Data Communication

SIGNALS

ANALOG & DIGITAL DATA COMMUNICATION

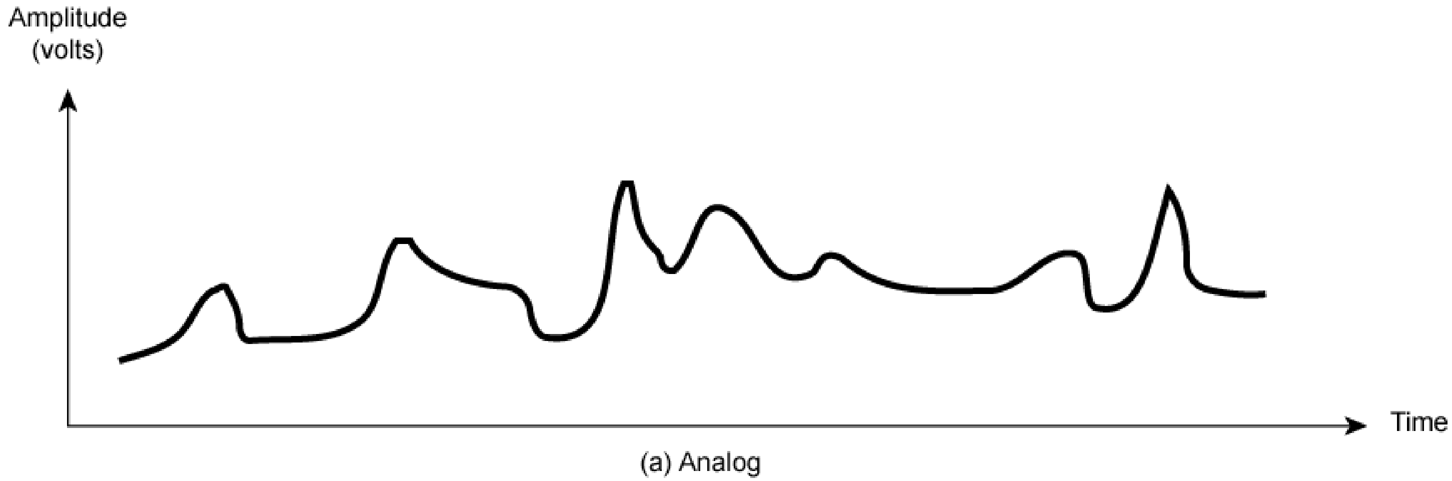
Data Communication Terms

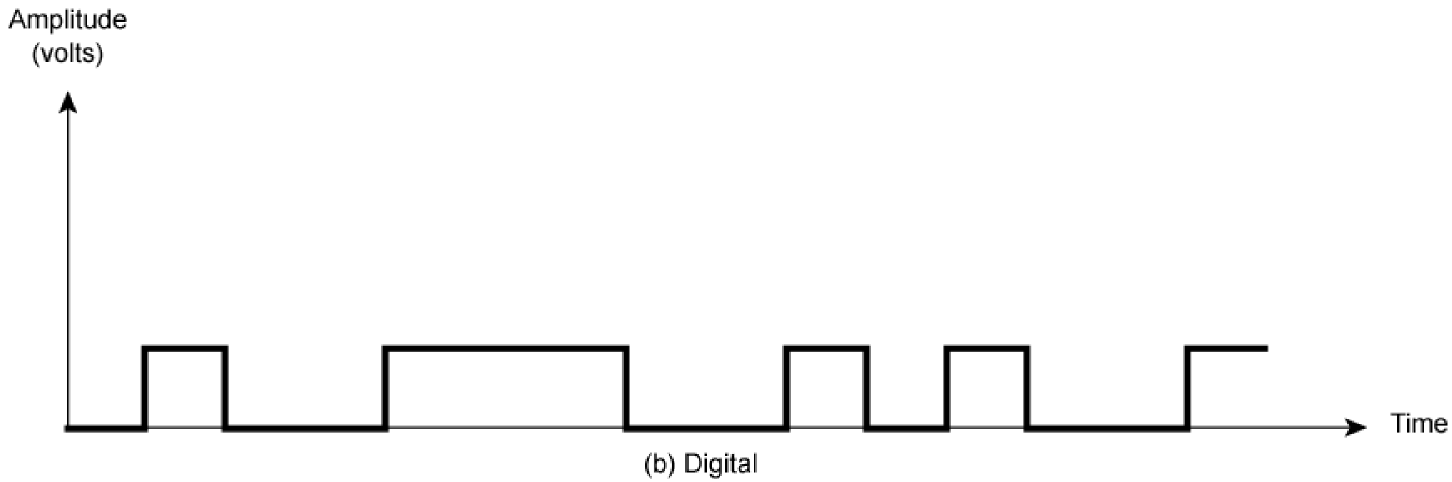
- Data: unit that contains information
  - Analog Data – Voice, Video
  - Digital Data – 010101011 (text, integer)
- Signal: electrical or electromagnetic visulation of data
  - Analog Signal
  - Digital Signal
- Transmission: transmission of data via propagation of signals
  - Analog Transmission
  - Digital Transmission

