MWC Experiment 6

Shivani Bhat

BE EXTC A
2022200013

Aim:

To perform GFSK and QPSK on GNURadio

Theory:

1. QPSK (Quadrature Phase Shift Keying)

- **Concept**: Extends PSK by using **4 phase states** (0°, 90°, 180°, 270°), each representing **2 bits per symbol**.
- **Advantage**: Doubles data rate compared to BPSK with the same bandwidth.
- **Signal Representation**:
  [
  s(t) = \sqrt{\frac{2E_s}{T_s}} \cos(2\pi f_c t + \phi)
  ]
  where (\phi \in {0, \pi/2, \pi, 3\pi/2}).
- **Key Concepts in Implementation**:
  - **I/Q Modulation**: Splitting signal into In-phase (I) and Quadrature (Q) components using mixers.
  - **Symbol Synchronization**: Required for correct bit mapping.
  - **Constellation Diagram**: Four equidistant points on a circle.

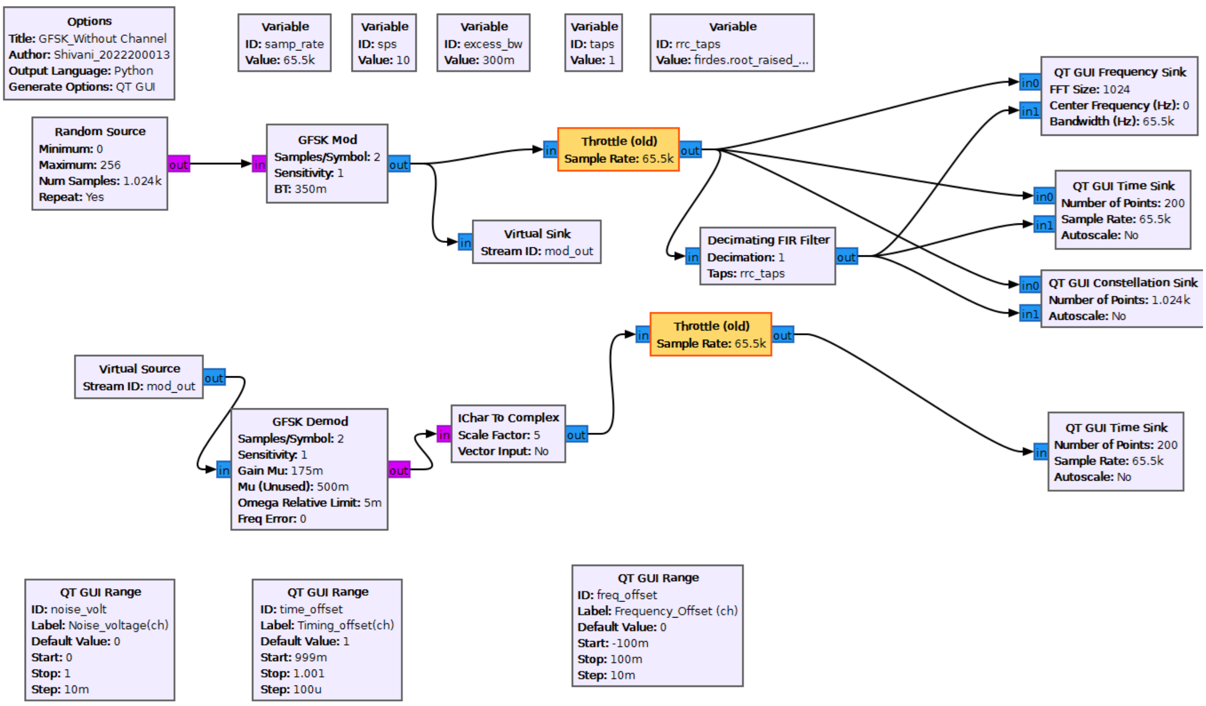
2. GFSK (Gaussian Frequency Shift Keying)

