



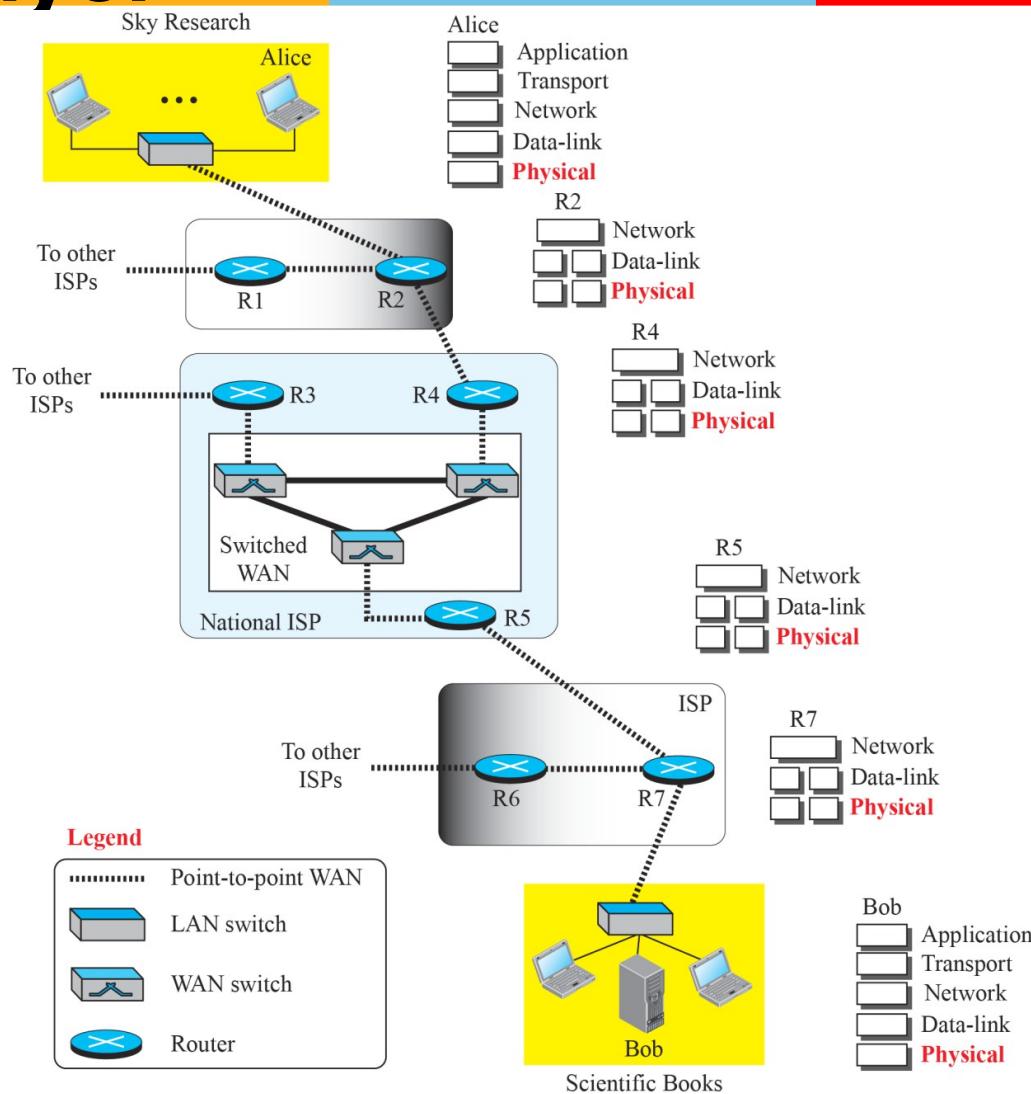
Computer Networks: Physical layer

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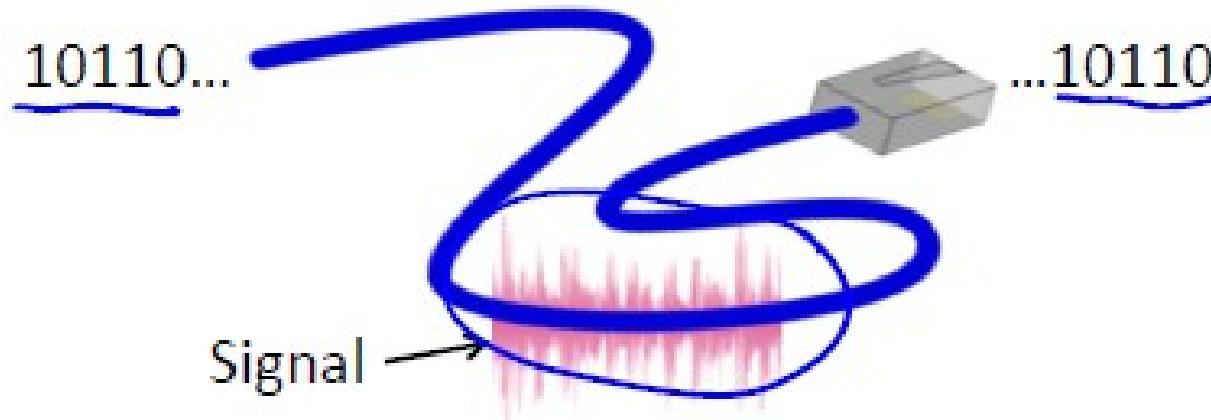