Frequency, Spectrum and Bandwidth

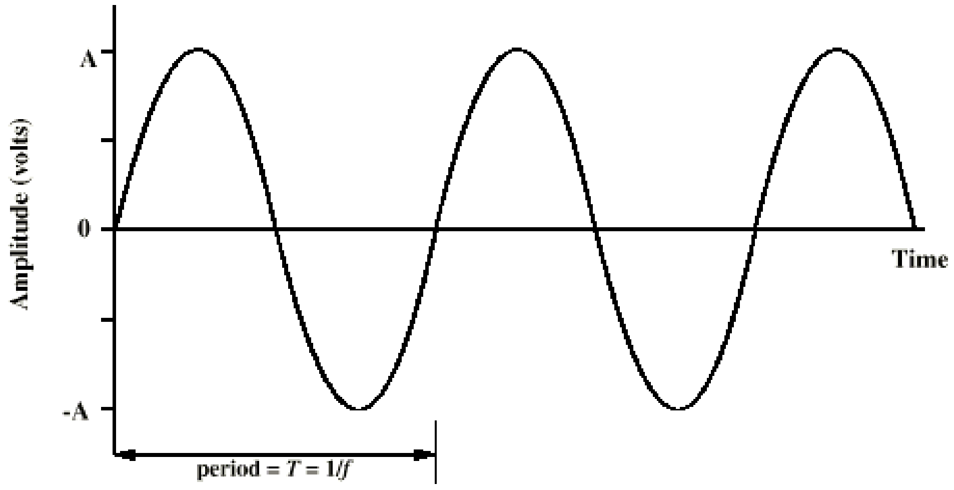
- time domain concepts
  - analog signal
    - various in a smooth way over time
  - digital signal
    - maintains a constant level then changes to another constant level
  - periodic signal
    - pattern repeated over time
  - aperiodic signal
    - pattern not repeated over time

Analogue & Digital Signals

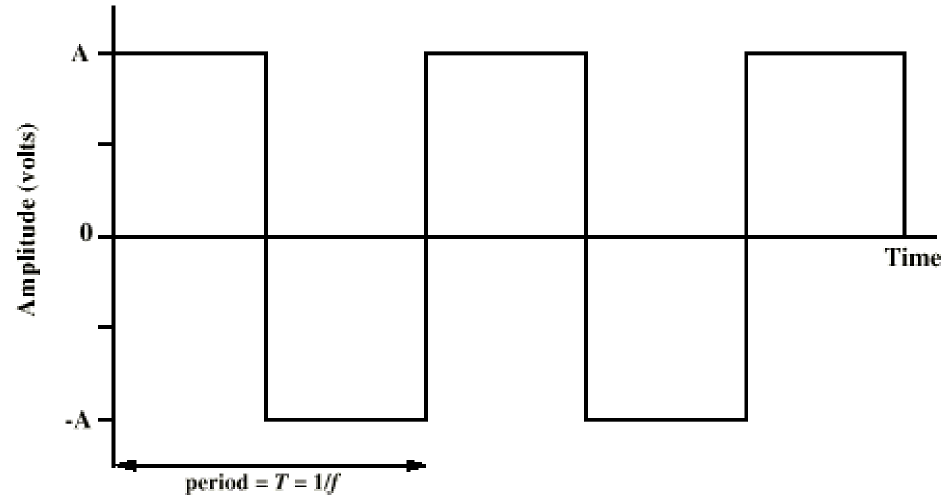




Periodic Signals



(a) Sine wave



(b) Square wave

Sine Wave

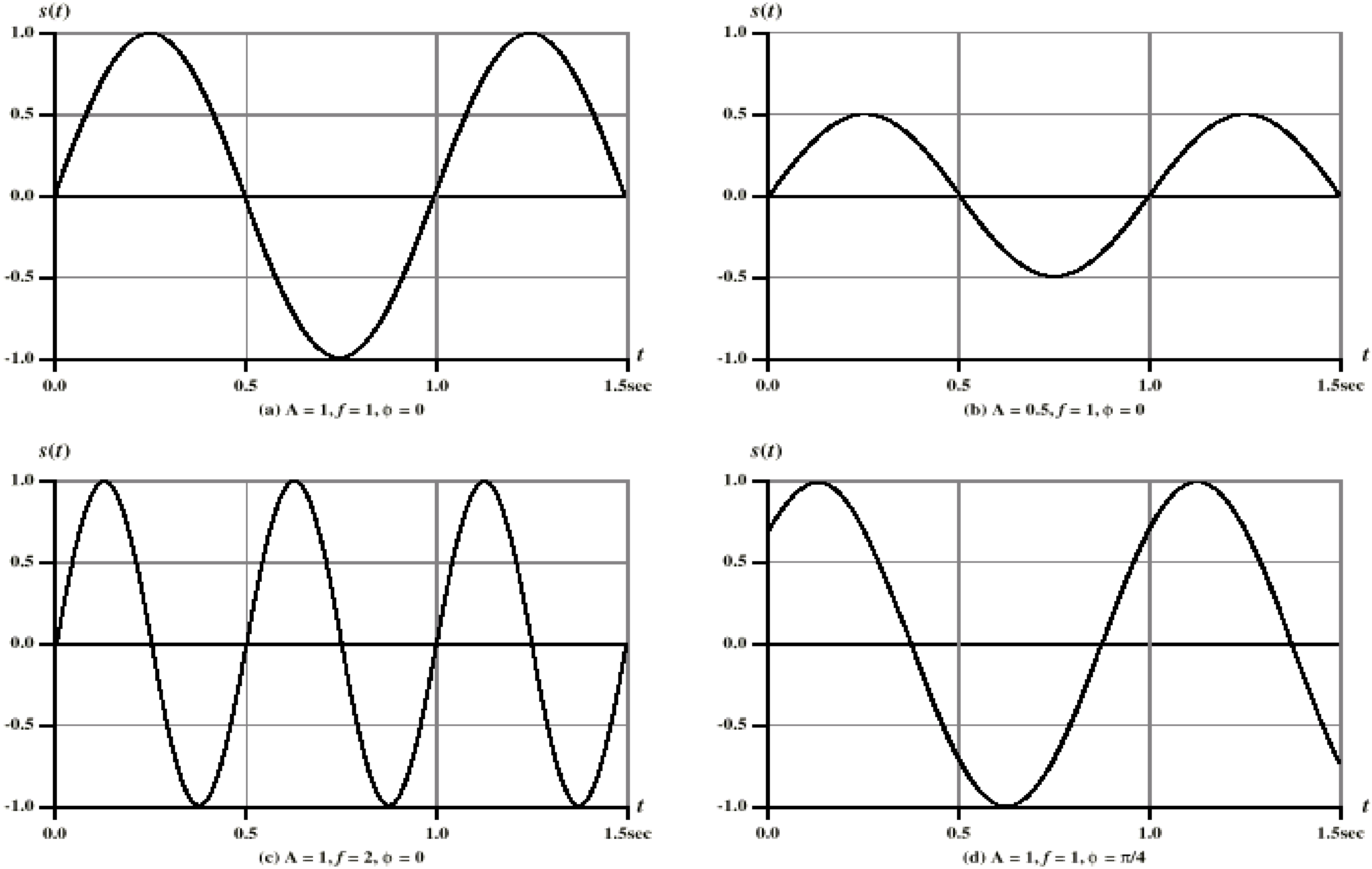
- peak amplitude (A)
  - maximum strength of signal
  - volts
- frequency (f)
  - rate of change of signal
  - Hertz (Hz) or cycles per second
  - period = time for one repetition (T)
  - $T = 1/f$
- phase (ϕ)
  - relative position in time

