**1. Normal Case**

**Description:**

Simulates EEG data without seizure activity but includes realistic baseline rhythms, noise, and artifacts.

**Parameters:**

* **Baseline Waveforms:**
  + Frequencies: Alpha (8–12 Hz), Beta (13–30 Hz), Theta (4–8 Hz), Delta (0.5–4 Hz).
  + Frequency variation: ±20% of the base frequency (variability=0.2).
  + Amplitude: Random between 5 and 20 μV.
  + Noise: Normally distributed random noise (mean=0, std=5).
* **Noise:**
  + Power-line noise: Sine wave at 50 Hz with random amplitude (0.1 to 1.0 μV).
  + Additional Gaussian noise: Mean = 0, SD = 10.
  + Uniform noise: Random value between -5 and 5 μV.
* **Artifacts:**
  + **Random sine wave artifacts:**
    - Count: 0 to 3 per dataset.
    - Amplitude: Random between 50 and 100 μV.
  + **Muscle artifacts (EMG):**
    - Count: 1 to 5.
    - Frequency: 20–300 Hz.
    - Amplitude: 10–50 μV.
  + **Eye movement artifacts (EOG):**
    - Count: 4 to 8.
    - Affects frontal electrodes (Fp1, Fp2).
    - Frequency: 1 Hz.
    - Amplitude: 50–200 μV.
  + **Electrode pops/drifts:**
    - Count: 1 to 3.
    - Amplitude: -100 to 100 μV.

**2. Generalized Seizure Case**

**Description:**

Simulates seizure activity that affects all electrodes uniformly, representing a generalized seizure.

**Parameters:**

* **Seizure Activity:**
  + **Duration:** Random between 10,000 and 20,000 samples (~10–20 seconds).
  + **Frequency:**
    - Base seizure frequency: 3 Hz.
    - Amplitude: Random between 100 and 200 μV with ±10% variation.
    - Phase: Random between 0 and 2π2\pi2π.
  + **Polyspike-and-wave discharges:**
    - Frequency: 15 Hz.
    - Amplitude: 50% of the main seizure amplitude.
    - Duration: 20% of seizure duration (random chance of adding spikes).
* **Noise and Artifacts:**
  + Same as **Normal Case**, including baseline rhythms, noise, and artifacts.

**3. Focal Seizure Case**

**Description:**

Simulates seizure activity localized to a specific electrode and its neighbors, representing focal seizures.

**Parameters:**

* **Seizure Activity:**
  + **Focal Electrode:**
    - Randomly chosen from ELECTRODE\_LIST.
  + **Neighbors:** Defined by adjacency matrix ADJACENCY\_MATRIX.
  + **Duration:** Random between 5,000 and 10,000 samples (~5–10 seconds).
  + **Frequency:**
    - Base seizure frequency: 5 Hz.
    - Amplitude: Random between 50 and 150 μV.
  + **High-Frequency Oscillations (HFOs):**
    - Frequency: 100 Hz.
    - Amplitude: 30 μV.
    - Added to the focal electrode only.
  + **Spread to Neighbors:**
    - Neighboring electrodes receive seizure activity at 50% amplitude.
* **Noise and Artifacts:**
  + Same as **Normal Case**, including baseline rhythms, noise, and artifacts.

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| **Parameter** | **Normal Case** | **Generalized Seizure Case** | **Focal Seizure Case** |
| **Description** | EEG without seizures; baseline rhythms, noise, artifacts. | Seizures affect all electrodes uniformly. | Seizures localized to specific electrodes. |
| **Baseline Waveforms** | Alpha (8–12 Hz), Beta (13–30 Hz), Theta (4–8 Hz), Delta (0.5–4 Hz). | Same as Normal. | Same as Normal. |
| **Seizure Activity** | None | Duration: 10–20 sec, 3 Hz, 100–200 μV. | Duration: 5–10 sec, 5 Hz, 50–150 μV. |
| **Noise** | Powerline (50 Hz), Gaussian, Uniform. | Same as Normal. | Same as Normal. |
| **Artifacts** | Sine waves, EMG, EOG, electrode pops. | Same as Normal. | Same as Normal. |
| **Special Features** | None | Polyspike discharges (15 Hz). | Spread to neighbors at 50% amplitude. |