Communication at Physical layer

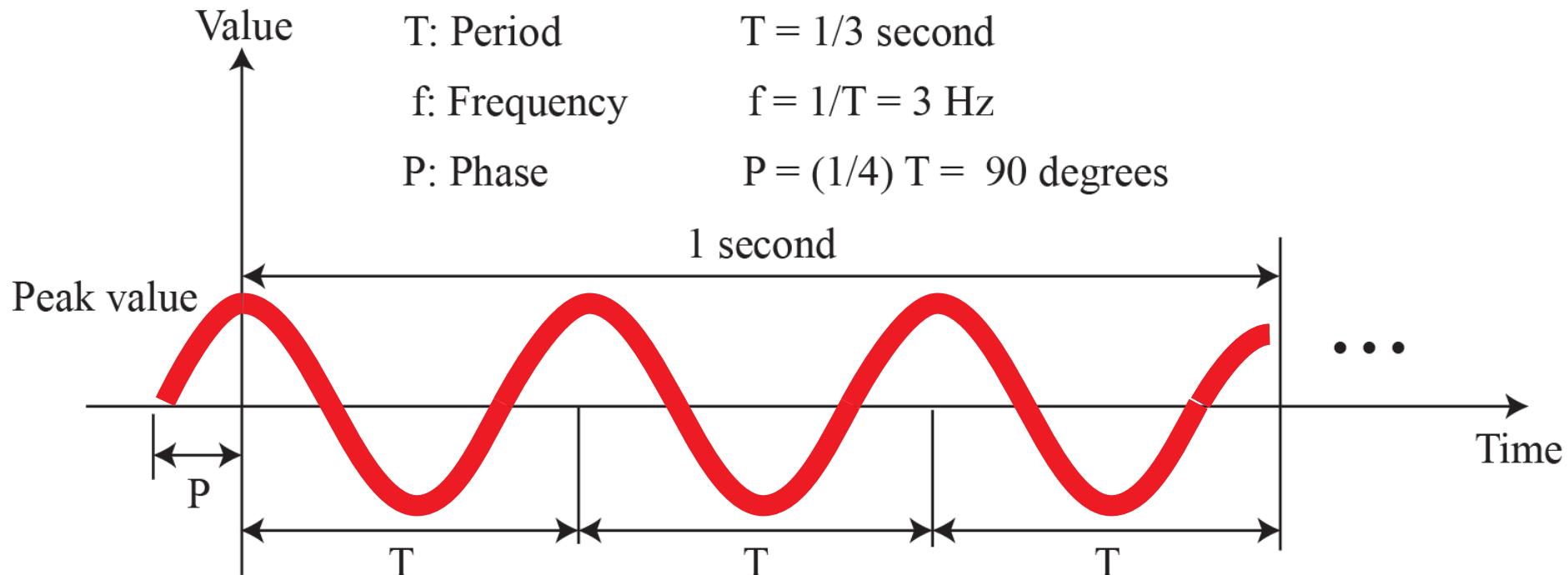


Scope of Physical layer

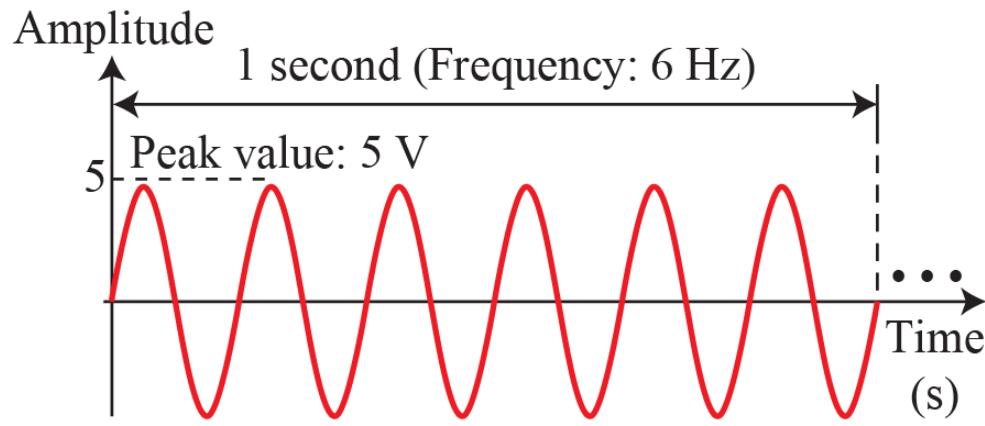
- Concerns how signals are used to transfer message bits over a link
 - Wires etc. carry analog signals
 - We want to send digital bits



