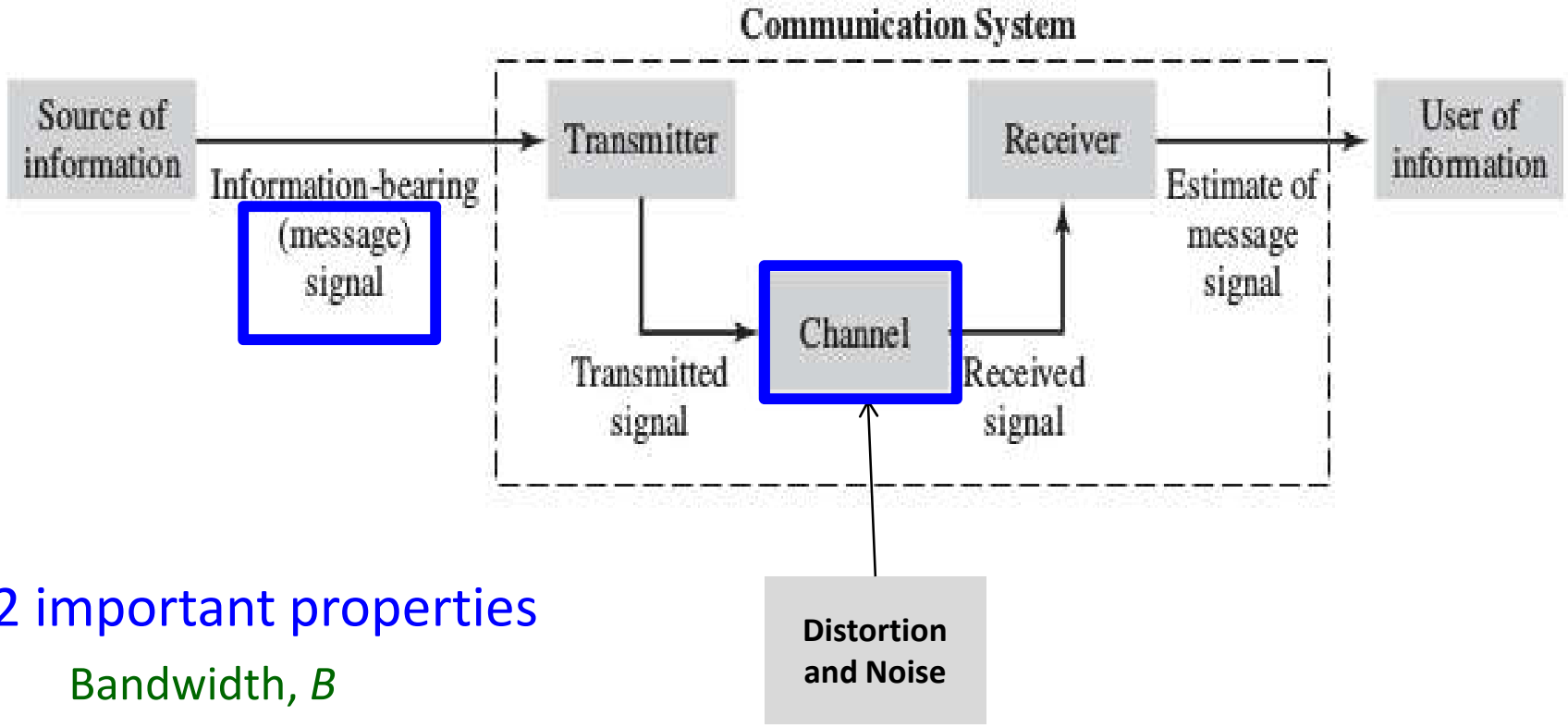
CSE 311:
Data Communication

Instructor:

Dr. Md. Monirul Islam

Channel & signal Characteristics



- 2 important properties
  - Bandwidth, B
  - Signal power, P_s

Channel & signal Characteristics

- Bandwidth
  - Channel Bandwidth
  - Signal bandwidth

Channel & signal Characteristics

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    - Range of frequencies that a channel can transmit
    - Ex: if transmit 0-5 kHz frequencies, Channel bandwidth B = 5 kHz
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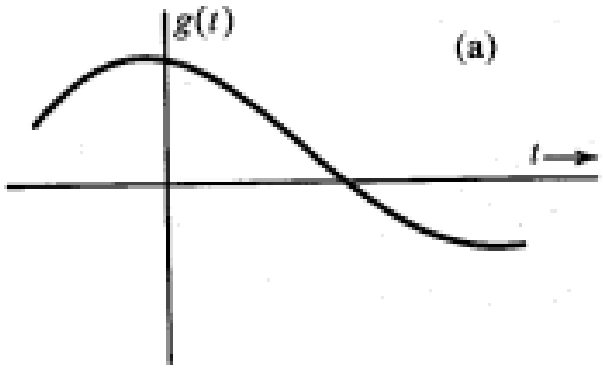

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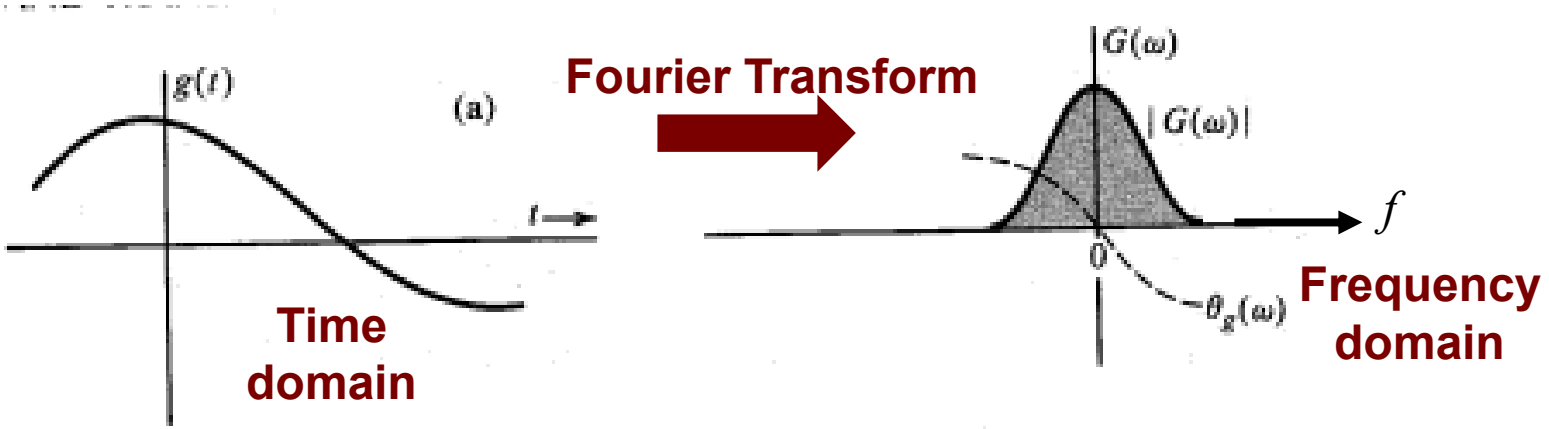

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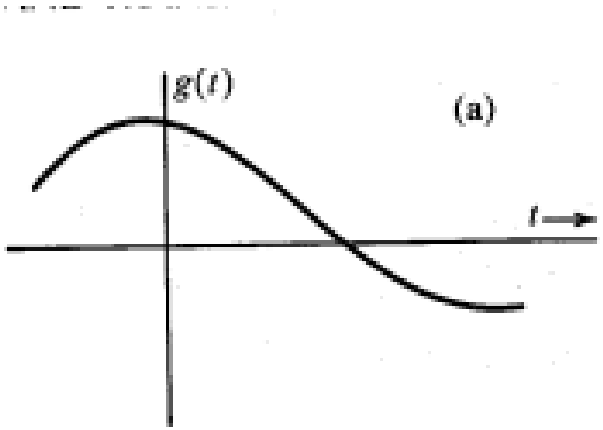