Period & Frequency

Unit	Equivalent	Unit	Equivalent
Second s(s)	1 s	Hertz (Hz)	1 Hz
Milliseconds (ms)	10^{-3} s	Kilohertz (KHz)	10^{3} Hz
Microseconds (ms)	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

Varying Sine Waves

$$s(t) = A \sin(2\pi f t + \Phi)$$



Wavelength (λ)

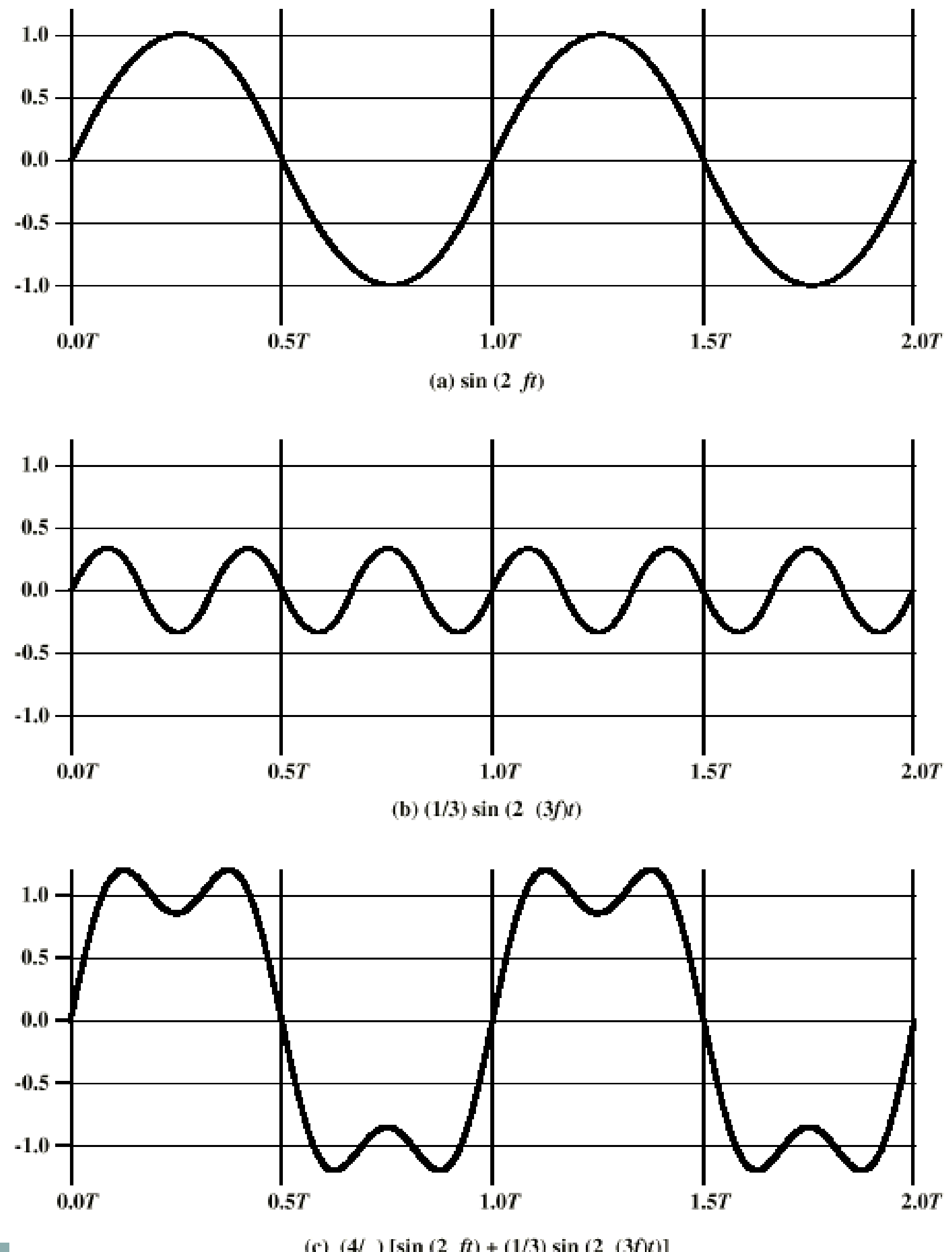
- is distance occupied by one cycle
- between two points of corresponding phase in two consecutive cycles
- assuming signal velocity v have $\lambda = vT$
- or equivalently $\lambda f = v$
- especially when $v=c$
  - $c = 3*10^8$ ms^{-1} (speed of light in free space)