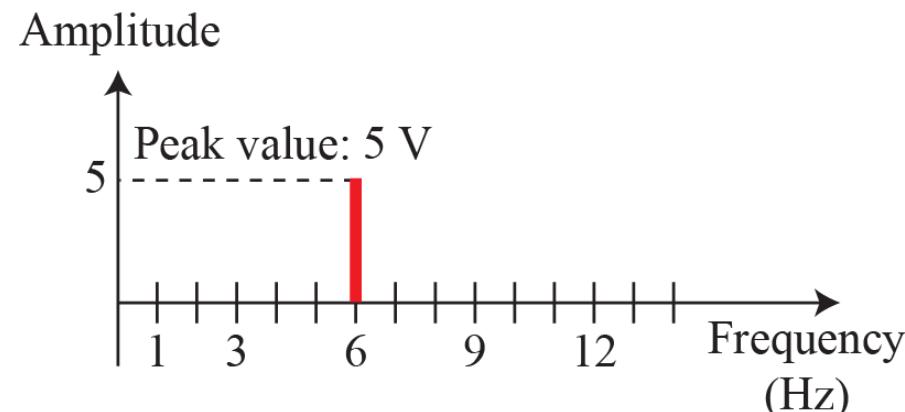
Analog Signals



Time and Frequency domains

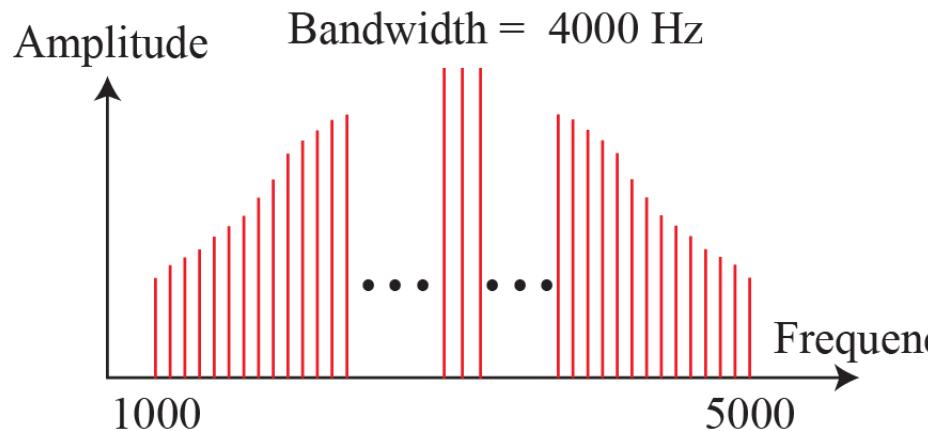
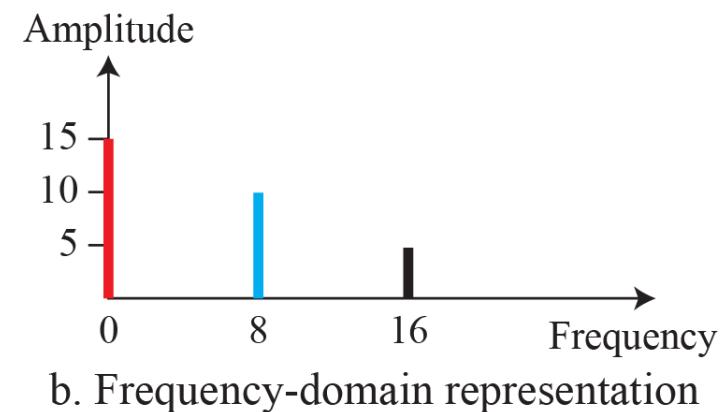
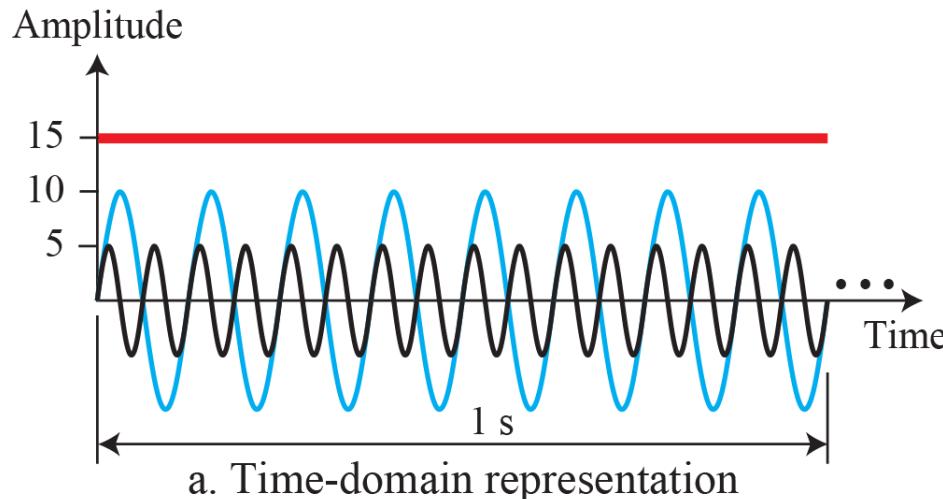


