GOVERNMENT POLTECHNIC DARBHANGA

Department of Electronics Engineering

5th Semester:-Mobil and Wireless Communication Manual Lab Subject Code [2021507]

LIST OF EXPERIMENTS

S.NO.	Experiment Name
1	To understand the cellular frequency reuse concept to find the cochannel cells for a particular cell.
2	To understand the path loss
3	Understand the path loss with shadowing
4	Understanding the Flat fading
5	Understanding the Frequency selective fading
6	Understanding the Multipath channel for the following objectives 1. No Fading 2. Flat Fading 3. Dispersive Fading
7	To simulate a dipole antenna (λ, λ/4, Λ/2, 3λ/2) for a particular frequency using 4NEC2
8	Perform following experiments using CDMA trainer kit 1. PSK modulation and demodulation experiment 2. Bit synchronization extraction experiment 3. Error correction encoding experiment

List of Major Laboratory Equipment, Tools and Software:

S. NO.	Name of Equipment, Tools, and Software	Broad Specifications	Relevant Experiment/Practical Number

Experiment:01

To understand the cellular frequency reuse concept to find the cochannel cells for a particular cell.

Aim

To understand the concept of **Frequency Reuse** and to identify **co-channel cells** for a given cell in a cellular system.

Apparatus Required

- Graph paper (hexagonal grid preferred)
- Pencil, ruler, eraser
- Calculator
-

Theory

In cellular communication, the total frequency spectrum is divided among cells. Since frequencies are limited, the same frequencies are reused in different cells separated by a certain distance.

 Cells using the same frequency are called **co-channel cells**.

A group of cells using different frequencies is called a **cluster**.

Cluster Size Formula

$N = i^2 + ij + j^2$

Where:

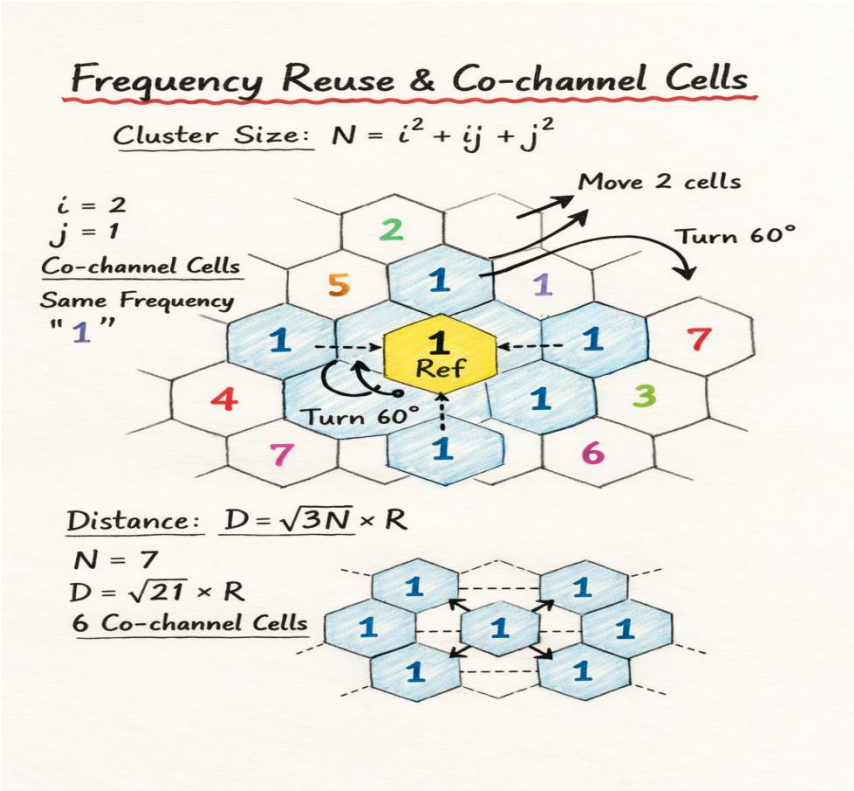
- i,j = integers representing shift pattern

Co-channel Distance Formula

$D = \sqrt{3N} \times R$
$N = i^2 + ij + j^2$

Where:

- D = distance between co-channel cells
- R = radius of each cell
- N = cluster size



Procedure

1. Draw a **hexagonal cellular layout** on graph paper.
2. Label the central cell as the **reference cell**.
3. Choose values of iii and j (e.g., i=2,j=1
4. Calculate cluster size using:

   $N = i^2 + ij + j^2$

5. From the reference cell:
   - Move **i cells** in a straight direction.
   - Turn **60° anticlockwise**.
   - Move **j cells**.
6. Mark the obtained cell as a **co-channel cell**.
7. Repeat the same movement in other directions to find all co-channel cells.
8. Measure or calculate distance using:

$D = \sqrt{3N} \times R$

Example Calculation

Let:

- i = 2, j=1

Cluster Size:

N = 22 + (2×1) + 12 = 7

Co-channel Distance:

$D = \sqrt{21} \times R$

Observation

- Cluster size obtained: **7**
- Number of co-channel cells: **6 surrounding cells**
- Co-channel cells are equally spaced
- Frequency reuse pattern is maintained

Result

The concept of **frequency reuse** is verified.
Co-channel cells for a given cell were successfully identified using the **(i, j) movement method**, and cluster size was calculated correctly.

Precautions

- Draw hexagons accurately
- Maintain equal cell size
- Follow correct movement (i, j) directions
- Label cells clearly

Experiment:02

To understand the path loss

Aim

To study and understand **Path Loss** in a wireless communication system and how signal strength decreases with distance.

Apparatus Required

- Transmitter (RF signal source / mobile hotspot)
- Receiver (mobile phone / RF receiver)
- Measuring scale or distance markers
- Signal strength measuring app (RSSI meter)
- Open area for measurement

Theory

Path loss refers to the **reduction in power density** of a signal as it propagates through space.

As distance between transmitter and receiver increases, the signal becomes weaker due to:

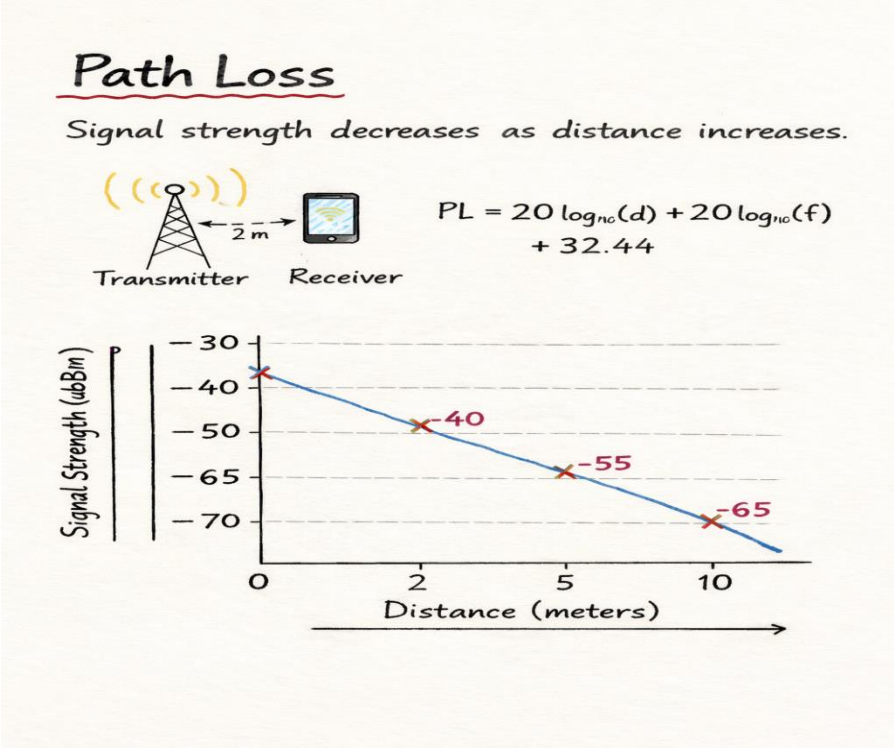
- Free space spreading
- Obstacles (buildings, trees)
- Reflection, diffraction, scattering