Frequency Domain Concepts

- signal are made up of many frequencies
- components are sine waves
- Fourier analysis can shown that any signal is made up of component sine waves
- can plot frequency domain functions

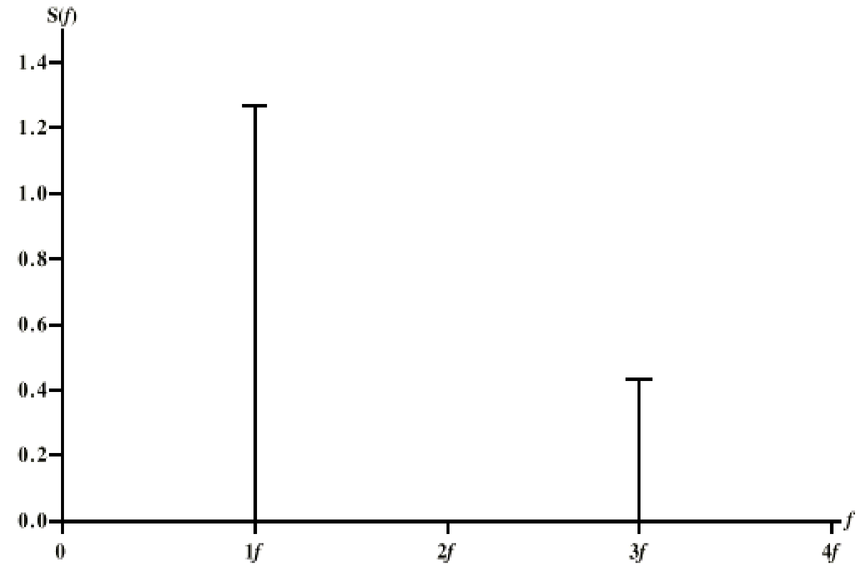
Addition of Frequency Components (T=1/f)

- c is sum of *f* & *3f*

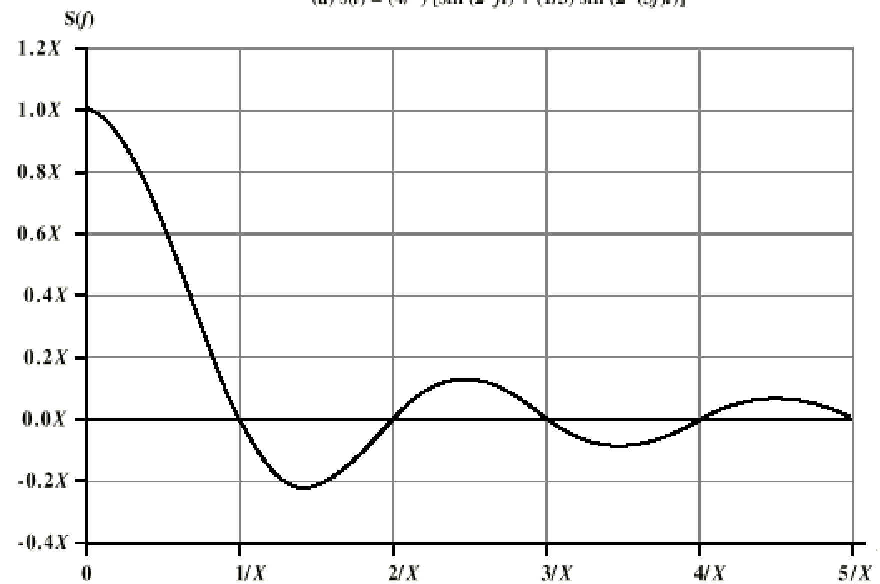


Frequency Domain Representations

- freq domain func of added two signals (f & 3f)
- freq domain func of single square pulse