a. A sine wave in the time domain

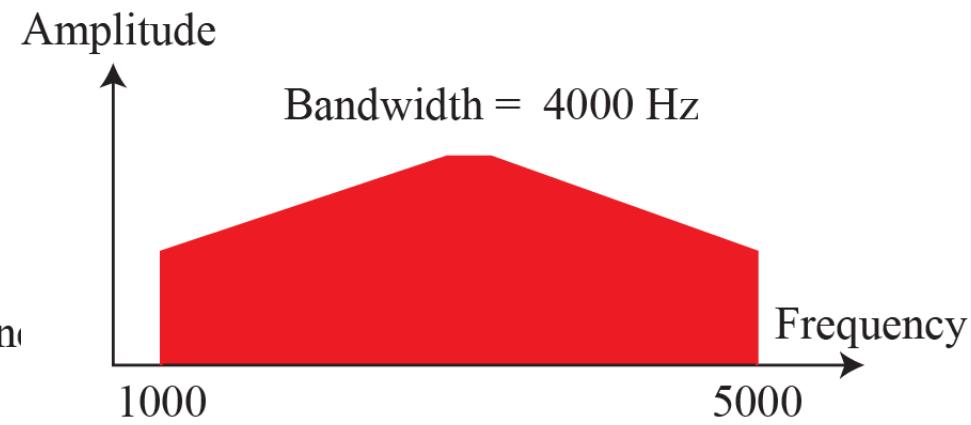


b. The same sine wave in the frequency domain

Composite signals and bandwidth

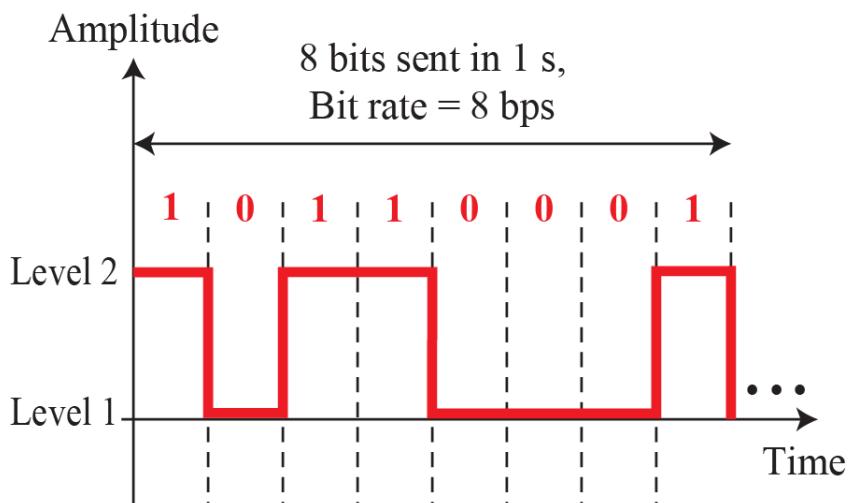


a. Bandwidth of a periodic signal

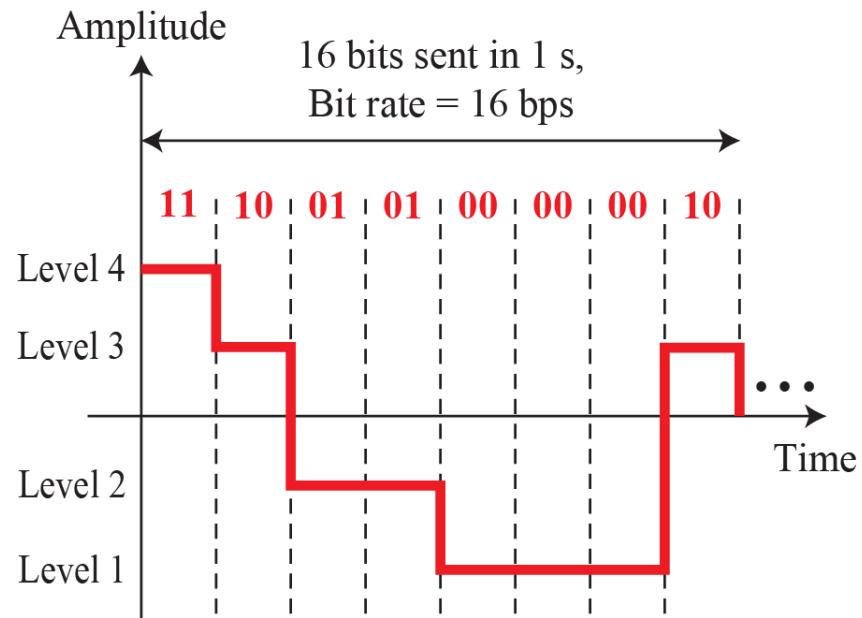


b. Bandwidth of a nonperiodic signal

Digital signals and bit rate



a. A digital signal with two levels



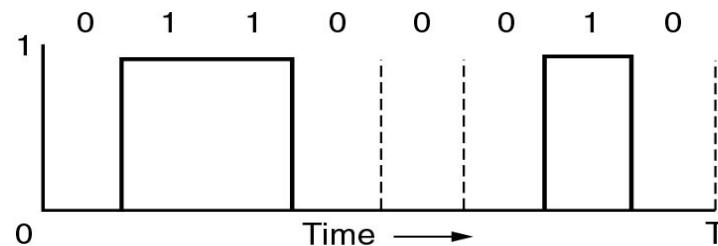
b. A digital signal with four levels

Frequency representation

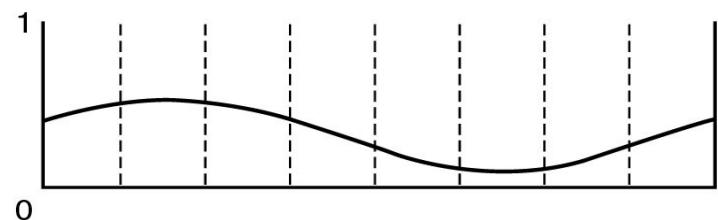