Free Space Path Loss Formula

$PL = 20 \log_{10} (d) + 20 \log_{10}(f) + 32.44$

Where:

- PL = Path Loss (dB)
- d = Distance (km)
- f = Frequency (MHz)



Procedure

1. Place the **transmitter** at a fixed location.
2. Set the receiver at a known distance (e.g., 1 meter).
3. Measure and note the **signal strength (RSSI)**.
4. Increase the distance step-by-step (2m, 5m, 10m, etc.).
5. Record signal strength at each distance.
6. Repeat readings to reduce errors.
7. Calculate path loss using formula.
8. Plot graph:
    - X-axis → Distance
    - Y-axis → Signal Strength / Path Loss

Observation Table

Distance (m)	Signal Strength (dBm)	Path Loss (dB)
1	-30	—
2	-40	—
5	-55	—
10	-65	—

Result / Conclusion

- Signal strength **decreases as distance increases**
- Path loss increases logarithmically
- Practical results approximately follow theoretical model

Precautions

- Avoid obstacles between transmitter and receiver
- Take readings in open space
- Keep transmitter power constant
- Avoid interference from other devices

Experiment:03

Understand the path loss with shadowing

Aim

To study **Path Loss** with **shadowing effect** in a wireless communication system.

Apparatus Required

- RF transmitter (WiFi router / mobile hotspot)
- Receiver (mobile phone with signal strength app)
- Obstacles (wall, human body, books, etc.)
- Measuring tape
- Notebook for readings

Theory

In real environments, signal attenuation is not only due to distance but also due to obstacles like buildings, trees, and walls.

 This additional variation is called **Shadowing** (or slow fading).

So, total path loss includes:

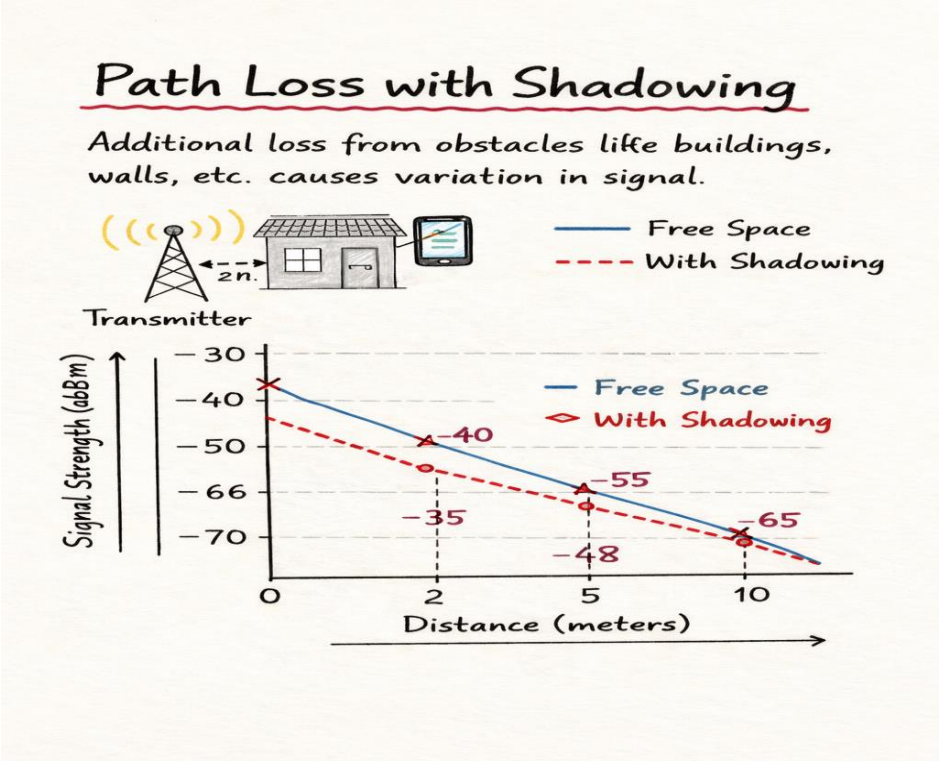
- Distance-based loss
- Shadowing effect

Log-Distance Path Loss Model with Shadowing

$PL(d) = PL(d0) + 10n \log_{10}(\frac{d}{d_0}) + X\sigma$

Where:

- PL(d) = Path loss at distance ddd
- PL(d0) = Path loss at reference distance
- n = Path loss exponent (2 to 4 typically)
- Xσ = Shadowing factor (Gaussian random variable)



Procedure

1. Place transmitter at a fixed position.
2. Measure signal strength at different distances (1m, 2m, 5m, 10m).
3. Record values **without obstacles** (free space).
4. Now place obstacles (wall, person, etc.) between transmitter and receiver.
5. Again measure signal strength at same distances.
6. Compare both readings.
7. Note variation due to shadowing.
8. Plot graph:
    - Distance vs Signal Strength (with and without shadowing)

Observation Table

Distance (m)	Signal (No Obstacle)	Signal (With Obstacle)
1	-30 dBm	-35 dBm
2	-40 dBm	-48 dBm
5	-55 dBm	-65 dBm
10	-65 dBm	-78 dBm

Observation

- Signal strength decreases with distance
- Additional loss occurs due to obstacles
- Shadowing causes **random variations** in signal

Result

Path loss with shadowing was successfully studied.
It is observed that obstacles introduce additional attenuation, causing deviation from ideal path loss.

Precautions

- Keep transmitter power constant
- Use same environment for fair comparison
- Avoid interference from other signals
- Take multiple readings for accuracy

Experiment:04

Understanding the Flat fading

Aim

To study and understand **Flat Fading** in a wireless communication system.

Apparatus Required

- RF transmitter (WiFi router / signal generator)
- Receiver (mobile phone / RF receiver)
- Obstacle objects (optional)
- Signal strength measuring app (RSSI)
- Open/indoor environment

Theory

Flat fading occurs when the **entire signal bandwidth** is affected equally by the channel.

 It happens when:

- Signal bandwidth < **channel bandwidth**
- All frequency components experience **same attenuation and phase shift**

In this case, the signal is not distorted in shape, but its **amplitude changes** over time.

Condition for Flat Fading

$Bs \ll Bc$

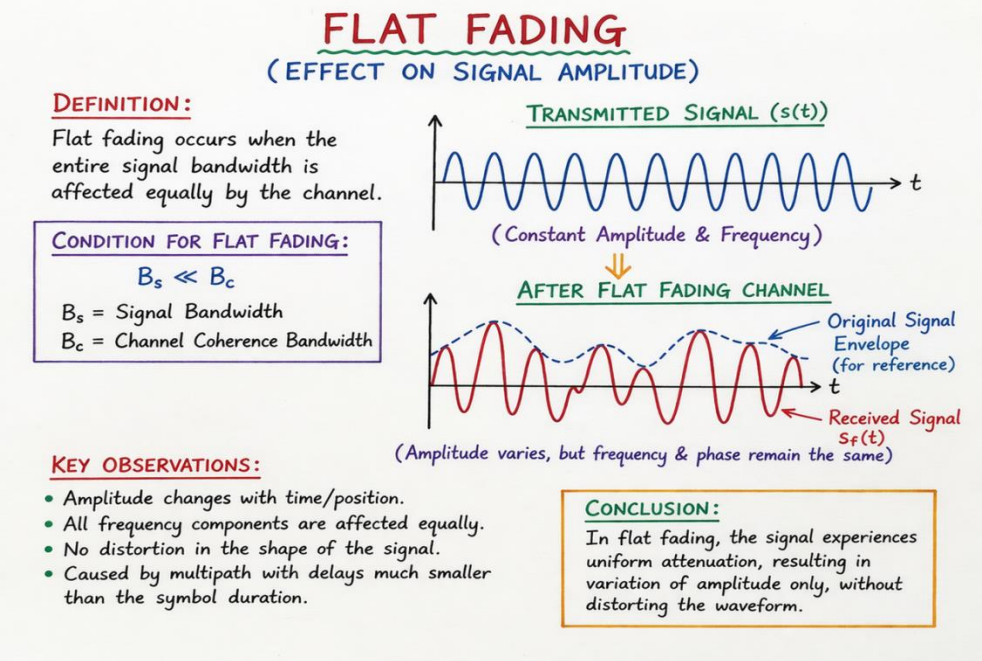
Where:

- Bs = Signal bandwidth
- Bc = Channel coherence bandwidth

Procedure

1. Set up transmitter and receiver in a fixed environment.
2. Transmit a signal with small bandwidth.
3. Measure received signal strength (RSSI).
4. Move receiver slightly or introduce motion in environment.