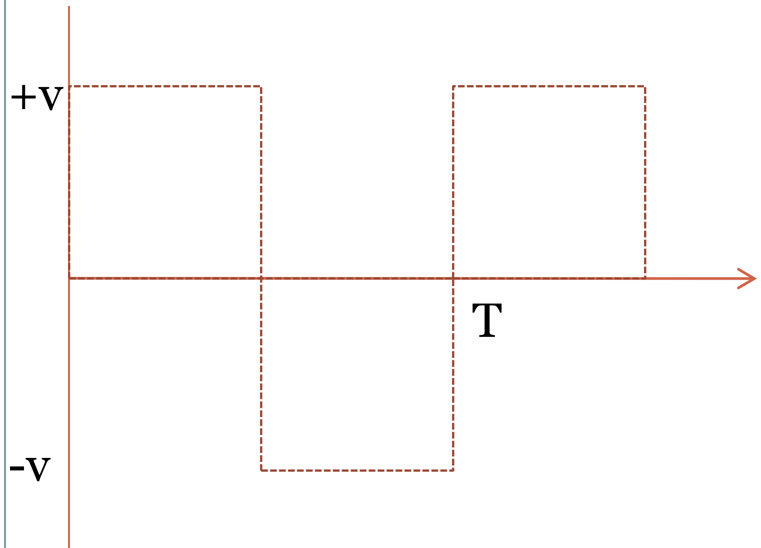


(a) s(t) = (4/) [sin (2 ft) + (1/3) sin (2 (3f)t)]



(b) s(t) = 1 −X/2 t X/2

Fourier Trans. Of Square Wave



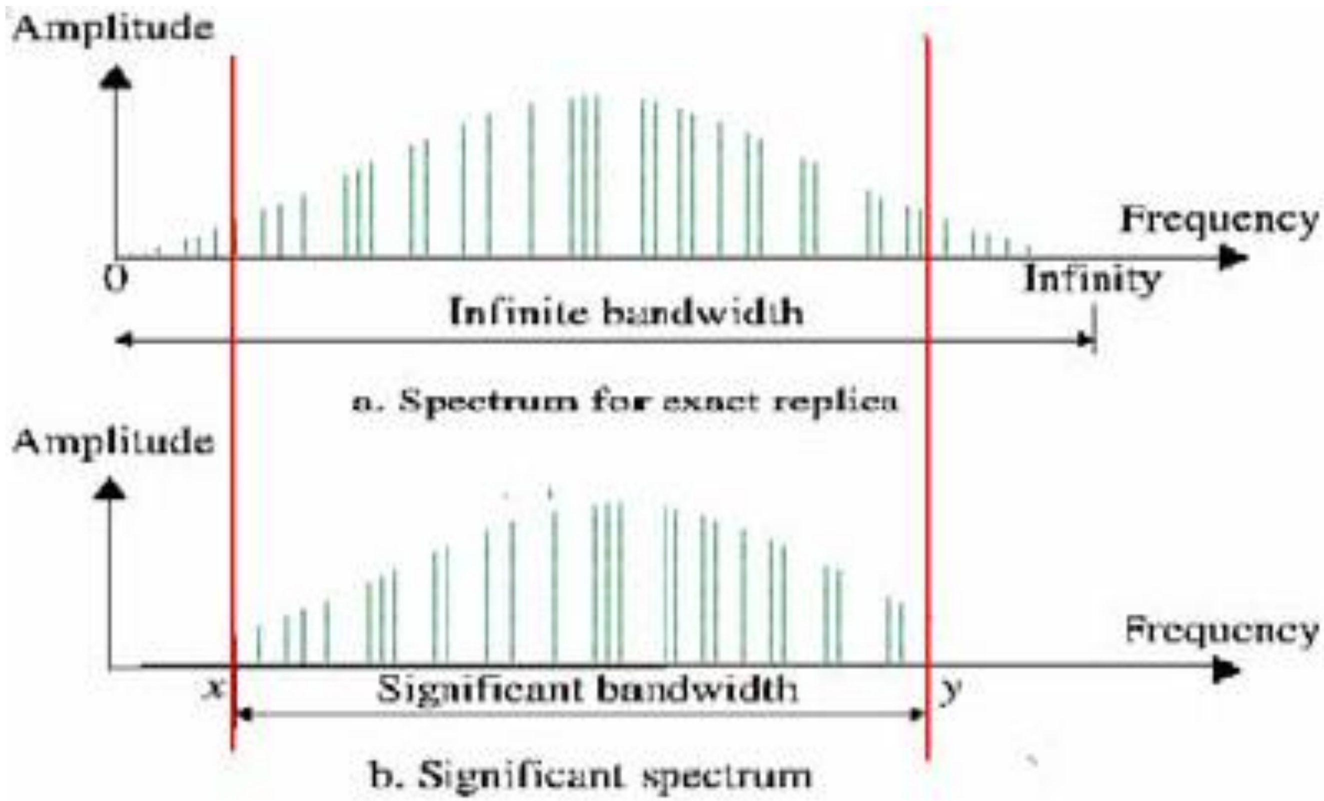
V(t)=(4V/π).Sin(ωt)+(4V/3π).Sin(3ωt)+….

$$V(t) = \sum_{N=odd}^{\infty} \frac{4V}{N\pi} Sin(N\omega t)$$

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 energy
- DC Component
  - component of zero frequency