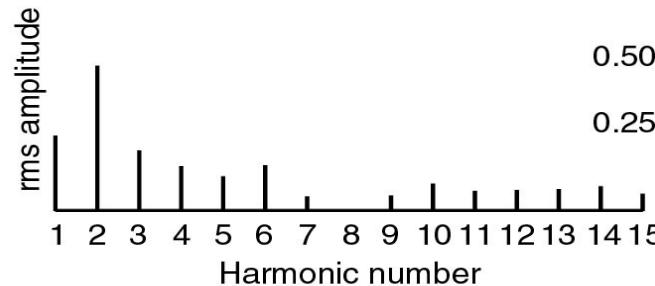
- A signal over time can be represented by its frequency components (called Fourier analysis)

$$g(t) = \frac{1}{2}c + \sum_{n=1}^{\infty} a_n \sin(2\pi nft) + \sum_{n=1}^{\infty} b_n \cos(2\pi nft)$$

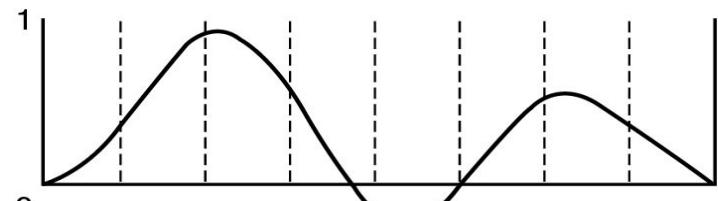
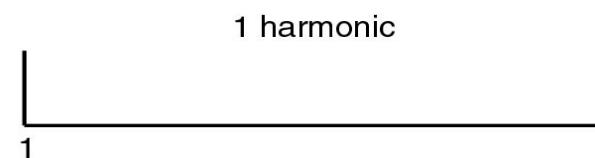
Bandwidth limited signal



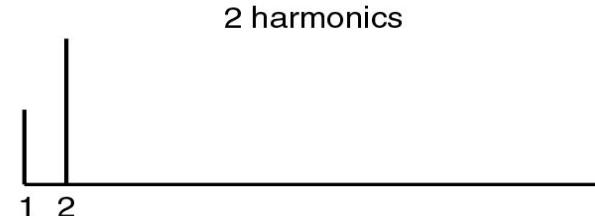
(a)



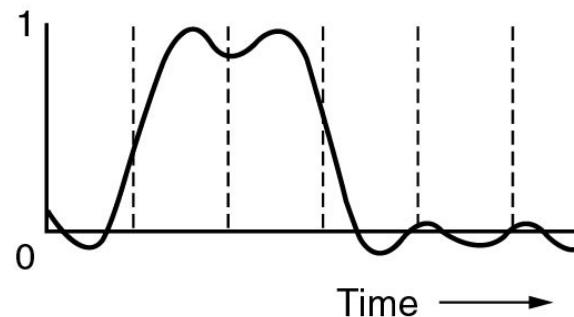
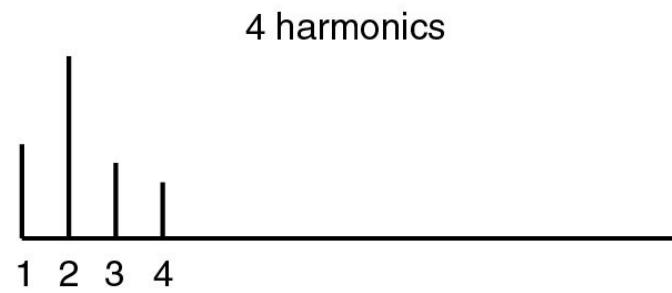
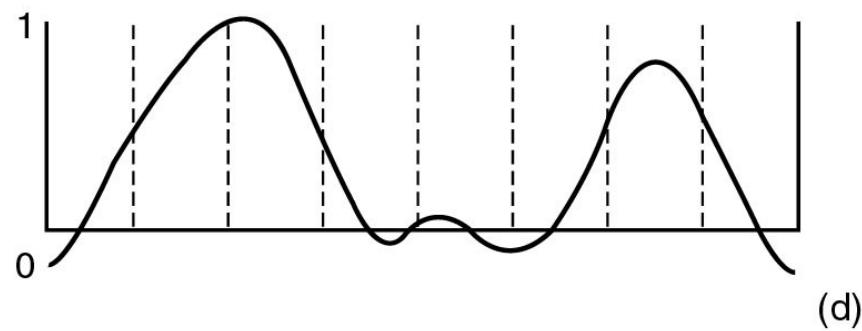
(b)



