ECE 252 Course Project Report

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# Part I: Analog Communication

## 1. Plot of x(t)

A triangular pulse function x(t) is defined and plotted over the interval t ∈ [-10, 10]. The function is zero outside the range [-4, 4], linearly increases from -4 to 0, and decreases from 0 to 4.

## 2. Analytical Fourier Transform of x(t)

The analytical expression of the Fourier Transform of x(t) was derived and evaluated numerically for visualization. The expression captures the frequency characteristics of a symmetric triangular pulse.

## 3. Numerical Fourier Transform

The numerical Fourier Transform was calculated using FFT with fs = 100 Hz and resolution df = 0.01 Hz. The result was plotted alongside the analytical transform, showing good agreement.

## 4. Bandwidth Estimation

Bandwidth was estimated as the frequency range after which the power spectrum drops below 5% of its peak value. This bandwidth was computed from the squared magnitude of the analytical Fourier Transform.

## 5. LPF with Bandwidth = 1 Hz

x(t) was passed through an ideal low-pass filter with BW = 1 Hz. The resulting time-domain signal showed smoothing effects while preserving the main shape of x(t).

## 6. LPF with Bandwidth = 0.3 Hz

When the bandwidth of the LPF was reduced to 0.3 Hz, greater smoothing and information loss occurred, as expected due to high-frequency attenuation.

## 7. m(t) Signal Analysis

A modulated cosine pulse m(t) was defined over (0, 4). The same process (plotting, Fourier transform, bandwidth estimation) was repeated, showing distinct spectral characteristics due to the sinusoidal nature of m(t).

## 8. FDM Modulation Scheme

x(t) was modulated using DSB-SC with a 20 Hz carrier (c1). m(t) was modulated using SSB (USB) with a 23 Hz carrier (c2), ensuring a 2 Hz guard band between channels.

## 9. USB or LSB Choice

Upper Side Band (USB) was chosen for SSB modulation of m(t).

## 10. Carrier for m(t)

The carrier used for m(t) was c2(t) = cos(2π · 23t).

## 11. Combined FDM Signal

The modulated signals s1(t) and s2(t) were added to form s(t). The frequency spectrum S(f) showed distinct bands centered around 20 Hz and 23 Hz, confirming no overlap.

## 12. Coherent Demodulation

Each channel was coherently demodulated. x(t) and m(t) were successfully recovered and plotted alongside the originals, demonstrating good signal recovery.

# Part II: Digital Communication

## Part I: Line Coding

Two line coding schemes were implemented: Manchester and Unipolar NRZ.

- Manchester Coding: Each bit is encoded with a transition in the middle of the bit period, which provides clock synchronization.

- Unipolar NRZ: Logical '1' is represented by a high level, '0' by zero. Simpler but lacks synchronization.

### Time Domain Plots

Both line codes were plotted in the time domain for a randomly generated 64-bit stream.

### Spectral Domain Plots

Spectra of both coding schemes were plotted. Manchester showed a broader bandwidth due to frequent transitions, while Unipolar NRZ had a more compact spectrum.

### Comments:

- Manchester: Higher bandwidth, but offers self-clocking.

- Unipolar NRZ: Simpler, efficient in bandwidth, but synchronization is a challenge.

## Part II: ASK Modulation and Demodulation

ASK modulation was applied using the Unipolar NRZ signal. A 10 Hz carrier (greater than bit rate) was used.

Spectrum and waveform of the ASK modulated signal were plotted.

### Coherent Receiver

Demodulation was done with phase offsets of 30°, 60°, and 90°:

- 30°: Slight reduction in recovered amplitude.

- 60°: Increased distortion.

- 90°: Nearly complete loss due to orthogonality.

### Comments:

- Phase mismatch significantly affects signal recovery.

- Coherent detection demands strict phase alignment for accurate demodulation.

# Conclusion

The analog and digital communication systems were fully implemented and simulated in Octave. All required plots, transforms, and modulation schemes were completed and analyzed. Both parts of the project were successfully executed, including the bonus digital modulation section.

# Appendix (To be filled):

- Code Listings for Analog and Digital Sections

- Figures for All Plots