Absolute and Effective Bandwidth



Bandwidth Examples

- Speech : 100 Hz – 7 KHz
- Telephone : 300 Hz – 3400 Hz
- Video : 4 MHz

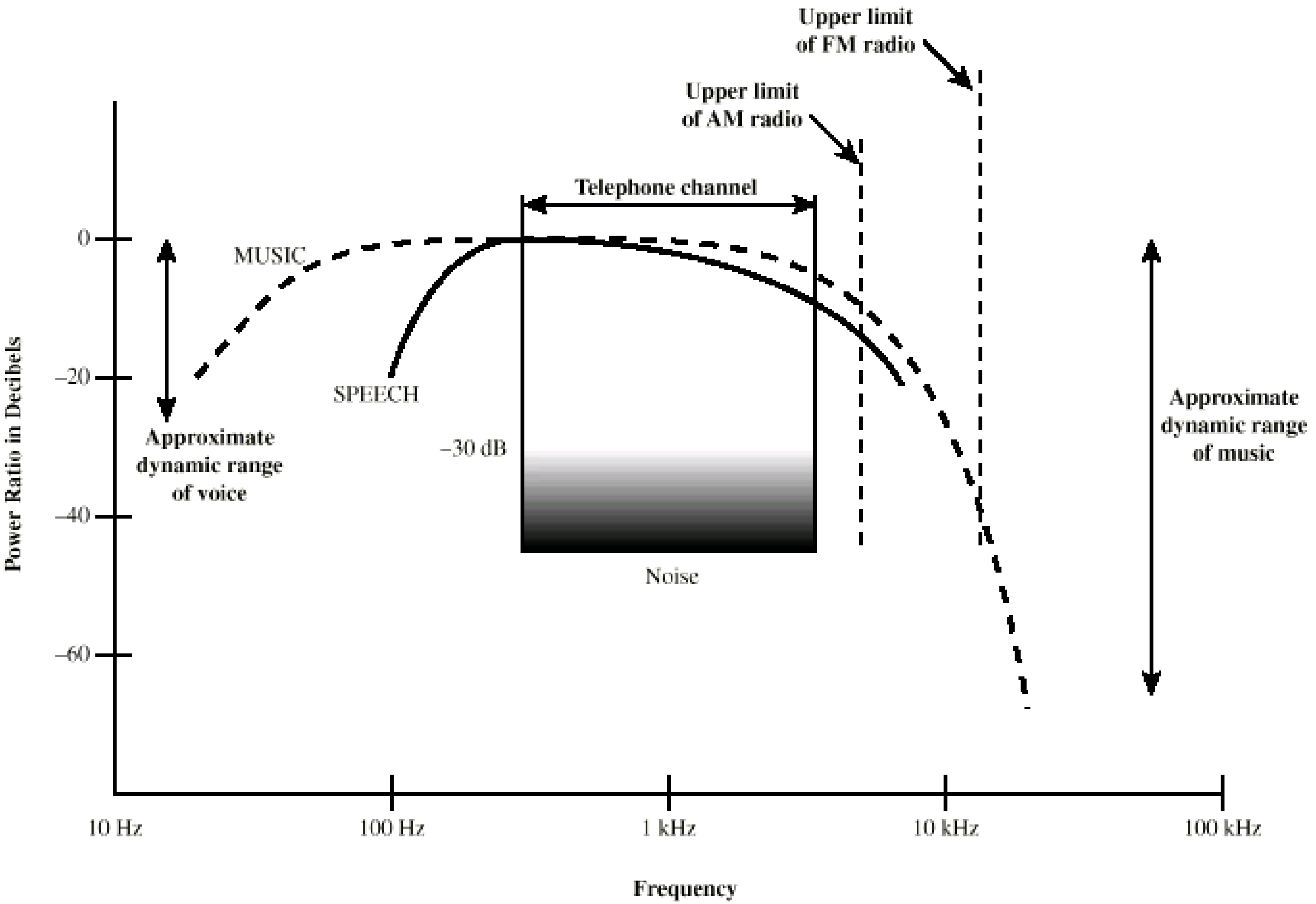
Spectrum and Bandwidth

- *Example:* Suppose that a signal has a spectrum of frequencies between 1000 and 2000 Hz (a 1000 Hz bandwidth). And suppose that a medium which transmits frequencies between 3000 and 4000 Hz (a 1000 Hz bandwidth). So, can this signal be transmitted through this medium?
- *Answer:* No. In spite of the same bandwidth (1000 Hz) signal is completely lost. Medium can transmit signal only between 3000-4000 Hz.

Analog and Digital Data Transmission

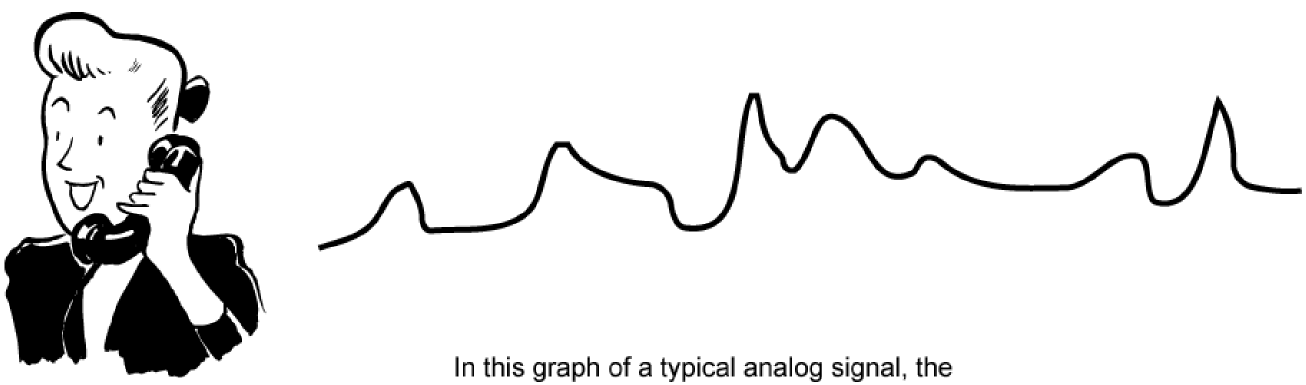
- data
  - entities that convey meaning
- signals & signalling
  - electric or electromagnetic representations of data, physically propagates along medium
- transmission
  - communication of data by propagation and processing of signals

