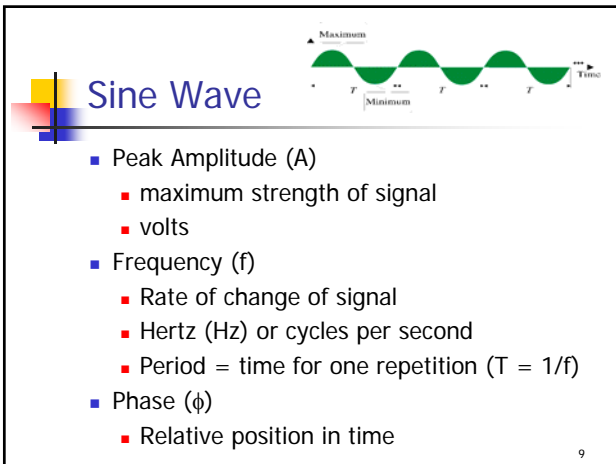
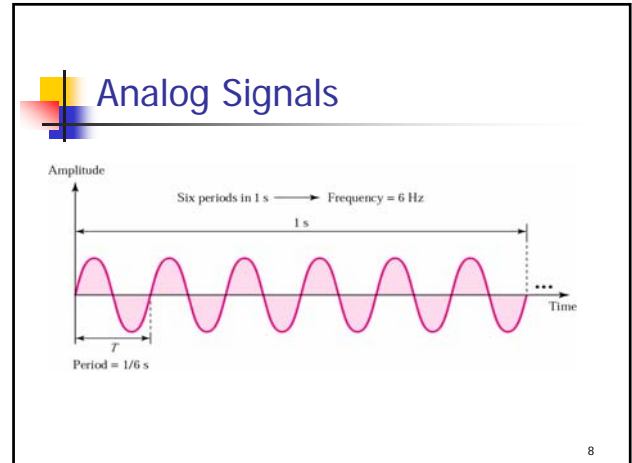
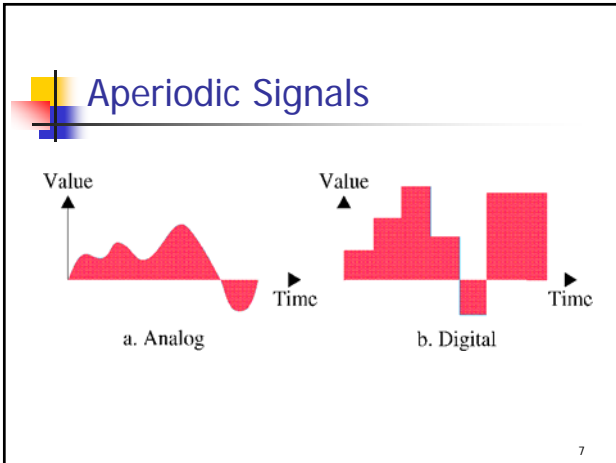
Analog and digital signal



In data communication, we commonly use periodic analog signals and aperiodic digital signals.

Periodic Signals (Period – T)

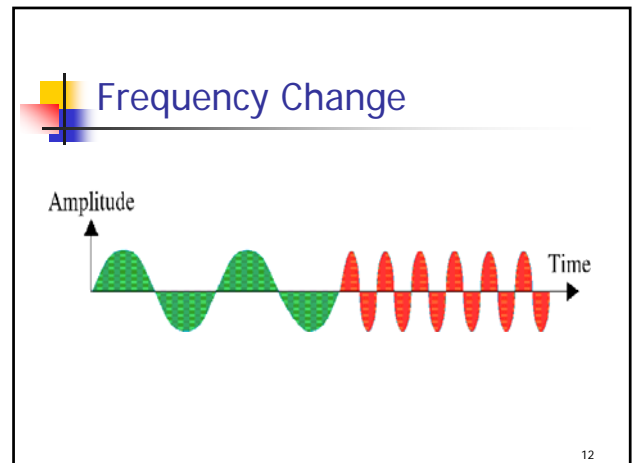
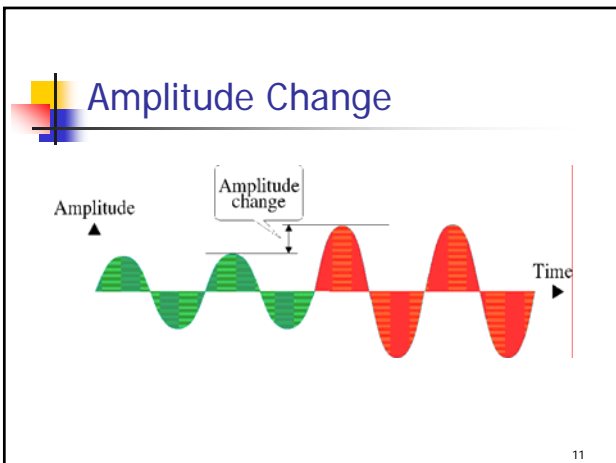