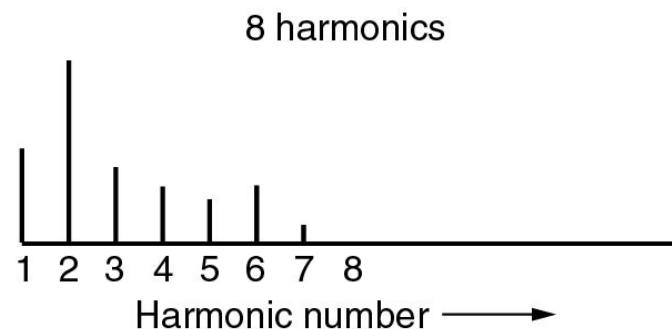
(c)



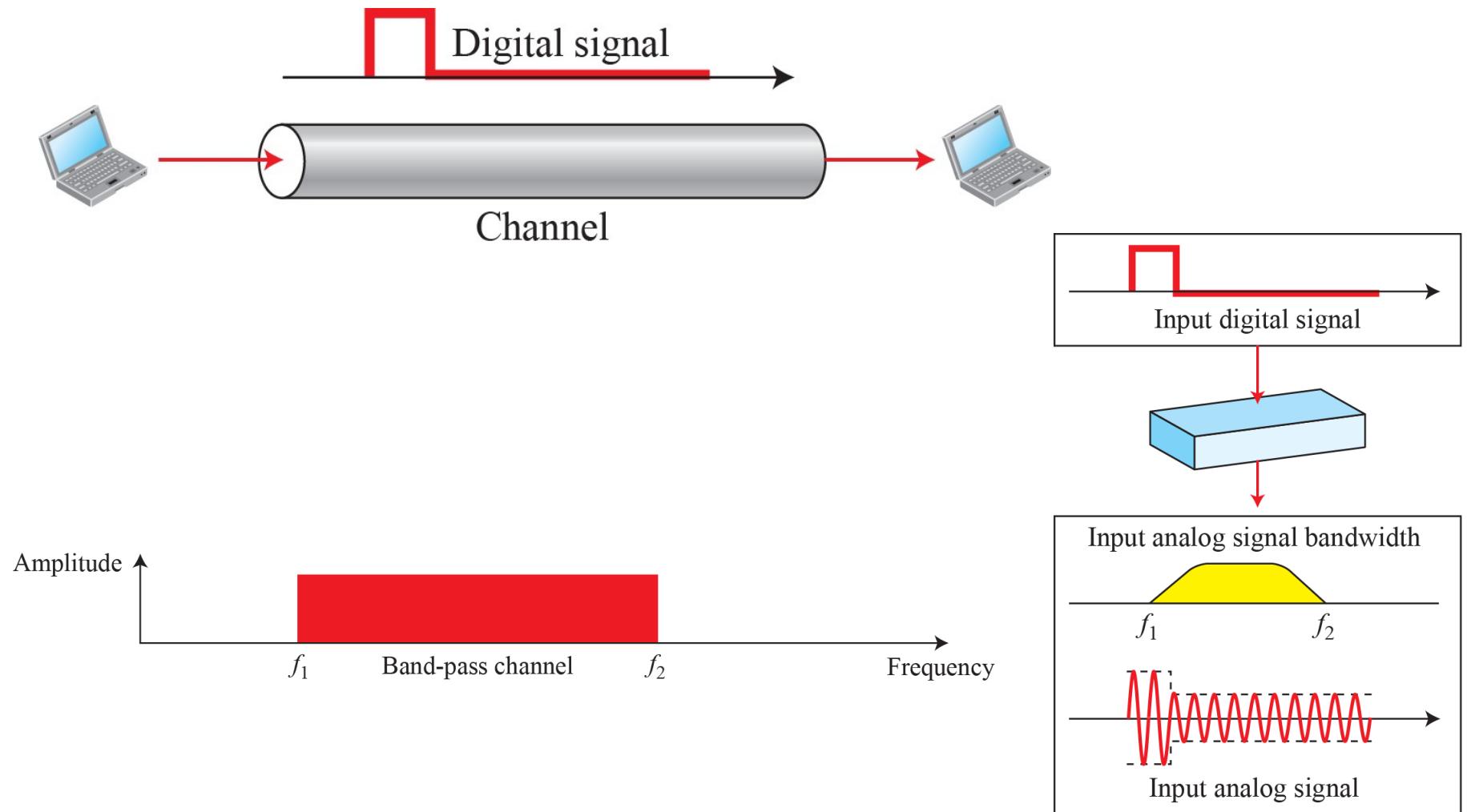