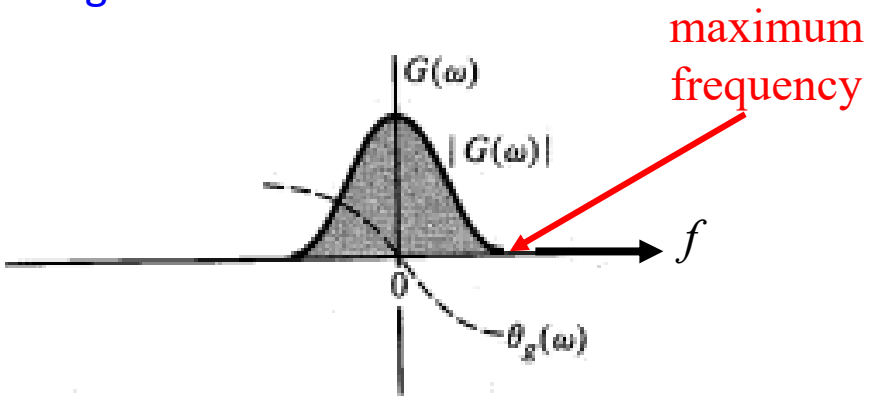

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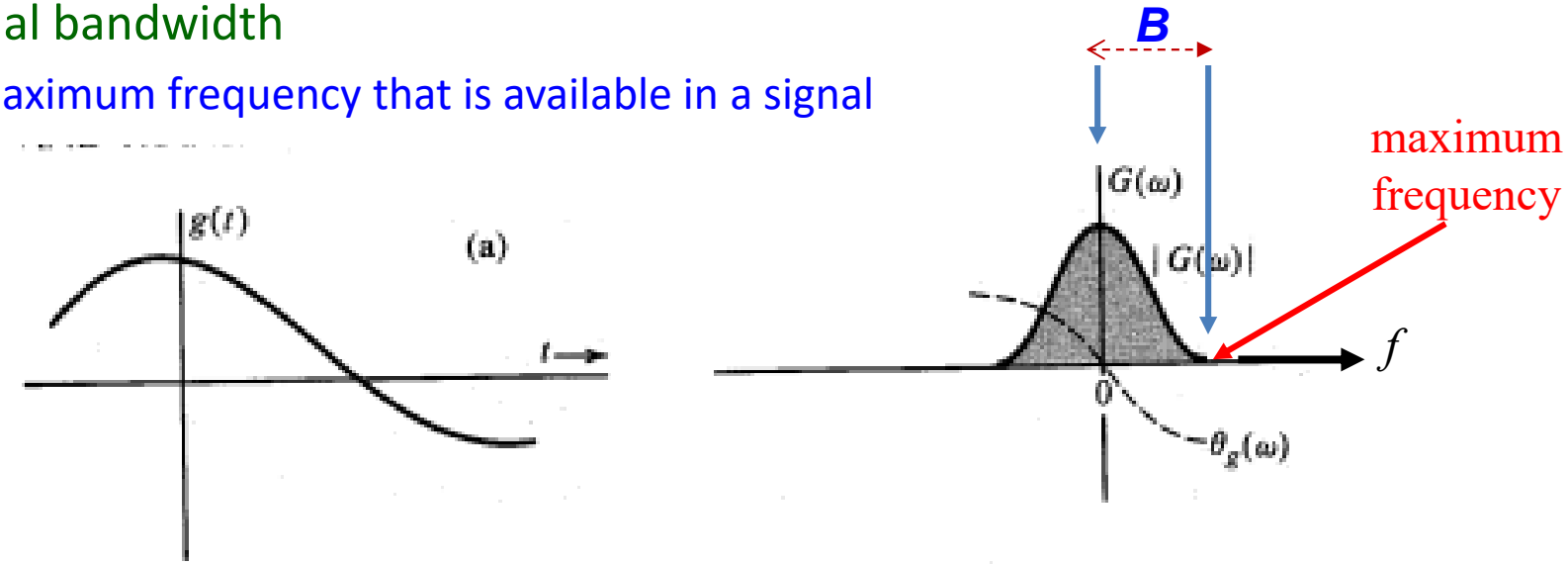
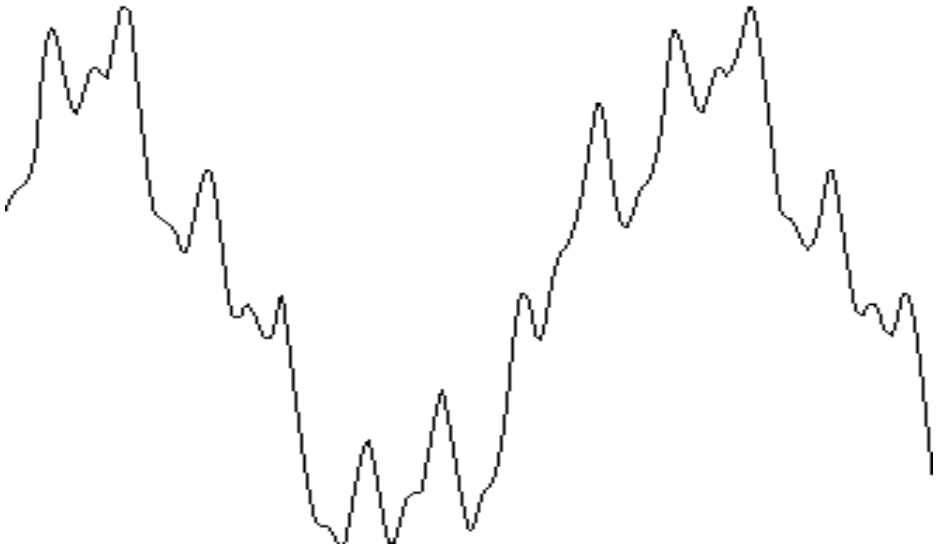
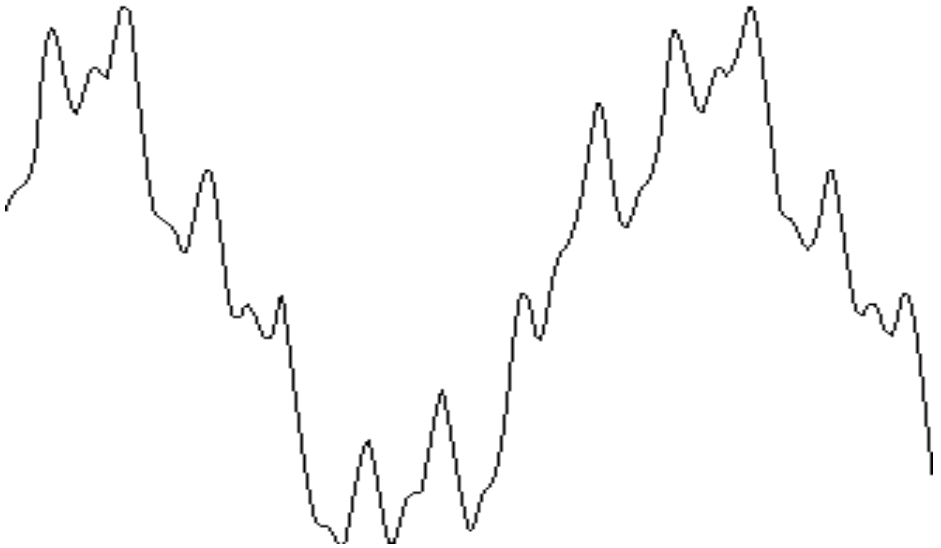


Channel & signal Characteristics



A complex signal with multiple frequencies

Channel & signal Characteristics



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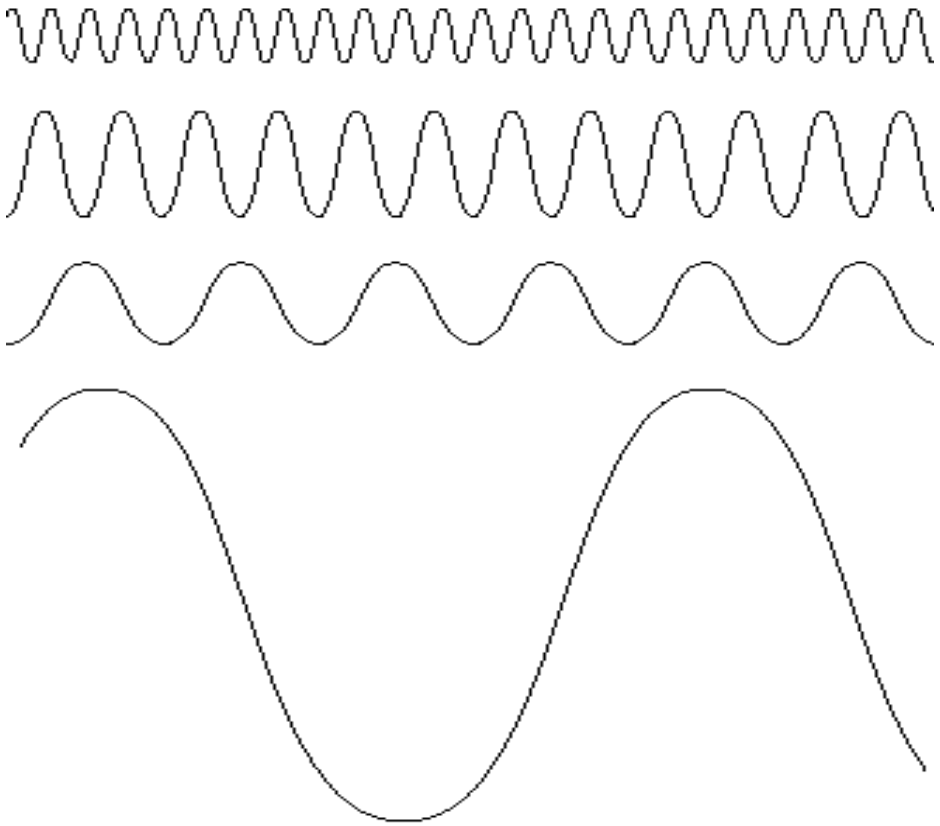