5. Observe variation in signal strength over time.
6. Ensure no major obstacles causing frequency-selective effects.
7. Record readings at different times/positions.



Observation

- Signal strength fluctuates with time
- No distortion in waveform shape
- All frequencies are affected equally
- Variation is mainly in **amplitude**

Result

Flat fading was successfully observed.
It is concluded that when signal bandwidth is much smaller than channel bandwidth, the signal experiences **uniform fading without distortion**.

Precautions

- Use low bandwidth signal
- Avoid wideband transmission
- Keep environment controlled
- Minimize external interference

Experiment:05

Understanding the Frequency selective fading

Aim

To study and understand **Frequency Selective Fading** in a wireless communication system.

Apparatus Required

- RF transmitter (signal generator / WiFi router)
- Receiver (mobile phone / RF receiver)
- Obstacles (walls, metal objects)
- Signal strength measuring app (RSSI)
- Open/indoor environment

Theory

Frequency selective fading occurs when **different frequency components** of a signal are affected differently by the channel.

 It happens due to **multipath propagation**, where signals take multiple paths and arrive with different delays.

This causes:

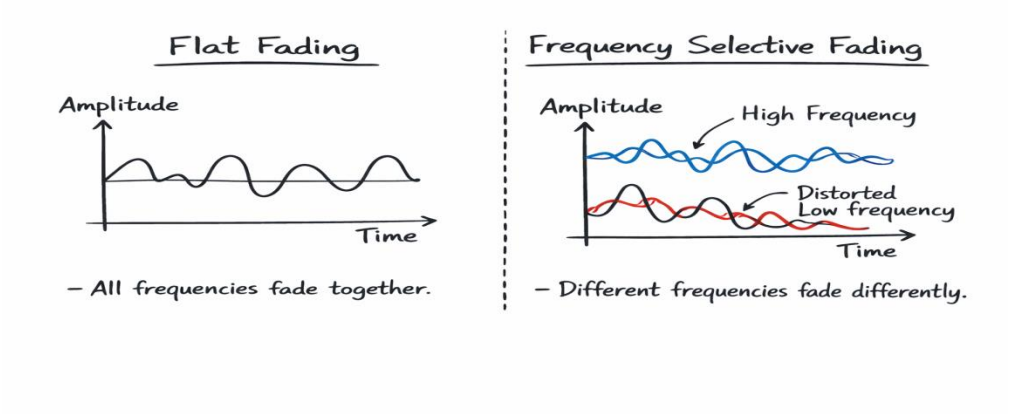
- Some frequencies to be **attenuated more**
- Signal **distortion** (shape changes)

Condition for Frequency Selective Fading

Bs > Bc

Where:

- Bs = Signal bandwidth
- Bc = Channel coherence bandwidth



Procedure

1. Set up transmitter and receiver.
2. Transmit a **wideband signal**.
3. Measure received signal strength.
4. Introduce obstacles to create multipath.
5. Move receiver slightly and observe variations.
6. Analyze signal distortion (if possible).
7. Record variations in signal at different frequencies or positions.

Observation

- Signal strength varies **unevenly**
- Some parts of signal fade more than others
- Signal waveform gets **distorted**
- Deep fades occur at certain frequencies

Result

Frequency selective fading was successfully observed.
It is concluded that when signal bandwidth exceeds channel bandwidth, different frequency components experience different fading, causing distortion.

Precautions

- Use wideband signal
- Ensure multipath environment (indoor works well)
- Keep transmitter power constant
- Avoid external interference

Experiment:06

Understanding the Multipath channel for the following objectives
1. No Fading
2. Flat Fading

3. D Aim

To study the behavior of a **Multipath Propagation** channel under:

1. No Fading
2. Flat Fading
3. Dispersive (Frequency Selective) Fading

Apparatus Required

- RF transmitter (signal generator / WiFi router)
- Receiver (mobile / RF receiver)
- Obstacles (walls, metal objects)
- Signal strength measuring app (RSSI)
- Open and indoor environments

Theory

In wireless communication, signals reach the receiver through multiple paths due to reflection, diffraction, and scattering. This is called **multipath propagation**.

