Digital Signal Processing

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Invalid Date

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Preface

My notes on ???.

Resources

Some relevant resources:

- Resource Name

Textbooks:

- Book 1

1 Introduction

1.1 Perspective

> Note 1: Definition - Some definition
>
> **Term** is defined as blah blah blah...

This note does ...

1.2 High Level Ideas

2 Signal Transform

What is signal transform?

- Basis
- Coefficients

Transform Examples:

- DFT (FFT)
- DCT
- Wavelet Transform
- Laplace Transform, Z transform, …

Why signal transform needed?

- Feature extraction
- Compression (compact signal representation)
- Complexity reduction
- Easier manipulation and analysis of signal

2.1 DFT, IDFT

2.1.1 Orthogonal Basis Function

2.1.2 Linear vs Circular Convolution

2.2 Fast Fourier Transform (FFT)

3 Wireless Communication Systems

- Source Coding
  - Entropy coding, transform compression, compressive sensing
    - Entropy Coding: Uses principles from information theory (Shannon entropy) to remove redundancy. Examples: Huffman coding, Arithmetic coding.
    - Transform Compression: Uses mathematical transforms (e.g., DCT in JPEG, FFT in OFDM) to represent signals efficiently.
    - Compressive Sensing: Uses sparse signal representations to reduce the number of required samples while preserving information.
- Cryptography
  - Authentication, encryption
  - Mostly in finite field arithmetic
- Channel Coding
  - Error correction coding: convolutional code, block code, Polar, LDPC,turbo code, ...

3.1 Modulation

High-level: Converts digital data into analog signals for transmission.

3.1.1 Linear Modulation

Used in WiFi, LTE, 5G due to efficient spectral usage.

3.1.2 Non-Linear Modulation

Used in Bluetooth, GSM due to power efficiency.

3.1.3 Passband Modulation

High-level: Involves shifting baseband signals to a higher frequency for RF transmission.

3.2 Wireless Channel Model

3.3 Demodulation

High-level: The process of recovering transmitted data.

3.3.1 Demodulation: Down-Conversion

High-level: Converts the received RF signal back to baseband using a local oscillator.

3.3.2 Demodulation: AWGN, Linear & Non-Linear Modulation

- AWGN: Basic noise model.
- Linear & Non-Linear Modulation: Different detection techniques apply based on the modulation scheme.

3.3.3 OFDM

(Orthogonal Frequency Division Multiplexing)

Uses multiple subcarriers to mitigate frequency-selective fading. Used in WiFi, LTE, 5G.

3.3.4 Zigbee (BPSK) Example

3.3.5 Bluetooth Example

3.3.6 WiFi IEEE 802.11a/g/n

Uses OFDM with various QAM levels for high data rates.

3.3.7 MIMO

High-level: Enhances spectral efficiency and reliability by using multiple antennas.

3.3.8 Spatial Multiplexing

High-level: Transmits independent data streams over multiple antennas to increase data rates.

3.3.9 MIMO Detection

3.3.10 MMSE

3.3.11 Eigen Beam-Forming

4 Source Channel Coding

4.1 Information Entropy

4.2 Huffman Code

4.2.1 Huffman Decode

4.3 Finite Field (Galois Field)

4.4 Scrambler / De-Scrambler

4.5 Cyclic Redundancy Check

5 DSP & VLSI

6 Summary

In summary...

References