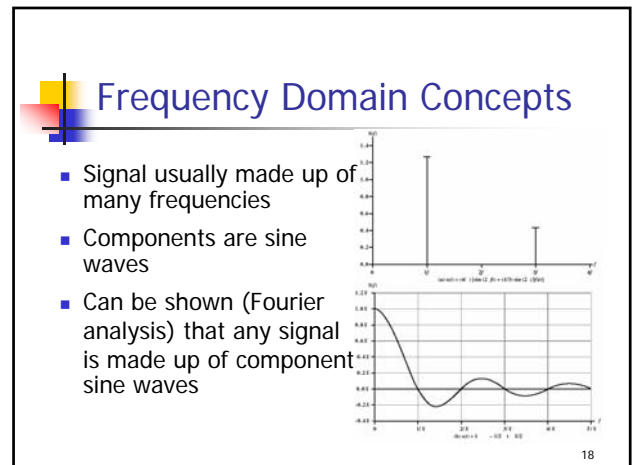
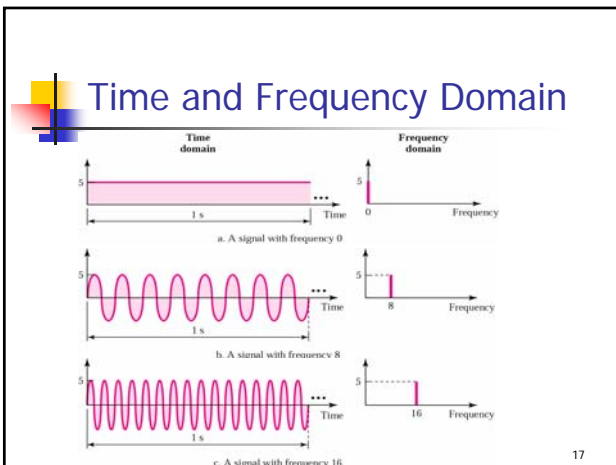
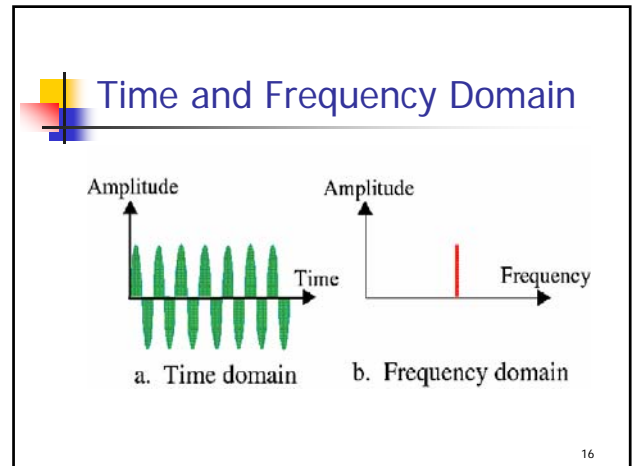
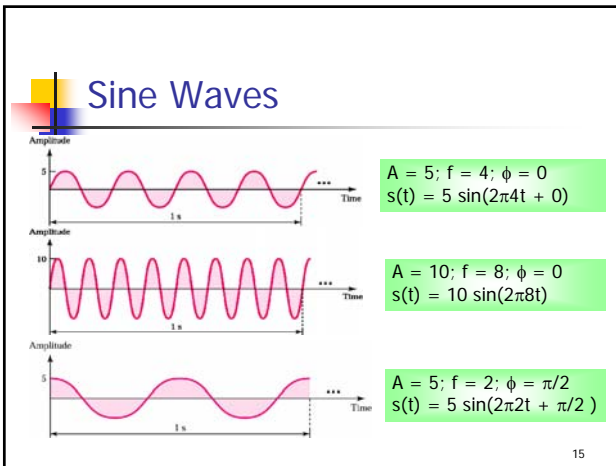
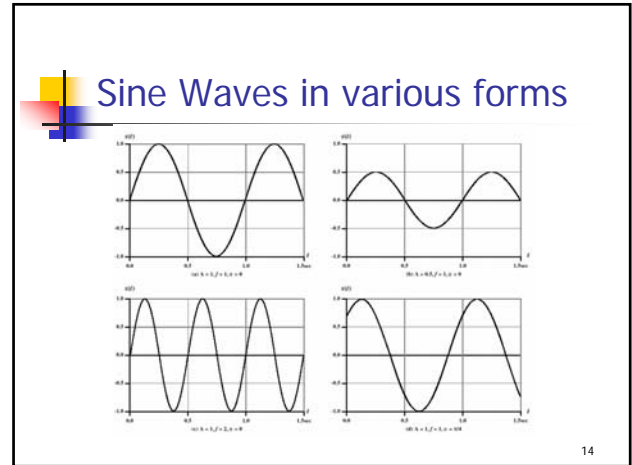
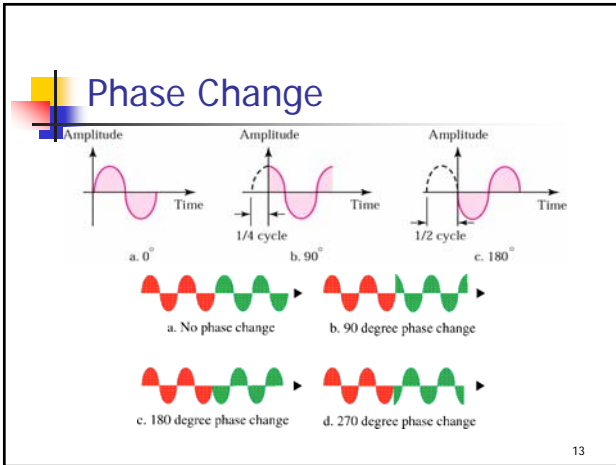