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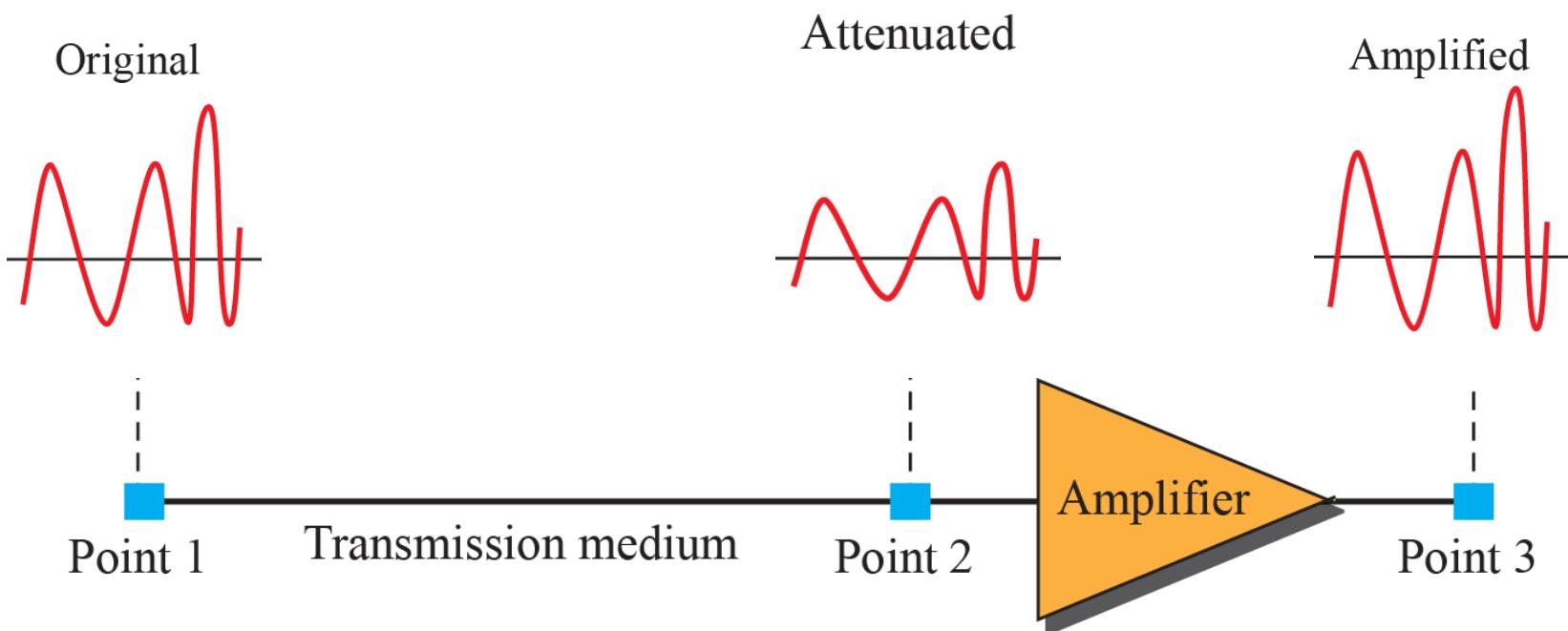
(e)