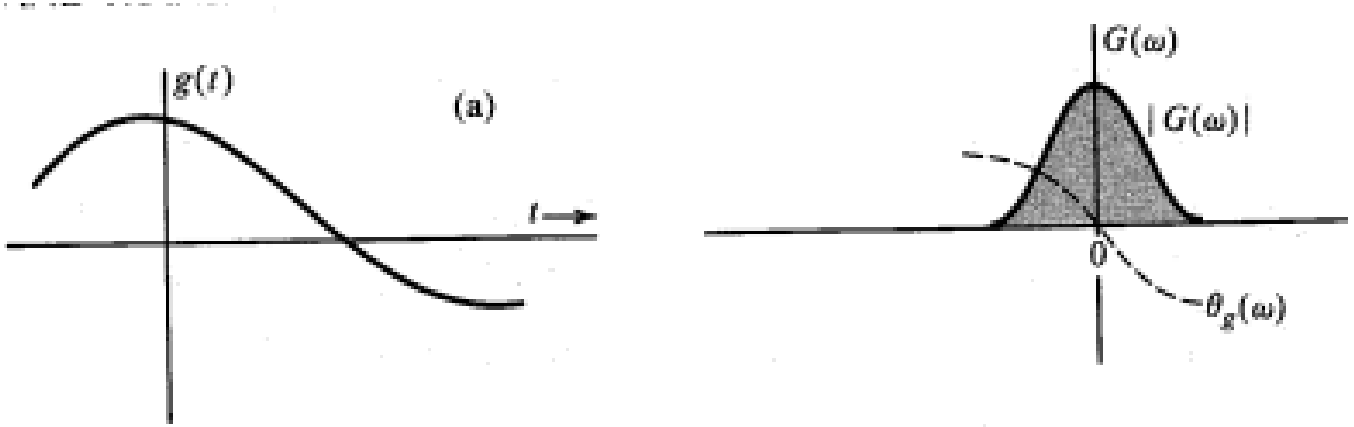
Individual signals each with a single frequency

Channel & signal Characteristics

- Frequency
  - Change in signal values
  - Faster change in values means higher frequencies
  - High frequency signals
    - Sports/battle scene
  - Low frequency signals
    - News/sleeping animal videos

Channel & signal Characteristics

- Frequency
  - Compressing in time, increases frequency, means higher channel Bandwidth



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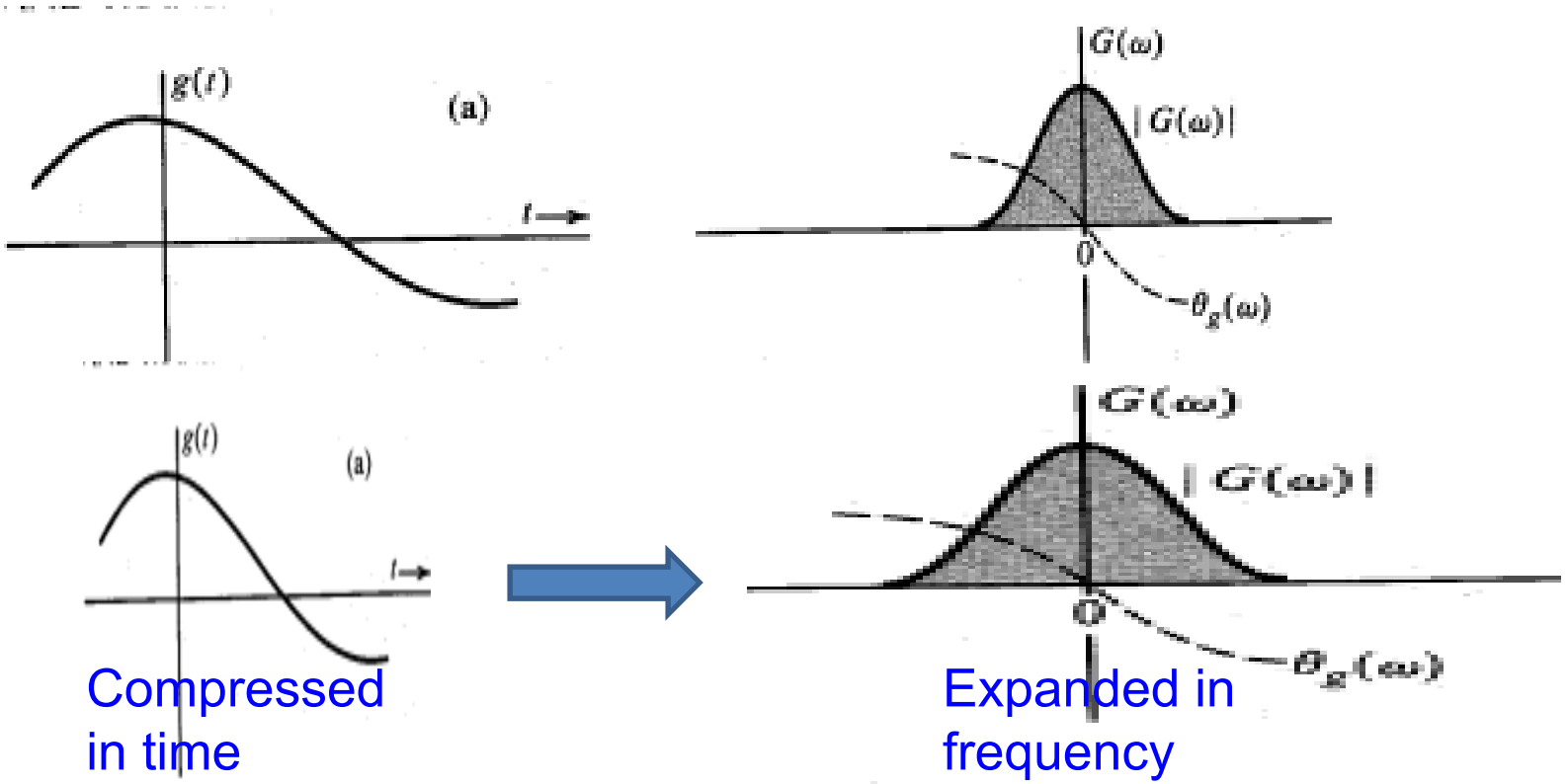

Compressed in time

Expanded in frequency

Channel & signal Characteristics

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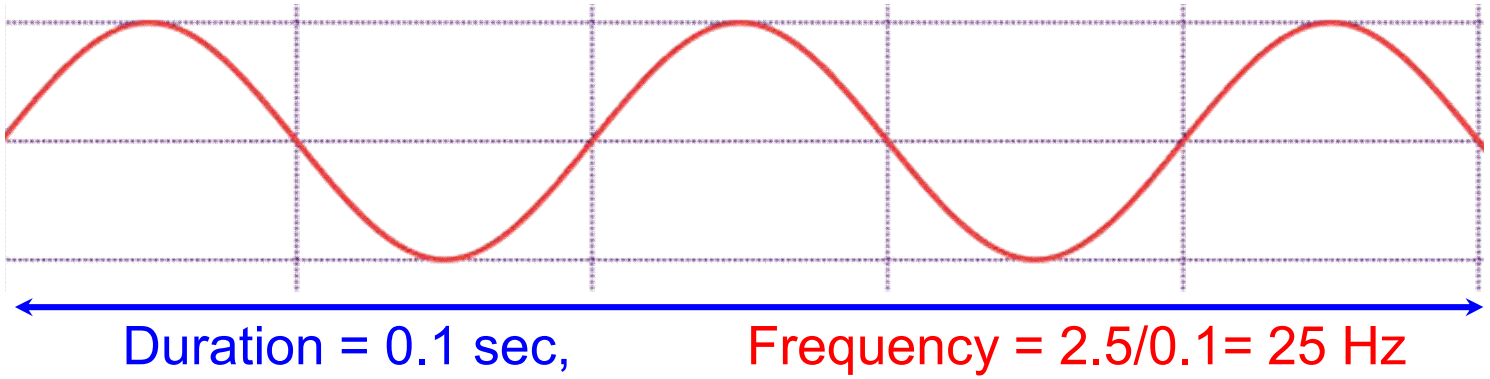

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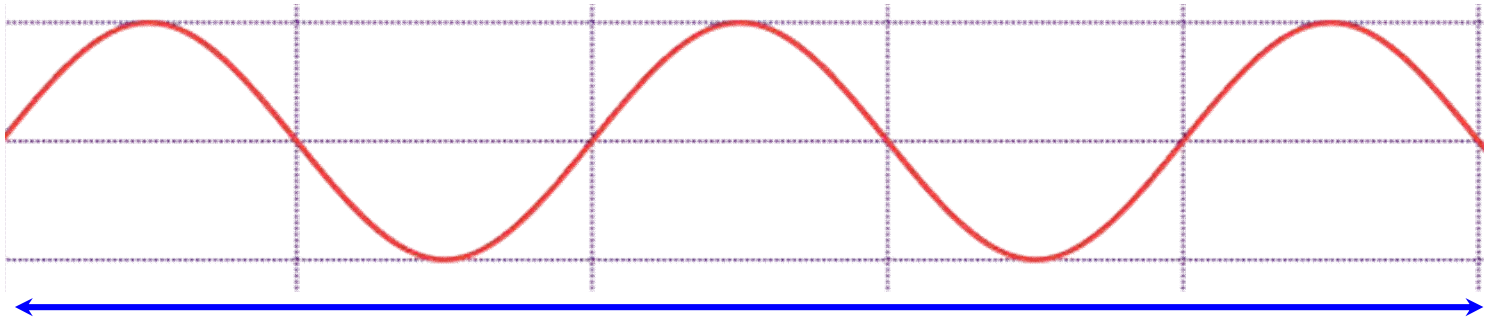
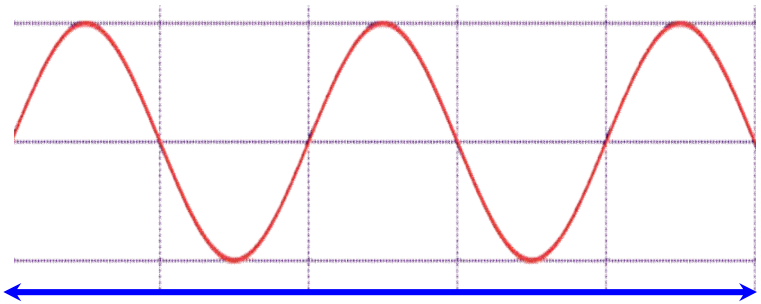