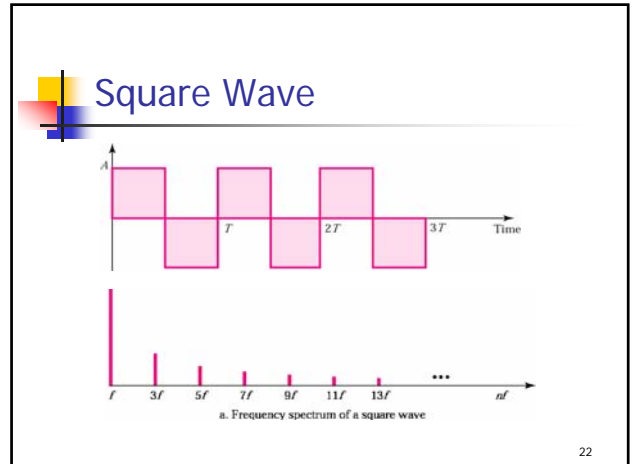
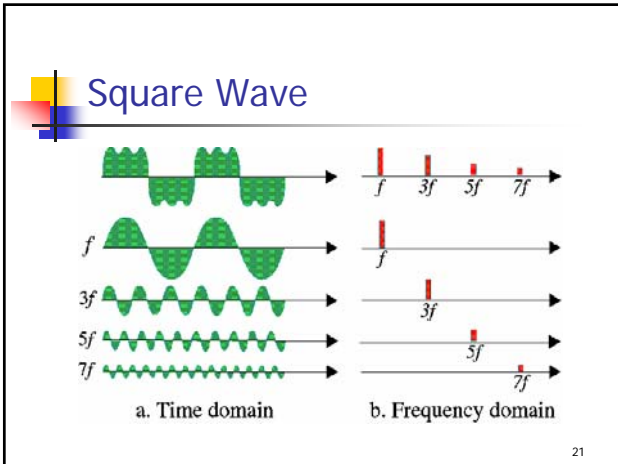
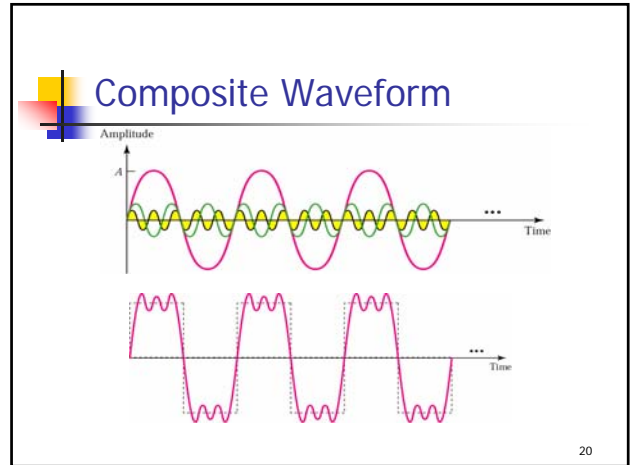
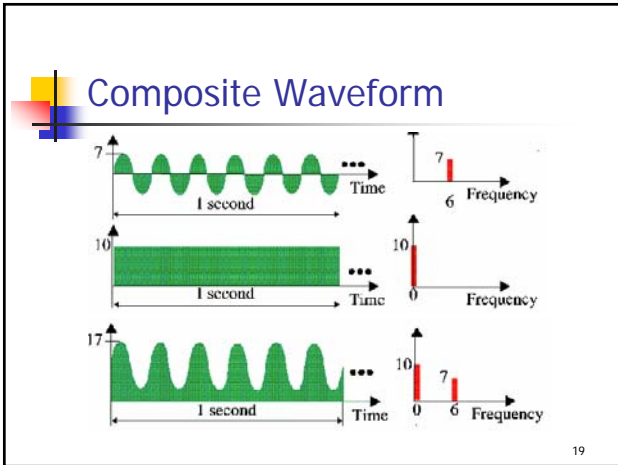
Period and frequency