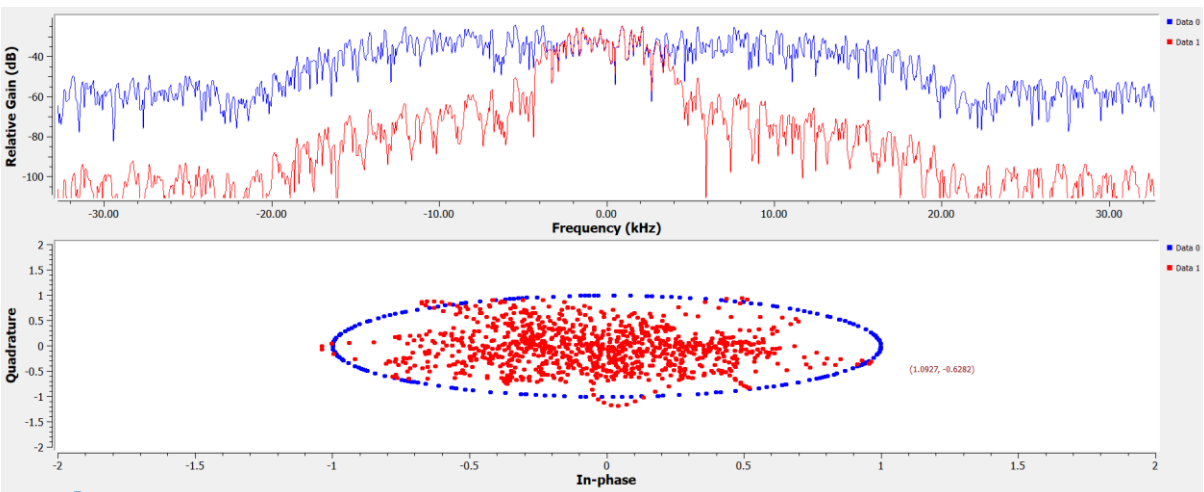
- **Concept**: A **continuous-phase frequency modulation** scheme derived from MSK (Minimum Shift Keying), but with a **Gaussian filter** applied to input data to smoothen phase transitions.
- **Advantages**:
  - Bandwidth-efficient (narrow spectrum).
  - Constant envelope (good for nonlinear RF power amplifiers).
  - Widely used in GSM cellular systems.
- **Key Concepts in Implementation**:

- **Gaussian Filter**: Shapes the baseband data pulses before modulation.
- **VCO (Voltage Controlled Oscillator)**: Implements continuous-phase frequency shift.
- **Nonlinear PA Compatibility**: Since envelope is constant, no distortion in high-power RF amplifiers.

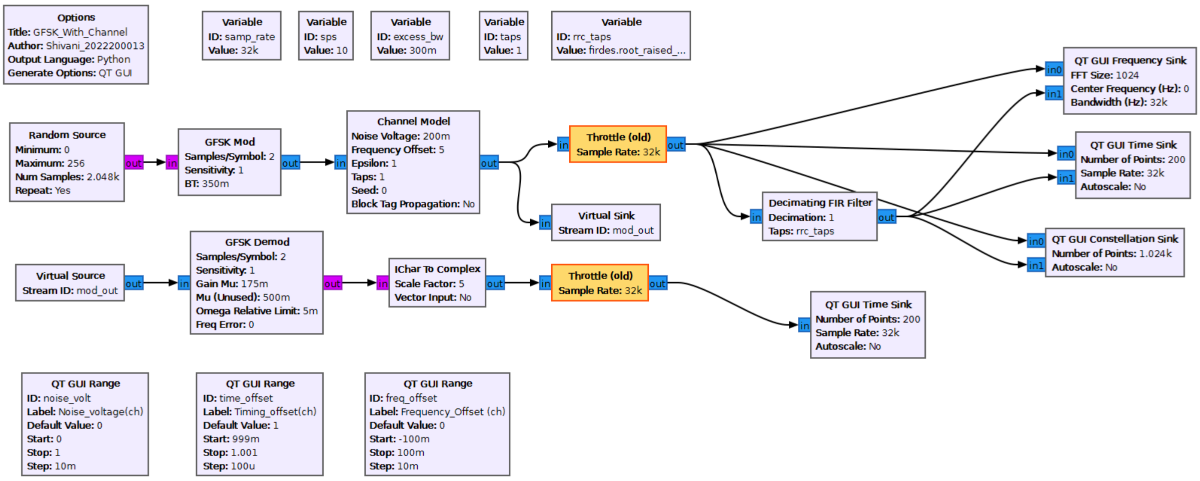
GNURadio Simulations:

1. GFSK (Without Channel)

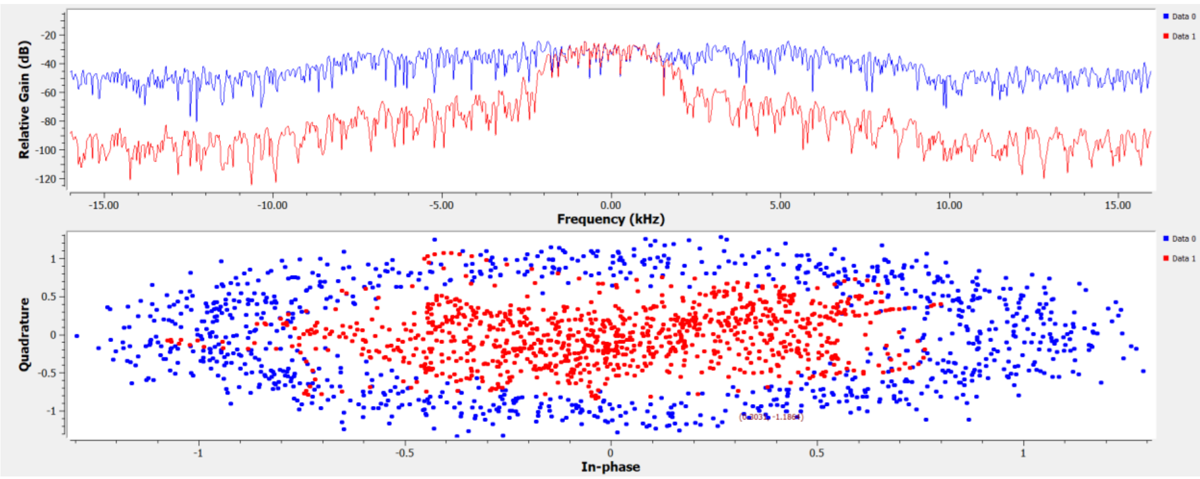




2. GFSK (With channel)



.



Conclusion:

1. **QPSK (Quadrature Phase Shift Keying)** conveys information through four distinct phase states, transmitting **two bits per symbol**, which enhances data rate and spectral efficiency.
2. **GFSK (Gaussian Frequency Shift Keying)**, on the other hand, encodes data by smoothly varying the carrier frequency, using a **Gaussian filter** to limit bandwidth and reduce sideband interference.
3. **Effect of the Gaussian Filter:**
   The Gaussian filter in GFSK smooths the transitions between frequency shifts, significantly reducing spectral sidebands and interference. This filtering ensures more compact bandwidth and efficient spectrum utilization compared to standard FSK.
4. **Signal Behaviour Without Channel Impairments:**
   In the ideal (no-channel) condition, the transmitted and received waveforms were nearly identical. The constellation diagram appeared stable, and the Bit Error Rate (BER) was close to zero, confirming that GFSK performs well under noiseless conditions.
5. **Importance of Filtering and Demodulation:**
   The simulation highlighted the importance of **proper filtering, timing recovery, and**

frequency correction in the receiver chain. Small frequency offsets or timing errors can lead to bit misinterpretation.

6. **Trade-offs in GFSK Design:**
   It was observed that while GFSK offers **excellent noise immunity and spectral efficiency**, it has a slightly **lower data rate** compared to phase-based schemes like QPSK due to the filtering and frequency deviation constraints.

Thus we conclude that **GFSK (Gaussian Frequency Shift Keying)** is widely used in **modern low-power and short-range wireless communication systems** where simplicity, noise immunity, and energy efficiency are more important than achieving very high data rates.s