Duration = 0.1 sec, Frequency = 2.5/0.1= 25 Hz



Duration = 0.05 sec, Frequency =2.5/0.05=50 Hz

Channel & signal Characteristics

- More transmission speed requires channel with higher bandwidth

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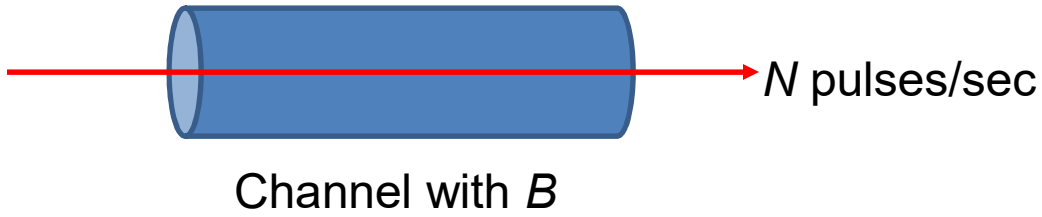

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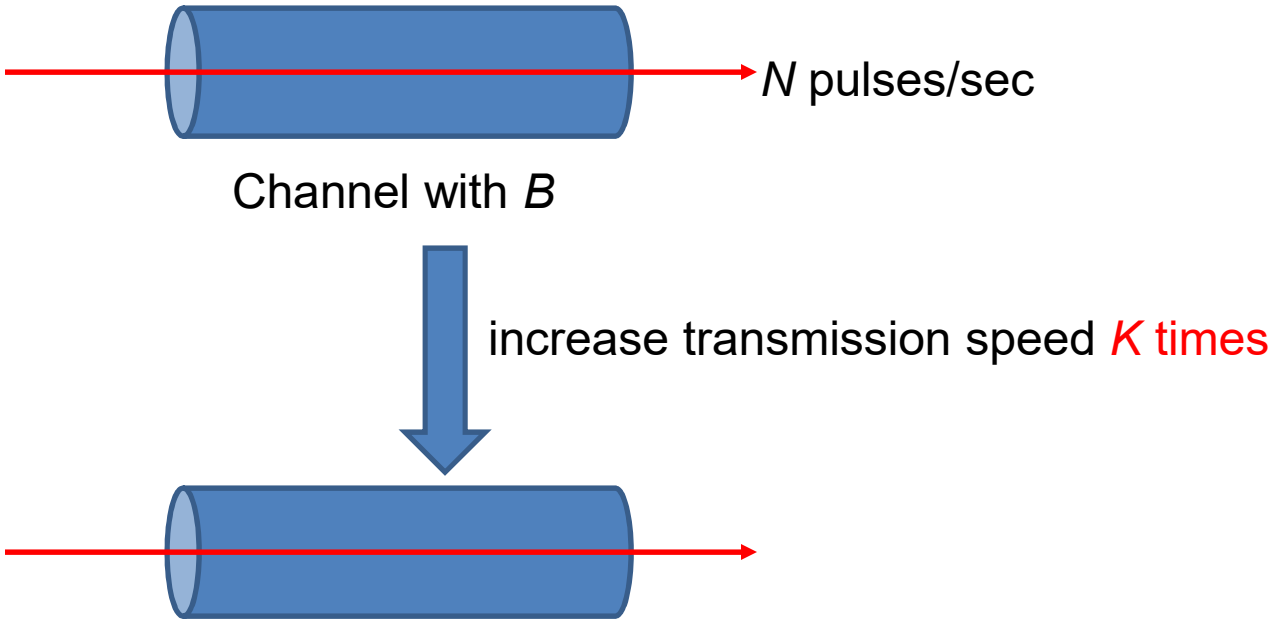

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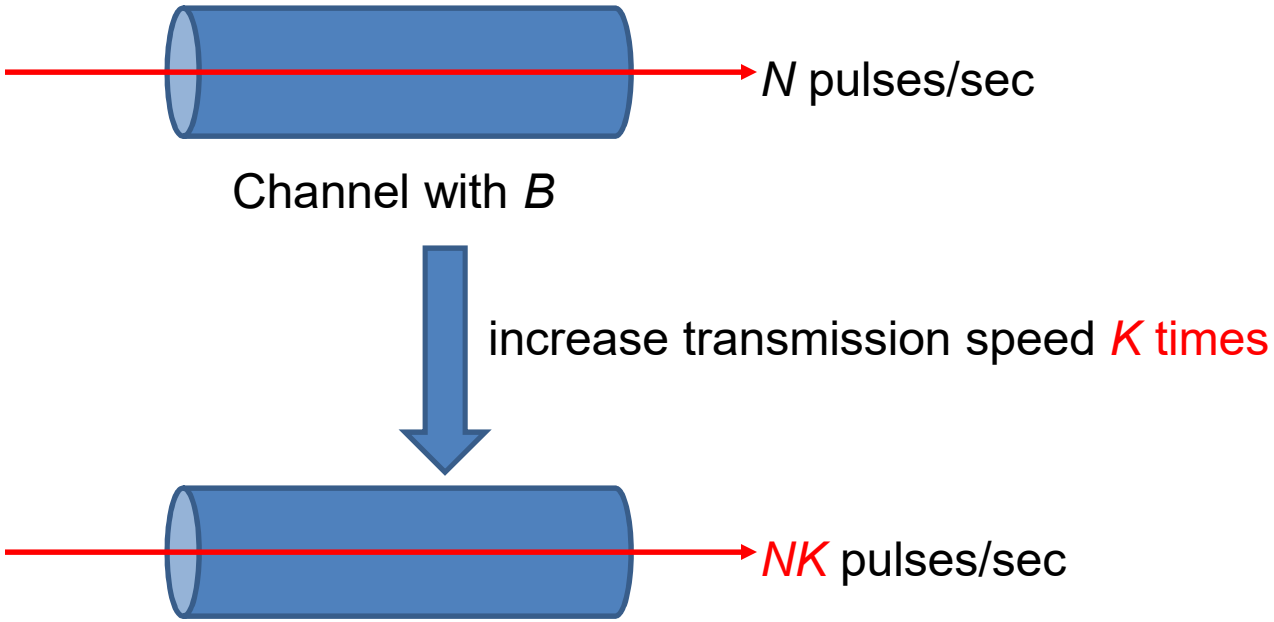

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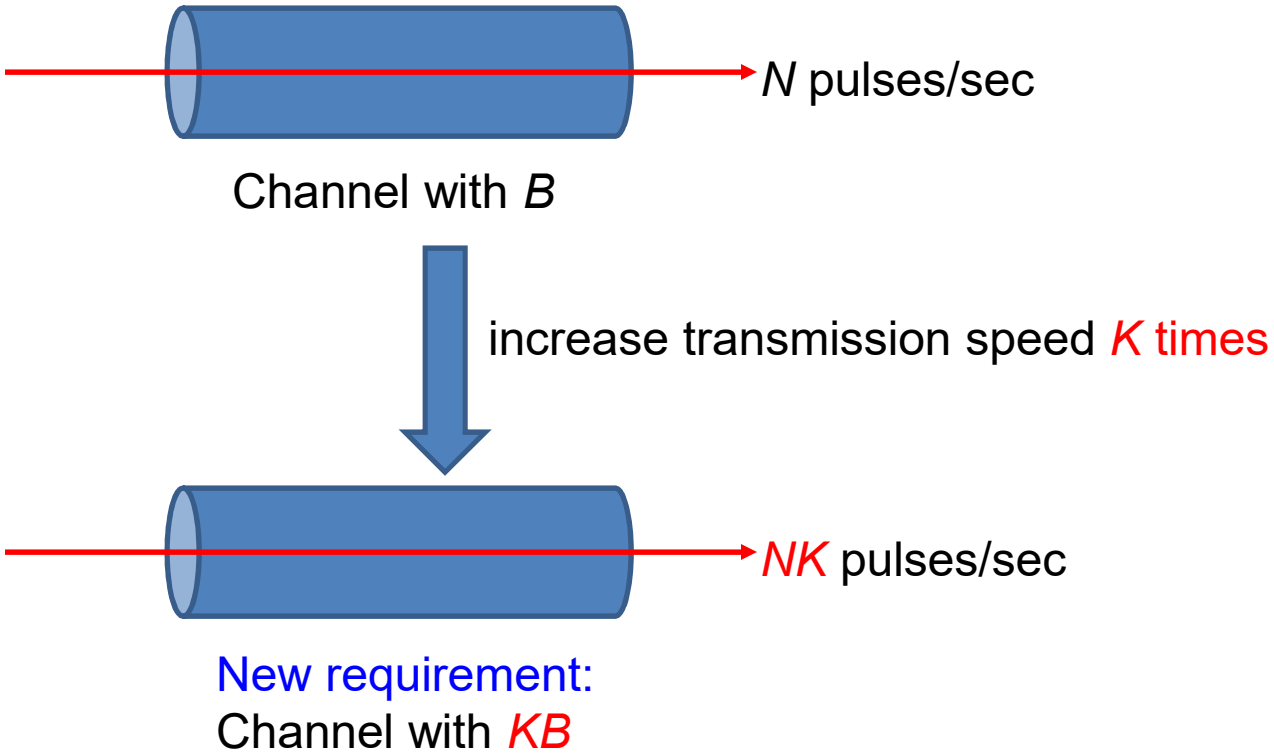


