Digital Signal Generator - Specification Report

Course: Data Communication

Project Title: Digital Signal Generator

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Objective:
To design and implement a Digital Signal Generator capable of simulating digital line coding schemes, scrambling
methods, and analog-to-digital modulation techniques. The system allows users to input either digital or analog signals
and visualize the corresponding encoded or modulated waveform graphically.

Language and Libraries Used:
Programming Language: Java
GUI Framework: JavaFX (via JOGL-compatible plotting through LineChart)
Development Environment: IntelliJ IDEA
Key Packages: javafx.application, javafx.scene.chart, javafx.scene.control, javafx.scene.layout

Features Implemented:
1. Line Coding Schemes: NRZ-L, NRZ-I, Manchester, Differential Manchester, and AMI.
2. Scrambling Techniques: B8ZS and HDB3 (applied over AMI).
3. Analog-to-Digital Modulation: Pulse Code Modulation (PCM) and Delta Modulation (DM).
4. Advanced Utilities: Longest palindromic substring detection (Manacher's Algorithm, O(n)); waveform-based
decoding (+5 marks extra credit).
5. Graphical Output: Real-time waveform plotting with amplitude visualization.

Assumptions and Conventions:

- Differential Manchester: Mid-bit transition always; 0 = transition at start, 1 = no transition. (Initial polarity = LOW,
  IEEE 802.4 Biphase Space convention.)
- AMI Encoding: Alternating pulse polarity, starting with negative (-1).
- PCM Quantization: 8-bit uniform quantization used for analog sampling.
- Delta Modulation: Fixed step size delta = amplitude/16.

How to Run:

1. Open the project in IntelliJ IDEA or any JavaFX-supported IDE.
2. Run the program via Launcher.java.
3. Choose the mode:
   - Digital Input -> enter bitstream -> select encoding scheme.
   - Analog Input -> enter parameters (e.g., freq=1;amp=1;duration=1;samples=50) -> choose PCM or DM.
4. If AMI is chosen, the program prompts for B8ZS/HDB3 scrambling.
5. Waveform and output appear instantly. Optionally select "Decode?" to reconstruct bitstream.

References:

- Behrouz A. Forouzan, Data Communications and Networking, 5th Edition.
- William Stallings, Data and Computer Communications.
- IEEE 802.3 and IEEE 802.4 Physical Layer Encoding Standards.
- Manacher, G. (1975). "A New Linear-Time 'On-Line' Algorithm for Finding the Smallest Initial Palindrome of a String."
  Journal of the ACM (JACM), 22(3), 346-351.

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