Acoustic Spectrum (Analog)



Audio Signals

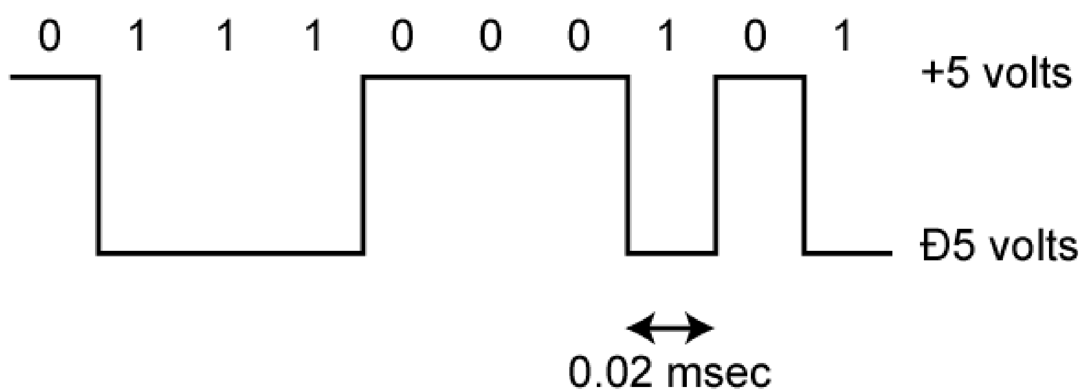
- freq range 20Hz-20kHz (speech 100Hz-7kHz)
- easily converted into electromagnetic signals
- varying volume converted to varying voltage
- can limit frequency range for voice channel to 300-3400Hz



In this graph of a typical analog signal, the variations in amplitude and frequency convey the gradations of loudness and pitch in speech or music. Similar signals are used to transmit television pictures, but at much higher frequencies.