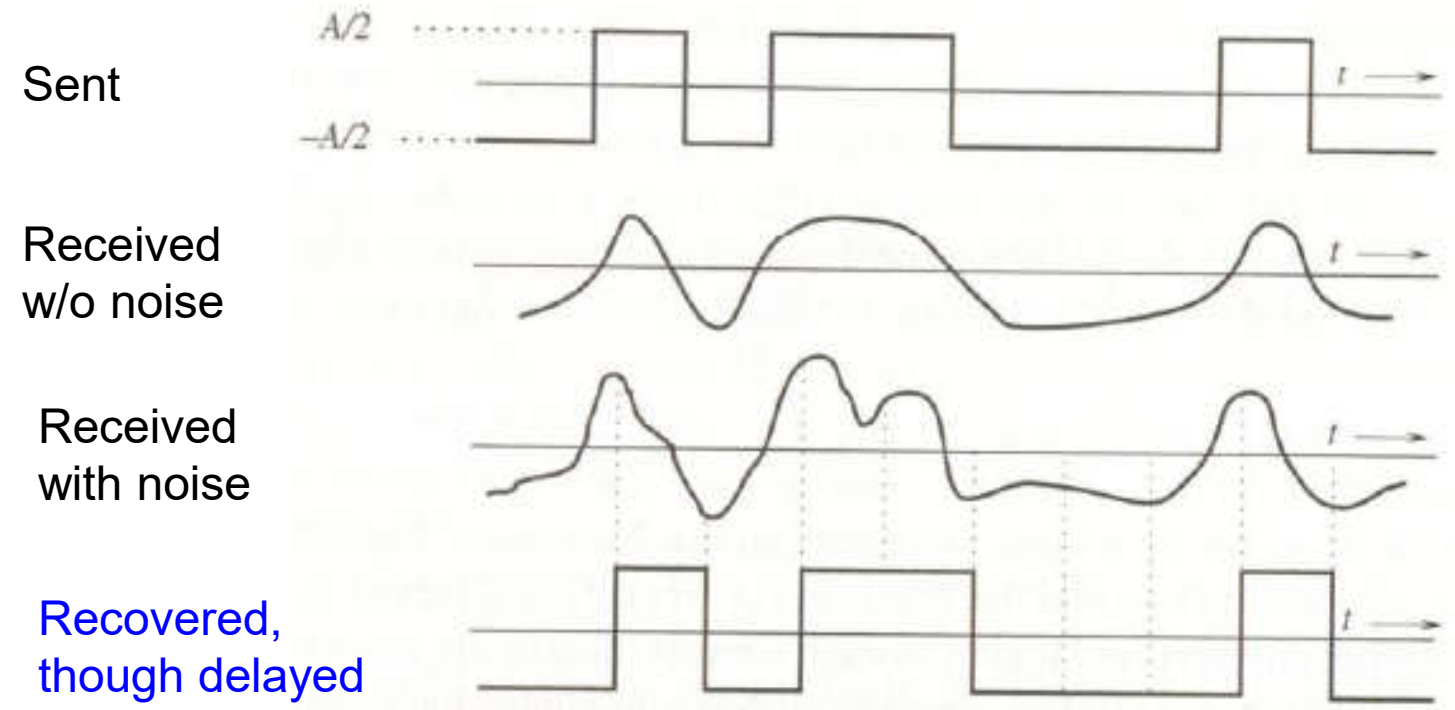
Channel & signal Characteristics

- Signal Power, P_s
  - Dual role
    - Higher Quality
    - Less channel bandwidth

Analog to Digital Conversion of Message/Signal

Recall this figure

- Detection is easy when A >> noise
- Usually A >> 5-10 times of noise



Channel & signal Characteristics

Signal Power, $P_s \propto Amplitude, A$

$=>$ *Increase in A means increase in* P_S

SNR = Signal / Noise

Channel & signal Characteristics

- Signal Power, P_s for higher quality
  - P_s++ -> *SNR*++
  - maintains minimum *SNR* for longer distance
  - Higher *SNR* means
    - more noise immunity
    - easier detection of pulses

Channel & signal Characteristics

- Signal Power, P_s needs less channel bandwidth
  - Higher signal P_s eases the channel

Channel & signal Characteristics

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  - Shannon's limit on channel capacity

$$C = B\log_2(1+SNR)\,bit/s$$

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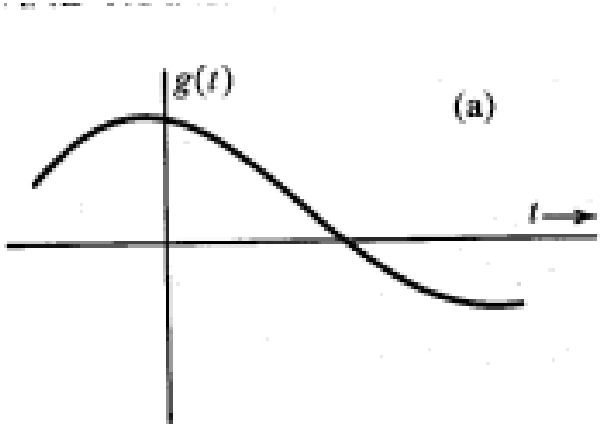
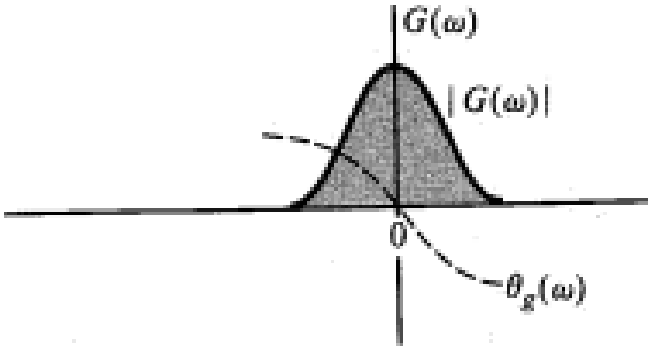
$$C = B\log_2(1+SNR)\,bit/s$$

What happens if *SNR* = ∞?

