## README:

## GFSK Modulation and BER Simulation in MATLAB

### Overview

This MATLAB script simulates a **Gaussian Frequency Shift Keying (GFSK)** communication system, where random bits are modulated, transmitted through an Additive White Gaussian Noise (AWGN) channel, and demodulated. It evaluates the system's performance by calculating the **Bit Error Rate (BER)** across different **Signal-to-Noise Ratio (SNR)** levels.

### Features

* **GFSK Modulation**: Modulates data using Gaussian Frequency Shift Keying.
* **AWGN Channel**: Simulates transmission over a noisy channel using Additive White Gaussian Noise.
* **Forward Error Correction (FEC)**: Supports FEC encoding and decoding for enhanced reliability (modes 2 and 8).
* **BER Calculation**: Computes the Bit Error Rate to measure performance.
* **SNR Sweeps**: Simulates the effect of various SNR levels on the system's performance.

### File Structure

* main.m: Main simulation script
* gfsk\_modulation.m: Function for GFSK modulation
* gfsk\_demod.m: Function for GFSK demodulation
* fec\_enc.m: FEC encoding function
* fec\_decode.m: FEC decoding function
* detector\_synch.m: Function for signal synchronization
* pattern\_mapping.m: Function for pattern mapping (mode 8)

### Requirements

* MATLAB R2020a or higher
* Signal Processing Toolbox (optional, but recommended)

### Simulation Parameters

* **Number of Bits**: 400 random bits are generated for each transmission.
* **Modulation Index (h)**: 0.5
* **Bandwidth-Time Product (B)**: 0.5
* **Sampling Rate**: 2 (upsampling factor)
* **SNR Range**: Simulates SNR values from -4 dB to 10 dB with a step of 2 dB.
* **Modes**:
  + mode = 1: No FEC.
  + mode = 2: FEC is applied to the payload.
  + mode = 8: FEC + Pattern Mapping.

### How It Works

1. **Payload Generation**: A random sequence of bits is generated.
2. **FEC Encoding** (Optional): If mode = 2 or mode = 8, Forward Error Correction is applied to the bits.
3. **Modulation**: The bits are modulated using GFSK.
4. **Transmission**: The modulated signal is transmitted through an AWGN channel.
5. **Noise Addition**: Noise is added to the signal according to the current SNR level.
6. **Receiver Synchronization**: The receiver synchronizes with the incoming signal.
7. **Demodulation**: The received signal is demodulated to retrieve the bits.
8. **FEC Decoding** (Optional): The demodulated bits are decoded if FEC was applied.
9. **BER Calculation**: The Bit Error Rate is computed by comparing the transmitted bits with the received bits.

### Usage

To run the simulation, execute the main script:

clear; close all;

main

This will:

* Modulate, transmit, and demodulate data across multiple SNR values.
* Plot the BER vs. SNR curve on a semilogarithmic scale.

### Outputs

* **BER Plot**: A graph displaying the Bit Error Rate against SNR values. The plot helps to visualize the performance of the GFSK system under different noise conditions.

### Function Descriptions

* gfsk\_modulation(): Performs GFSK modulation on the input bits.
* gfsk\_demod(): Recovers the original bits from the modulated signal.
* fec\_enc(): Encodes the bits using FEC for error correction.
* fec\_decode(): Decodes the FEC-encoded bits.
* detector\_synch(): Synchronizes the receiver with the start of the incoming signal.
* pattern\_mapping(): Maps the bits to a predefined pattern in mode 8.

### Example

The following SNR values are simulated: -4 dB to 10 dB. The output graph shows how the BER changes as the SNR improves, with lower BER at higher SNR values.

matlab

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semilogy(snrDb, BER); % Plot BER vs SNR on a semilog scale