Baseband and Broadband Transmission

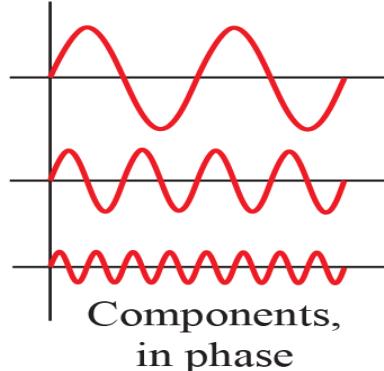
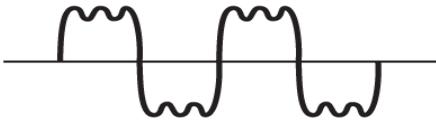


Transmission Impairments: Attenuation



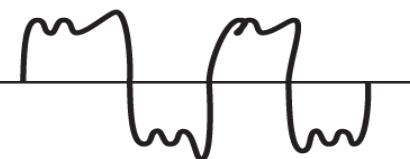
Distortion

Composite signal sent

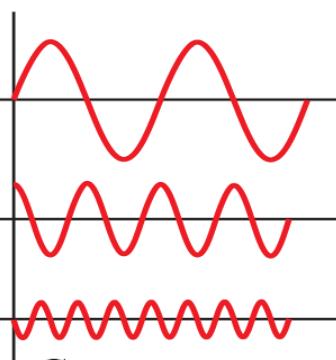


At the sender

Composite signal received

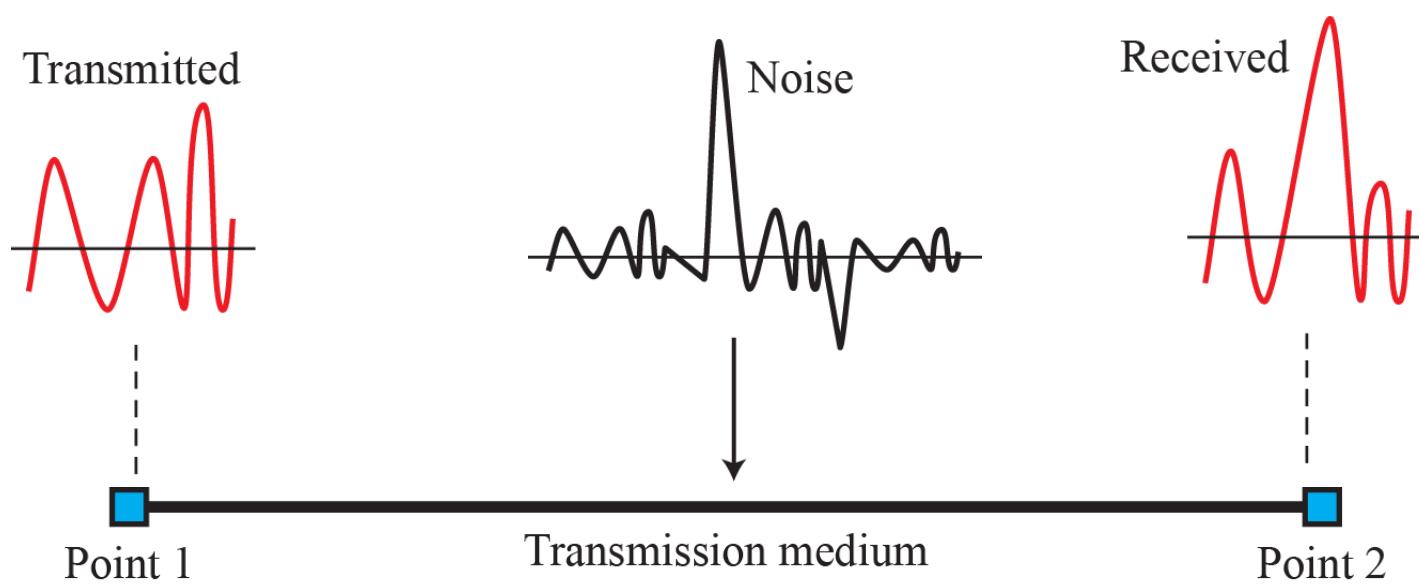


Components, out of phase

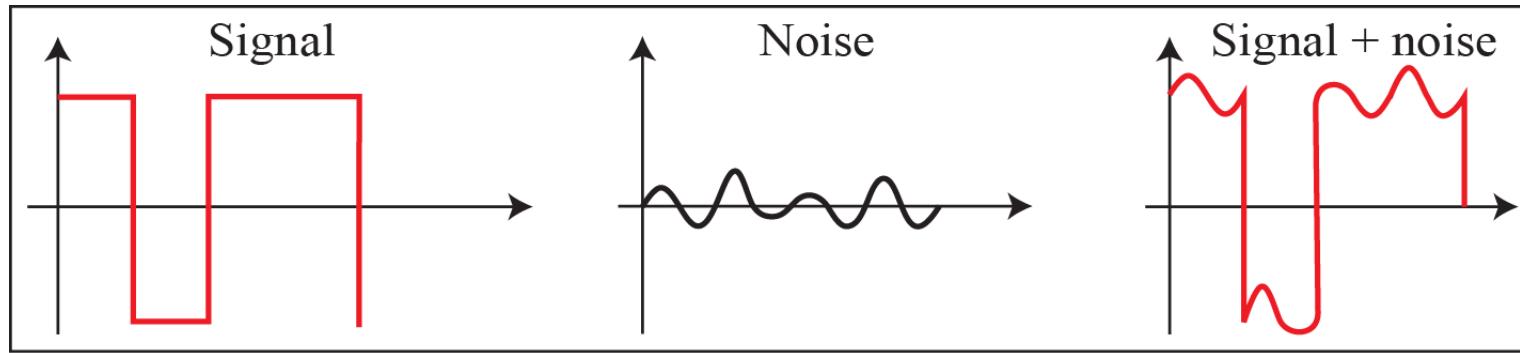


At the receiver

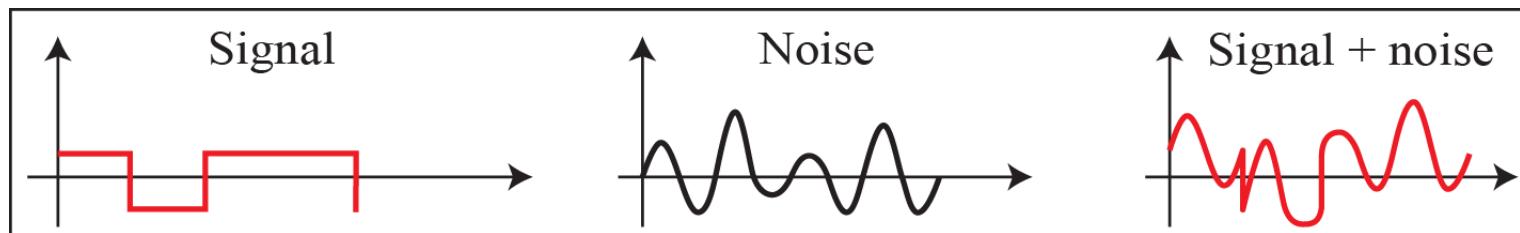
Noise



Signal to Noise Ration (SNR)



a. High SNR



b. Low SNR