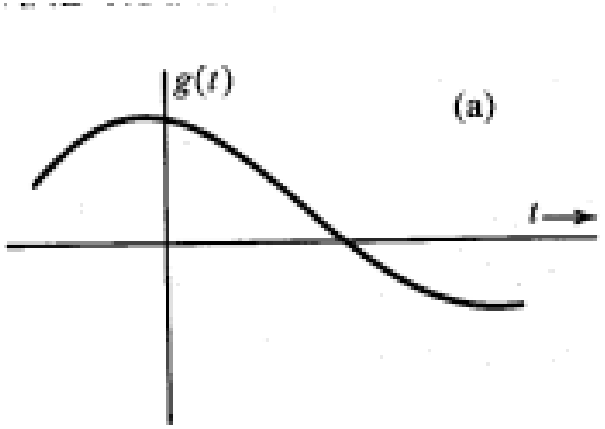
Channel & signal Characteristics

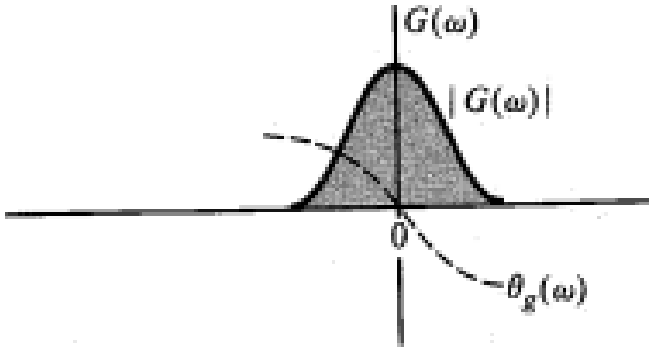




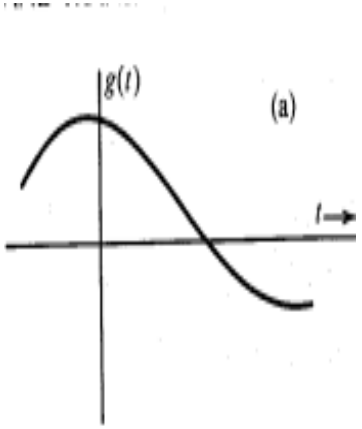
Baseband signal

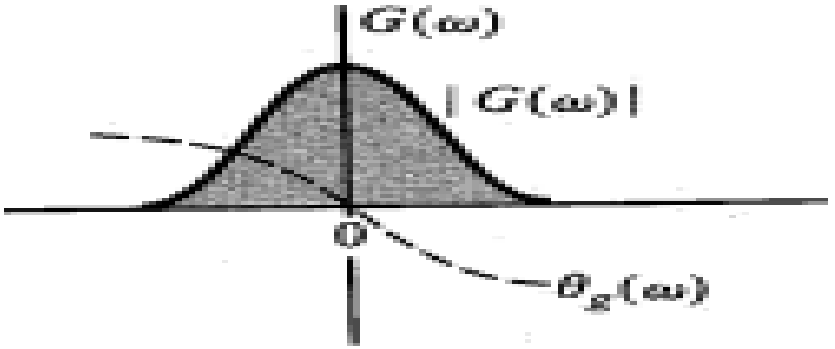
Channel & signal Characteristics





Baseband signal 1

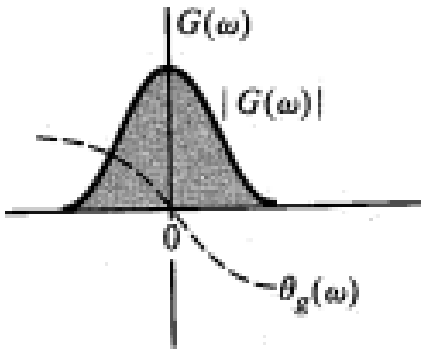




Baseband signal 2

Channel & signal Characteristics

- Assume, these 2 signals need to be transmitted



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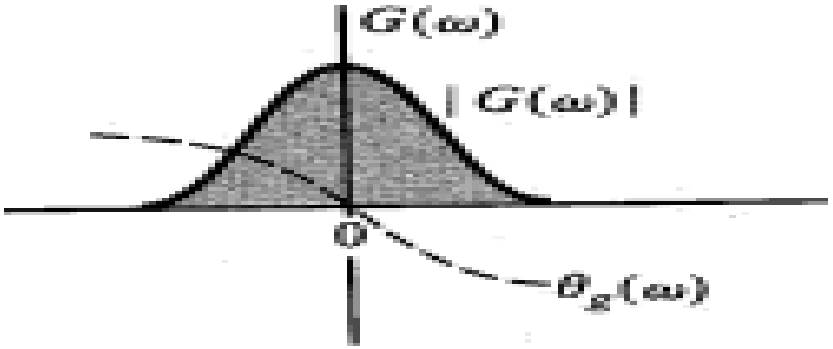
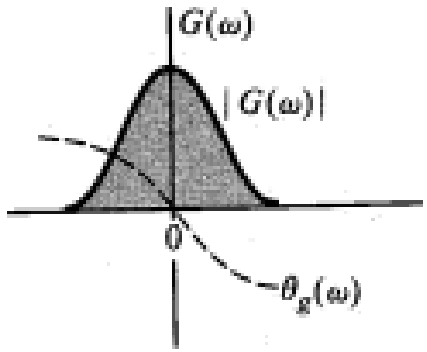


Baseband signal 2

Channel & signal Characteristics

- Assume, these 2 signals need to be transmitted
  - 2 different channels?



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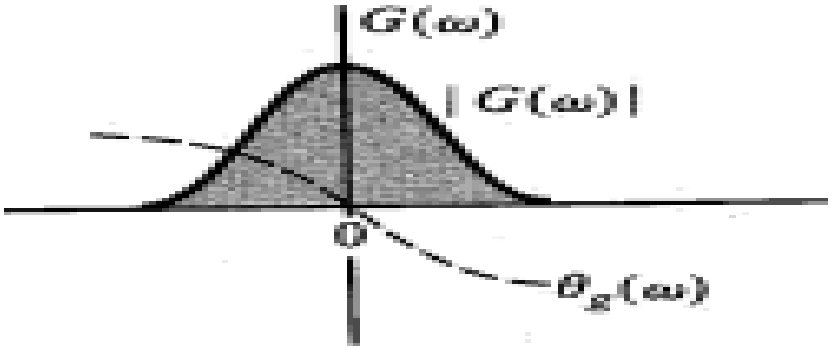
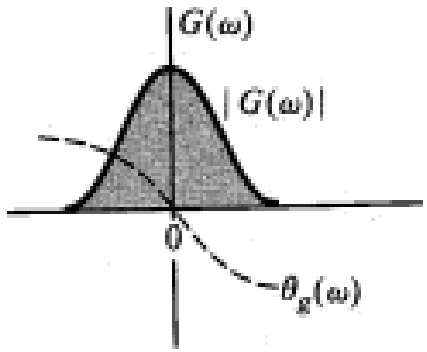


Baseband signal 2

Channel & signal Characteristics

- Assume, these 2 signals need to be transmitted
  - Even, channel bandwidth and signal bandwidth may NOT match!!



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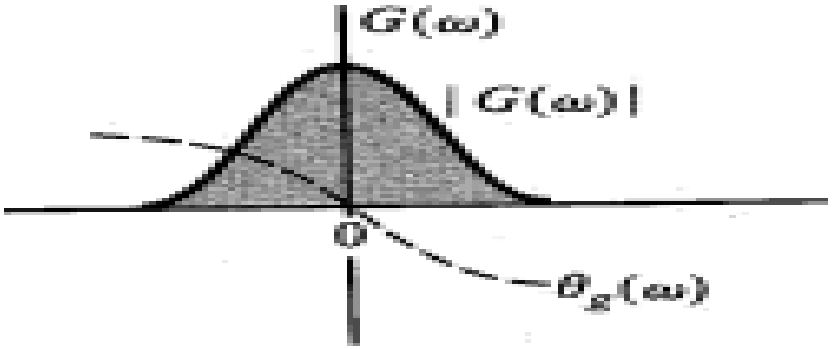

Baseband signal 2

Channel & signal Characteristics

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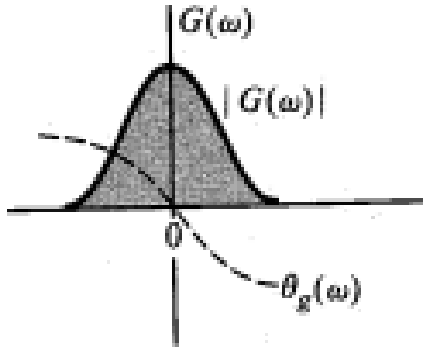
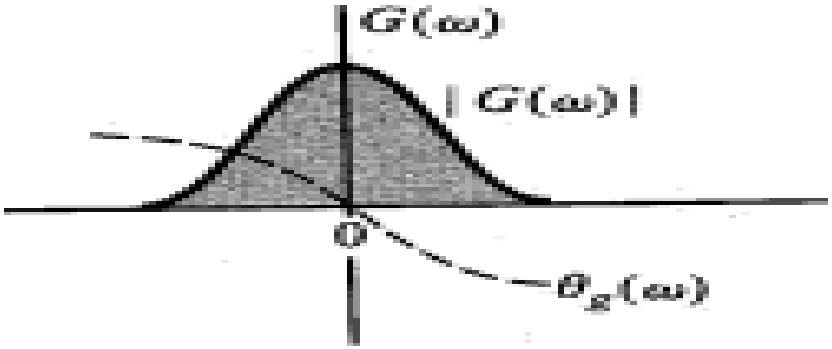


Baseband signal 1

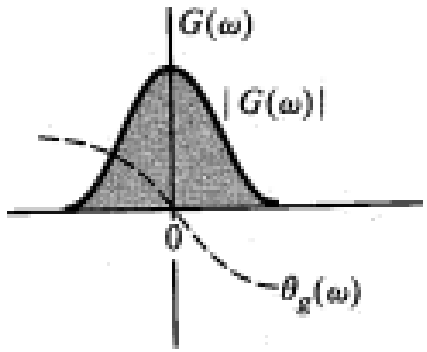
Solution is modulation



Baseband signal 2

Channel & signal Characteristics: *modulation*

- Use carrier signal to shift these 2 signals to different frequency positions



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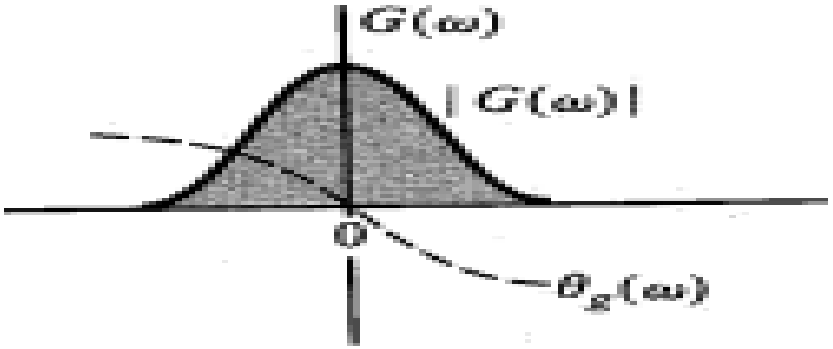

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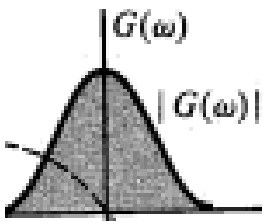

