

Applications of Signals and Systems

Application Areas

- Control
- Communications
- Signal Processing

Control Applications

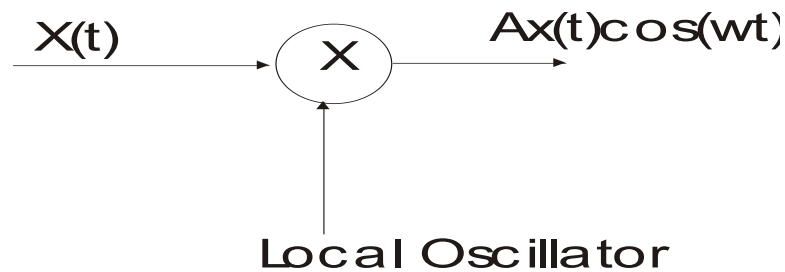
- Industrial control and automation (Control the velocity or position of an object)
- Examples: Controlling the position of a valve or shaft of a motor
- Important Tools:
 - Time-domain solution of differential equations
 - Transfer function (Laplace Transform)
 - Stability

Communication Applications

- Transmission of information (signal) over a channel
- The channel may be free space, coaxial cable, fiber optic cable
- A key component of transmission: Modulation (Analog and Digital Communication)

Modulation

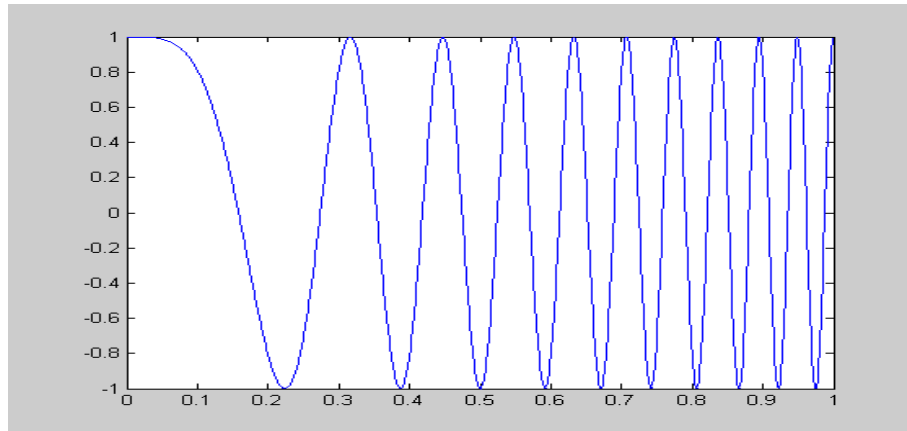
- Analog Modulation: Transmitting audio signals.



- Advantage: Higher frequency range \rightarrow good propagation

Modulation

- Frequency Modulation (FM), modulate the angle of the carrier.



- Advantage: More robust to interference

Digital Modulation

- Used in CDs, digital cellular service, digital phone lines and computer modems.
- Advantages:
 - Can be encrypted
 - Electronic routing of data is easier
 - Digital storage faster
 - Multimedia capability

Signal Processing Applications

- Signal processing=Application of algorithms to modify signals in a way to make them more useful.
- Goals:
 - Efficient and reliable transmission, storage and display of information
 - Information extraction and enhancement
- Examples:
 - Speech and audio processing
 - Multimedia processing (image and video)
 - Underwater acoustic
 - Biological signal analysis

Multimedia Applications

- Compression: Fast, efficient, reliable transmission and storage of data
- Applied on audio, image and video data for transmission over the Internet, storage
- Examples: CDs, DVDs, MP3, MPEG4, JPEG
- Mathematical Tools: Fourier Transform, Quantization, Modulation

JPEG Example

43K

13K

3.5K



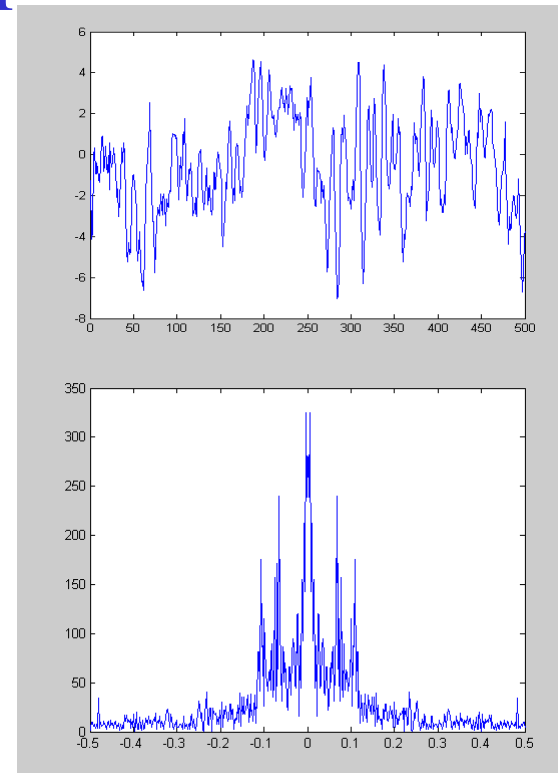
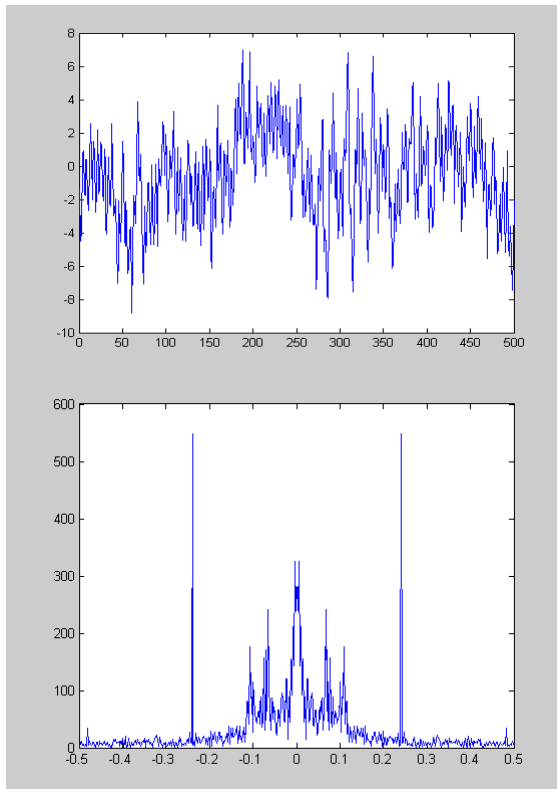
- JPEG uses Discrete-Cosine Transform (similar to Fourier Transform)

Biological Signal Analysis

- Examples:
 - Brain signals (EEG)
 - Cardiac signals (ECG)
 - Medical images (x-ray, PET, MRI)
- Goals:
 - Detect abnormal activity (heart attack, seizure)
 - Help physicians with diagnosis
- Tools: Filtering, Fourier Transform

Example

- Brain waves are usually contaminated by noise and hard to interpret



Biometrics

- Identifying a person using physiological characteristics
- Examples:
 - Fingerprint Identification
 - Face Recognition
 - Voice Recognition

Audio Signal Processing

- Active noise cancellation: Adaptive filtering
 - Headphones used in cockpits
- Digital Audio Effects
 - Add special music effects such as delay, echo, reverb
- Audio signal separation
 - Separate speech from interference
 - Wind sound from music in cars

Filtering Example