Unit	Equivalent	Unit	Equivalent
Seconds (s)	1 s	hertz (Hz)	1 Hz
Milliseconds (ms)	10^{-3} s	kilohertz (KHz)	10^3 Hz
Microseconds (μ s)	10^{-6} s	megahertz (MHz)	10^6 Hz
Nanoseconds (ns)	10^{-9} s	gigahertz (GHz)	10^9 Hz
Picoseconds (ps)	10^{-12} s	terahertz (THz)	10^{12} Hz

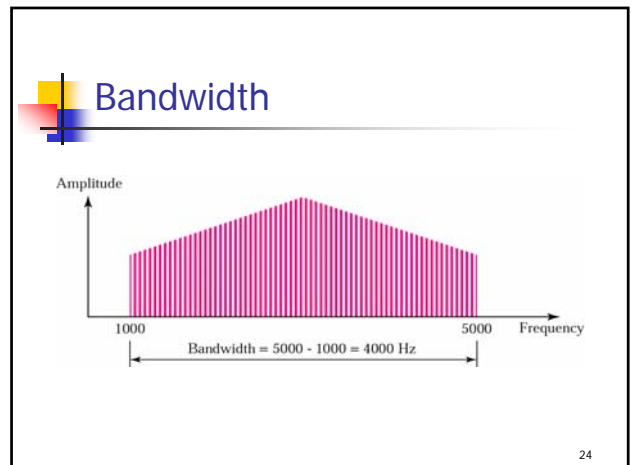
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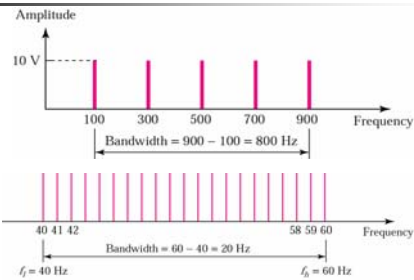




- ### Spectrum & Bandwidth
- Spectrum
 - range of frequencies contained in signal
 - Absolute bandwidth
 - width of spectrum
 - Effective bandwidth
 - Often just *bandwidth*
 - Narrow band of frequencies containing most of the energy
 - DC Component
 - Component of zero frequency
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Spectrum and Bandwidth



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Spectrum and Bandwidth

Example

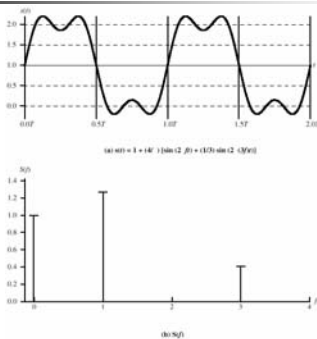
A signal has a spectrum with frequencies between 1000 and 2000 Hz (bandwidth of 1000 Hz). A medium can pass frequencies from 3000 to 4000 Hz (a bandwidth of 1000 Hz). Can this signal faithfully pass through this medium?

Solution

The answer is definitely no. Although the signal can have the same bandwidth (1000 Hz), the range does not overlap. The medium can only pass the frequencies between 3000 and 4000 Hz; the signal is totally lost.