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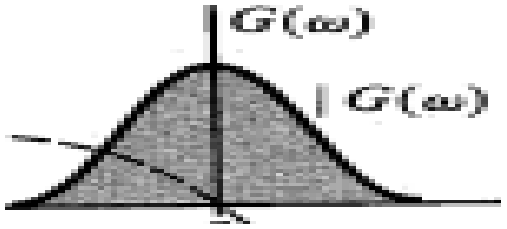
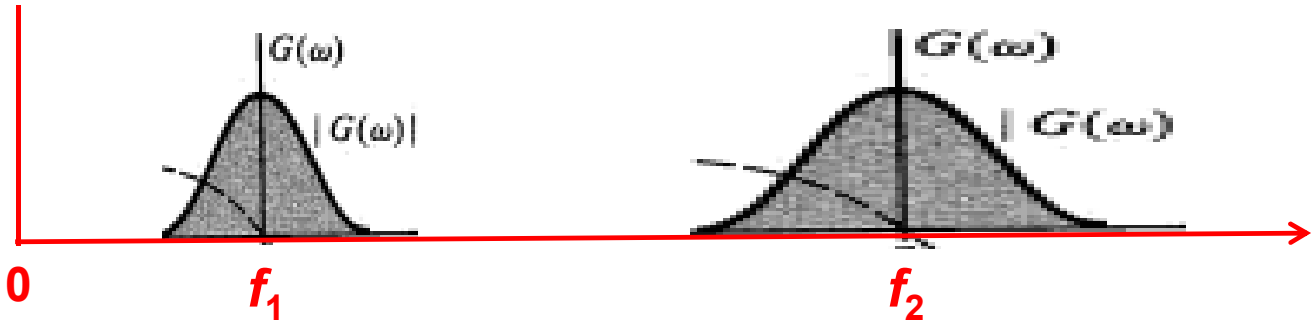


Baseband signal 2

After modulation:



Frequency axis

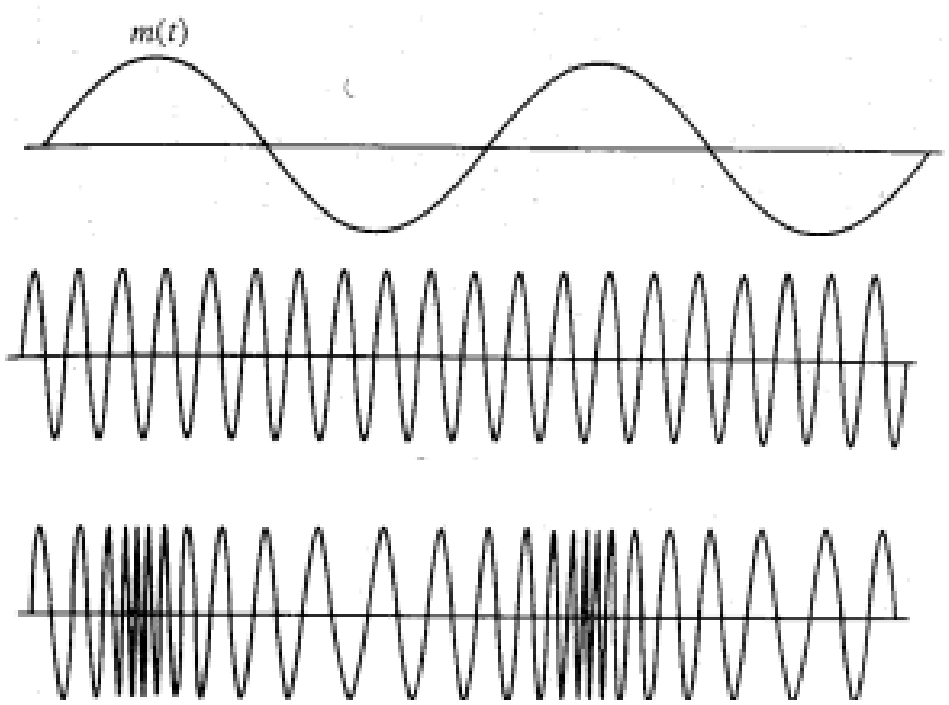
Channel & signal Characteristics: *modulation*

- other examples of modulation
  (shown in time domain)

Baseband signal

Carrier signal

Modulated signal



Channel & signal Characteristics: *modulation*

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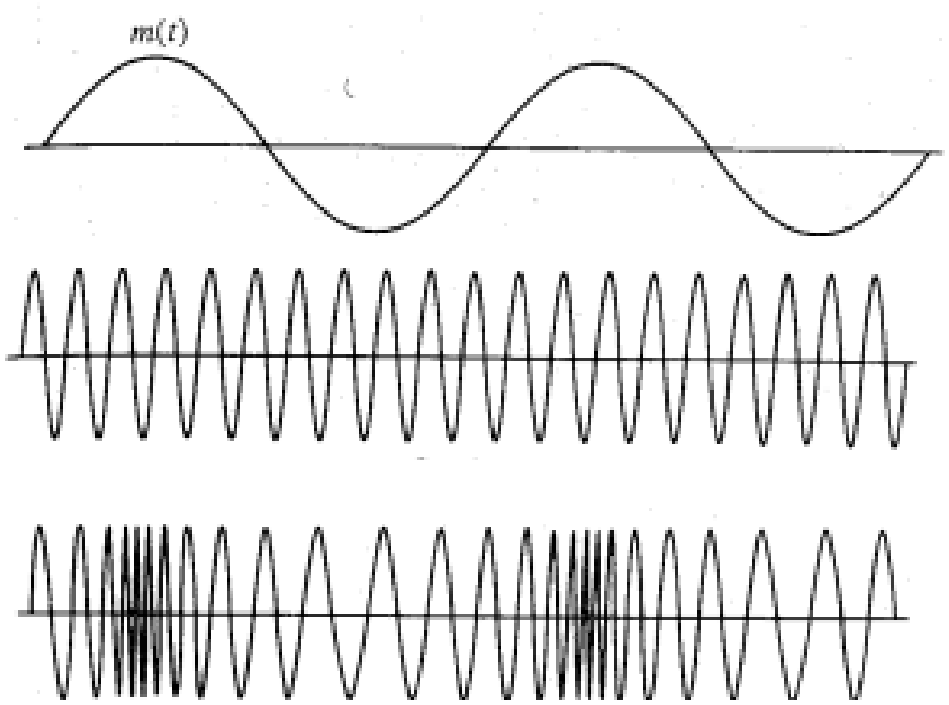
Baseband signal

Carrier signal

Modulated signal



Frequency modulation (FM)

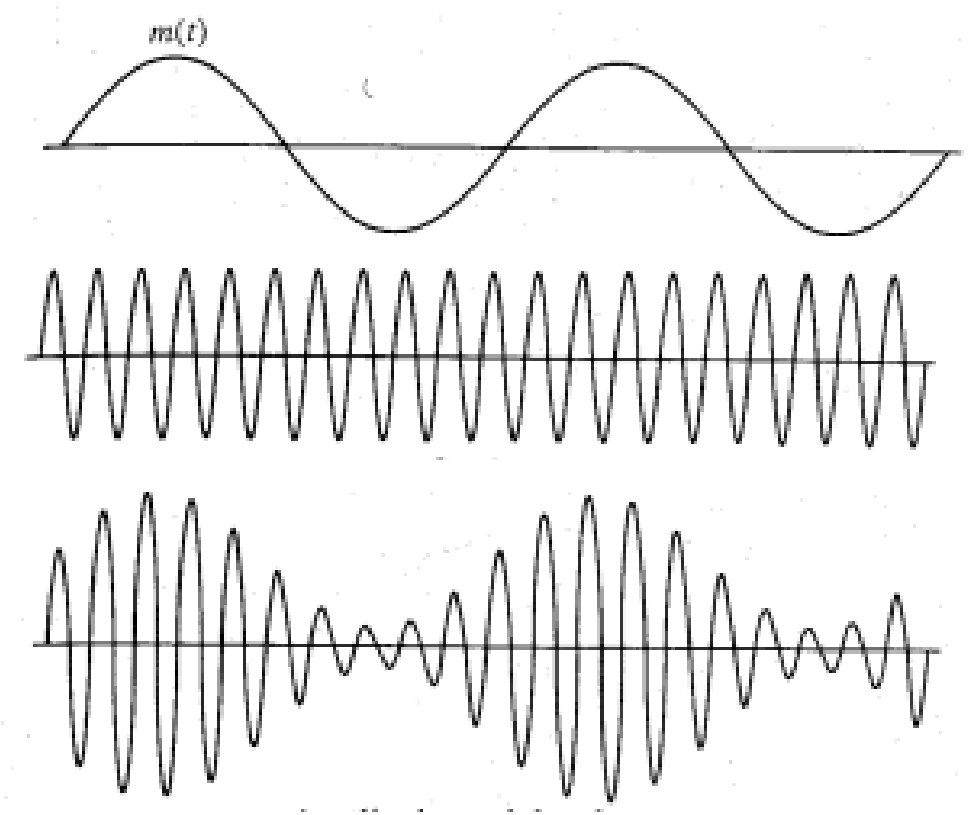
Channel & signal Characteristics: *modulation*

- other examples of modulation
  (shown in time domain)

Baseband signal

Carrier signal

Modulated signal



Amplitude modulation (AM)

Channel & signal Characteristics: *modulation*

- Phase modulation (PM)
- Changes phase angle of the signal

Channel & signal Characteristics: *modulation*

Other reasons for modulation

Low frequency → Higher wavelength → Generating antenna requires higher dimension

Channel & signal Characteristics: *modulation*

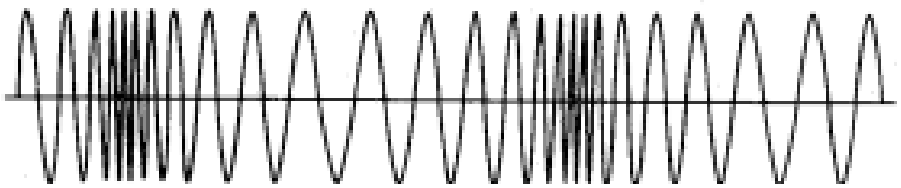
Other reasons for modulation

Low frequency → Higher wavelength → Generating antenna requires higher dimension

- Speech signal characteristics
  - Frequency range: 100 – 3000 Hz
  - Wavelength 100 to 3000 km
  - requires *impractically* large antenna