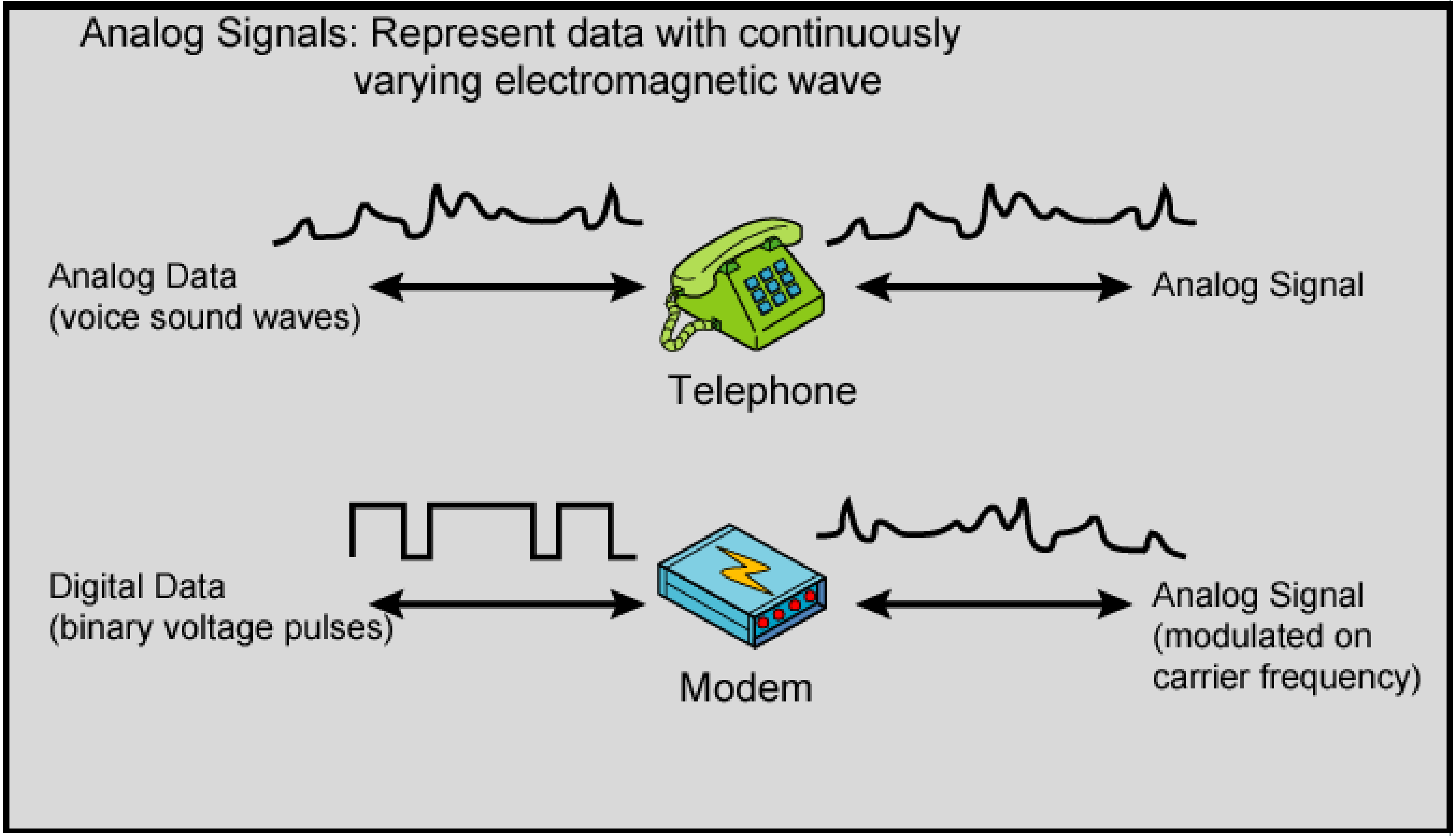
Digital Data

- as generated by computers etc.
- has two dc components
- bandwidth depends on data rate

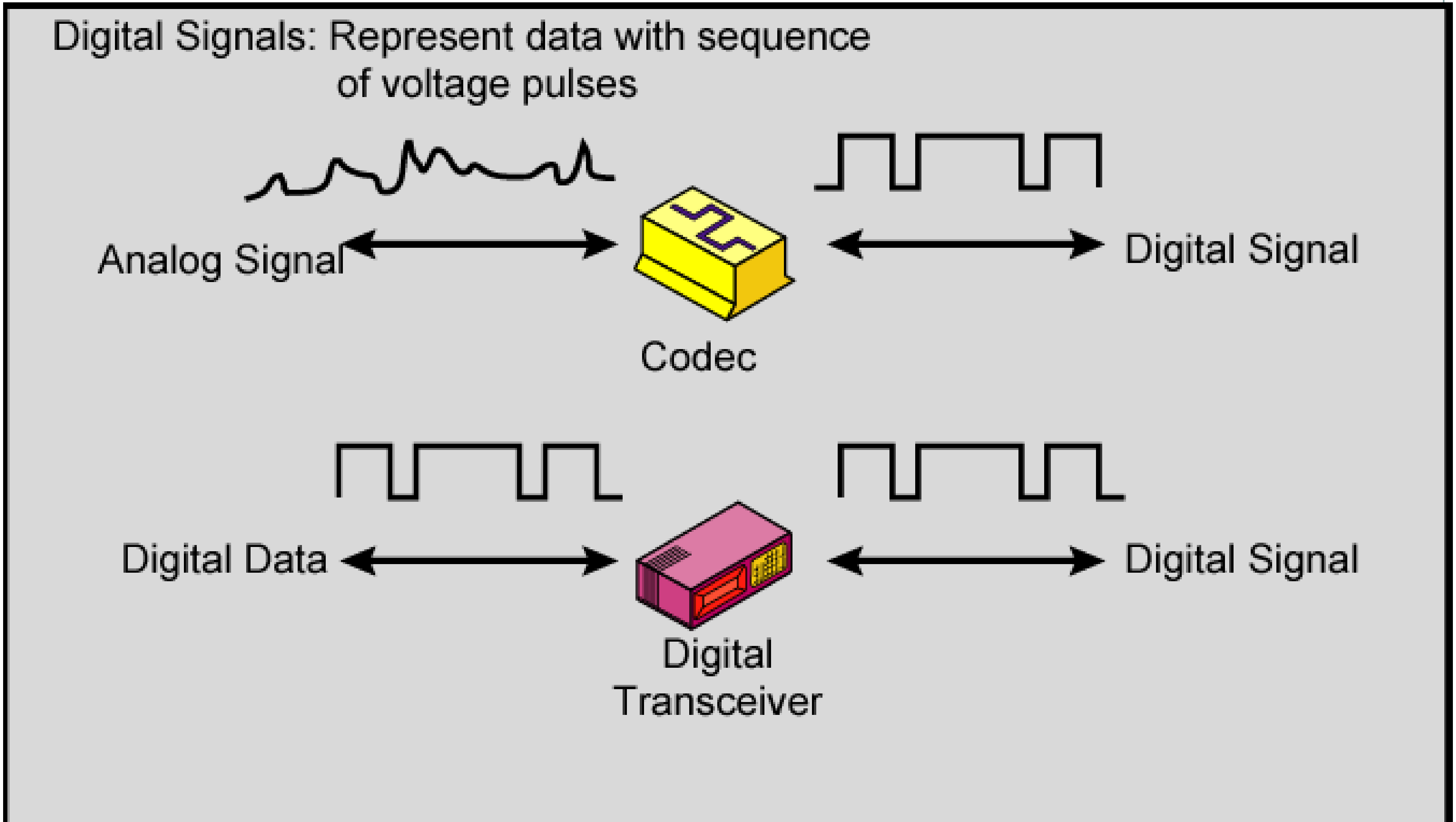


User input at a PC is converted into a stream of binary digits (1s and 0s). In this graph of a typical digital signal, binary one is represented by Ð5 volts and binary zero is represented by +5 volts. The signal for each bit has a duration of 0.02 msec, giving a data rate of 50,000 bits per second (50 kbps).

Analog Signals



Digital Signals



Advantages & Disadvantages of Digital Signals

- cheaper
- less susceptible to noise
- but greater attenuation
- digital now preferred choice