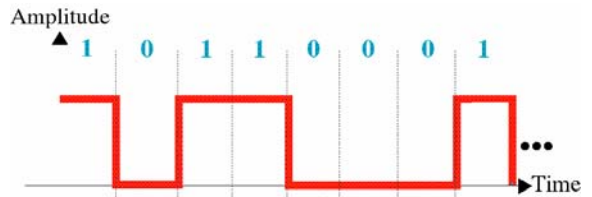
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Signal with DC Component



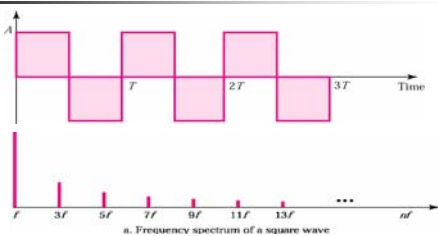
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Digital Signals



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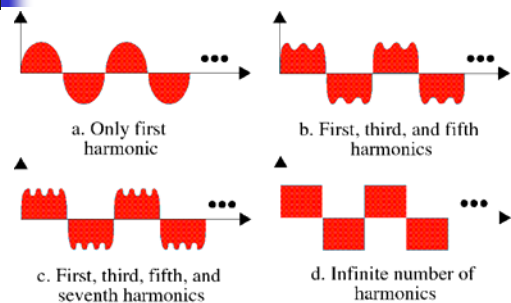
Square Wave



A digital signal is a composite signal with an infinite bandwidth

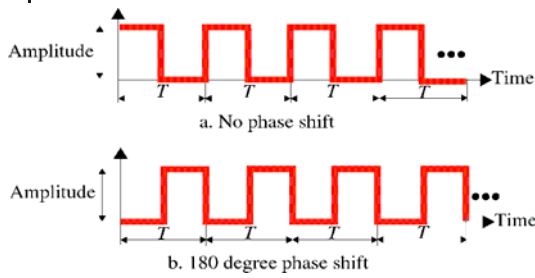
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Harmonics of a digital signal



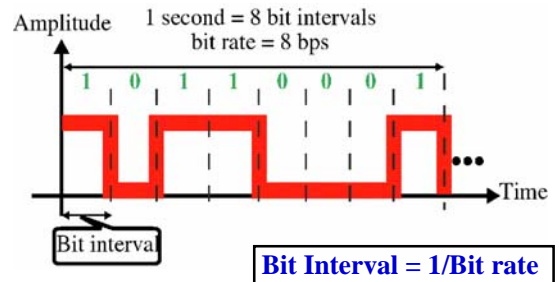
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Amplitude, Period, and Phase for a Digital Signal



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Bit Rate and Bit Interval



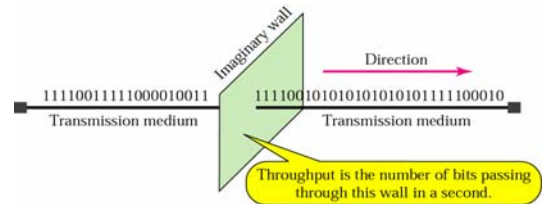
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Frequency Spectrum and Bandwidth

- Frequency Spectrum of a signal
 - Collection of all the component frequencies of the signal
- Bandwidth of a signal
 - The width of the frequency spectrum available in a communication channel
- BW is often used to refer to the Throughput of a system
 - Actually BW is indirectly related to throughput
 - Data rate (tx rate or capacity) is more suitable: bits per sec.

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Throughput



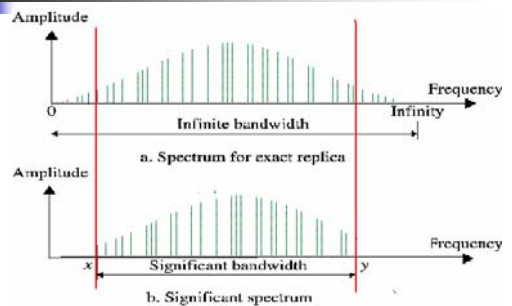
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Bandwidth Requirement

Bit Rate	Harmonic 1	Harmonics 1, 3	Harmonics 1, 3, 5	Harmonics 1, 3, 5, 7
1 Kbps	500 Hz	2 KHz	4.5 KHz	8 KHz
10 Kbps	5 KHz	20 KHz	45 KHz	80 KHz
100 Kbps	50 KHz	200 KHz	450 KHz	800 KHz

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Exact and Significant spectrums



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Insufficient Bandwidth