Channel & signal Characteristics: *modulation*

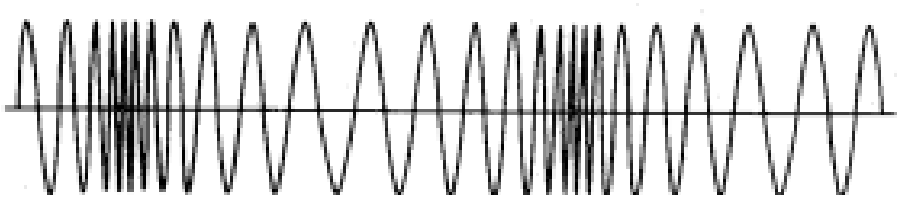
Other reasons for modulation



Modulating a High frequency carrier → Lower wavelength → Generating antenna requires lower dimension

Channel & signal Characteristics: *modulation*

Other reasons for modulation



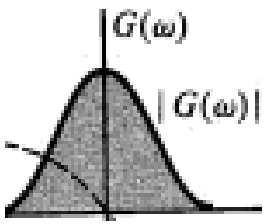
Modulating a High frequency carrier → Lower wavelength → Generating antenna requires lower dimension

- 10 MHz carrier signal characteristics
  - Wavelength 30 m
  - requires antenna of size 3m

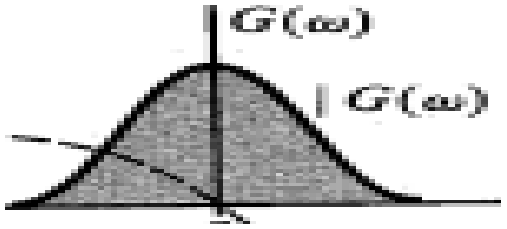
Channel & signal Characteristics: *modulation*

- Use carrier signal to shift these 2 signals in different frequency positions

recall this example!

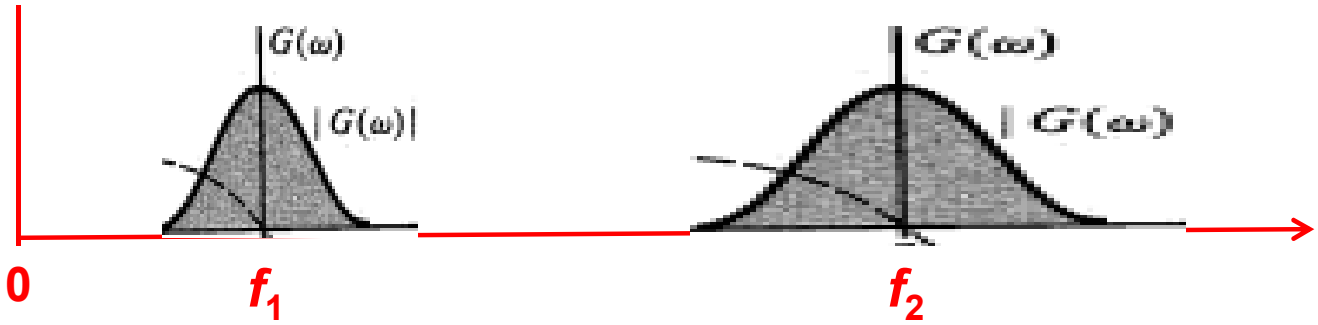


Baseband signal 1



Baseband signal 2

After modulation:

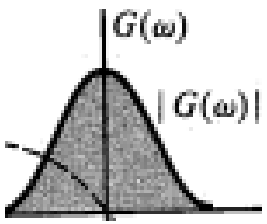


Frequency axis

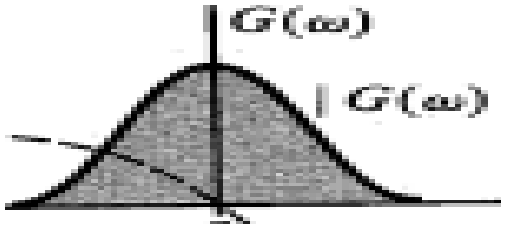
Channel & signal Characteristics: *modulation*

- Use carrier signal to shift these 2 signals in different frequency positions

also called
Frequency division multiplexing (FDM)

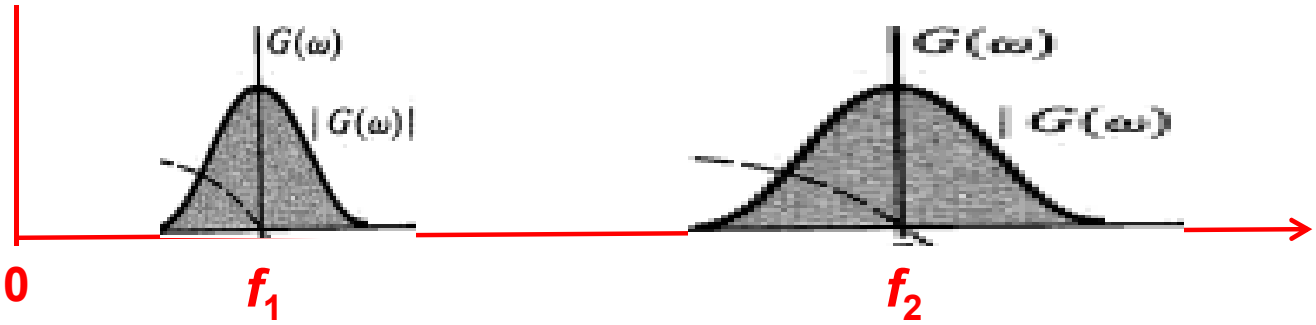


Baseband signal 1



Baseband signal 2

After modulation:



Frequency axis

Channel & signal Characteristics: *modulation*

- Time division multiplexing (TDM)
  - Interleave pulses from different signals in time domain signal

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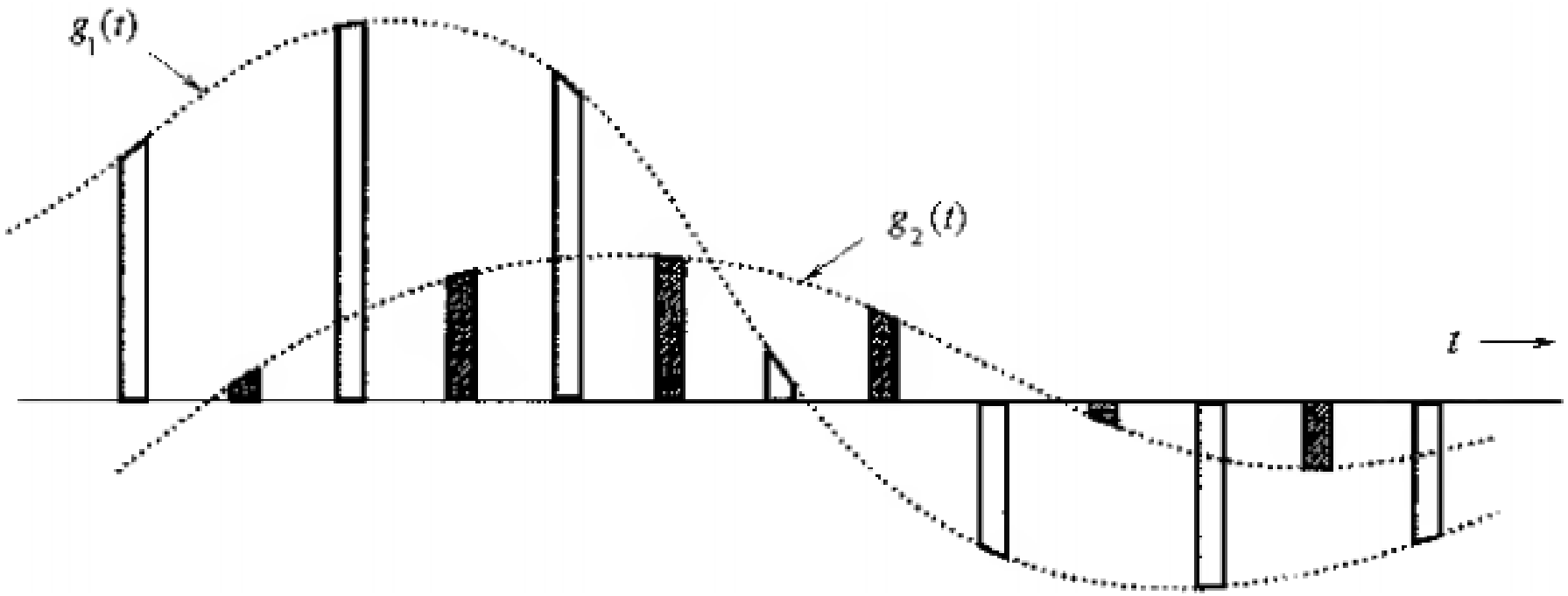

Channel & signal Characteristics: *DeModulation*

- Done at the receiving end
  - Bandpass filter separates appropriate signal
  - Makes necessary corrections for amplitude, frequency and phase changes