Depending on channel conditions, three cases arise:

1. No Fading (Ideal Channel)

✔Condition:

- Single direct path (Line of Sight)
- No obstacles

✔Characteristics:

- No signal fluctuation
- Constant amplitude
- No distortion

✔Representation:

$r(t) = s(t)$

 Received signal is same as transmitted signal.

2. Flat Fading

✔Concept:

Occurs when entire signal bandwidth is affected equally.

✔Condition:

$Bs \ll Bc$

✔Characteristics:

- Amplitude varies
- No waveform distortion
- All frequencies fade equally

✔Representation:

$r(t) = h(t)\, s(t)$

3. Dispersive Fading (Frequency Selective Fading)

 Also known as **Frequency Selective Fading**

✔Concept:

Different frequency components experience different fading.

✔Condition:

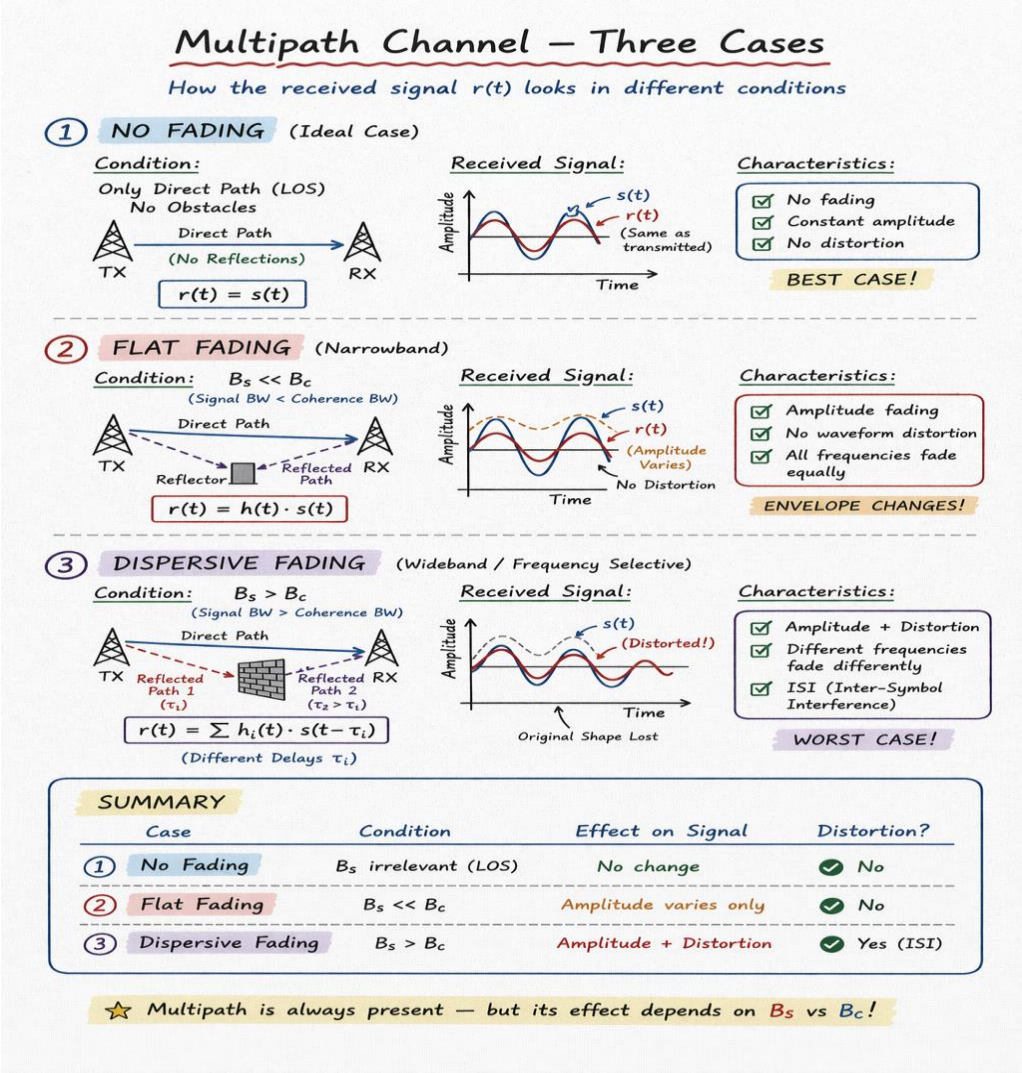
$Bs > Bc$

✔Characteristics:

- Signal distortion occurs
- Different delays (multipath)
- Inter-symbol interference (ISI)

✔Representation:

$r(t)=\sum h_i(t)\, s(t-\tau_i)$



Procedure

1. Set up transmitter and receiver.
2. **Case 1 (No Fading):**
   - Place in open area (LOS)
   - Record signal (stable)
3. **Case 2 (Flat Fading):**

    - Introduce slight movement
    - Use narrowband signal
    - Observe amplitude variation
4. **Case 3 (Dispersive Fading):**
    - Use indoor environment
    - Introduce obstacles
    - Use wideband signal
    - Observe distortion
5. Record signal strength and waveform behavior.

Observation Table

Condition	Amplitude Change	Distortion	Cause
No Fading	No	No	Direct path
Flat Fading	Yes	No	Small delay spread
Dispersive Fading	Yes	Yes	Large delay spread

Result

The multipath channel behavior was successfully studied:

- No fading gives ideal transmission
- Flat fading affects amplitude only
- Dispersive fading causes distortion due to multipath delays

Precautions

- Maintain constant transmitter power
- Avoid unwanted interference
- Use proper environment for each case
- Take multiple readings

Experiment:07

To simulate a dipole antenna (λ, λ/4, ∧/2, 3λ/2) for a particular frequency using 4NEC2

Aim

To simulate dipole antennas of different lengths (λ/4, λ/2, λ, 3λ/2) for a given frequency using **4NEC2**.

Apparatus / Software Required

- Computer / Laptop
- **4NEC2 software**
- Basic knowledge of antenna parameters

Theory

A **dipole antenna** is one of the simplest and most widely used antennas.

 The length of the antenna is related to wavelength:

Λ = fc

Where:

- c=3×10^8 m/s (speed of light)
- f = frequency

Dipole Lengths

Type	Length
Quarter Wave	λ/4\lambda/4λ/4
Half Wave	λ/2\lambda/2λ/2
Full Wave	λ\lambdaλ
3/2 Wave	3λ/23\lambda/23λ/2

Procedure (Using 4NEC2)

Step 1: Calculate Wavelength

- Choose frequency (example: **300 MHz**)

$\Lambda = \frac{3\times10^8}{300\times10^6}$ = 1 meter

Step 2: Open 4NEC2

- Go to **Geometry Editor**

Step 3: Create Dipole Structure

- Use **wire (GW command)**
- Define:
    - Length (based on λ)
    - Radius (small value, e.g., 0.001 m)
    - Segments (e.g., 21 segments)

Step 4: Define Different Dipoles

Dipole Type	Length (for λ = 1m)
λ/4	0.25 m
λ/2	0.5 m
λ	1 m
3λ/2	1.5 m

Step 5: Add Excitation

- Place source at center:

```
EX 0 1 11 0 1 0
```

Step 6: Set Frequency

```
FR 0 1 0 0 300 0
```

Step 7: Run Simulation

- Click **Calculate → NEC Output**
- Observe:
    - Radiation pattern
    - Gain

Experiment:08

Perform following experiments using CDMA trainer kit
1. PSK modulation and demodulation experiment
2. Bit synchronization extraction experiment
3. Error correction encoding experiment

Aim

To study **Phase Shift Keying** modulation and demodulation using a CDMA trainer kit.

Apparatus Required

- CDMA Trainer Kit
- CRO (Cathode Ray Oscilloscope)
- Connecting wires
- Power supply

Theory

In PSK, the **phase of the carrier signal** is varied according to the digital input.

- Binary 0 → one phase
- Binary 1 → another phase

In **BPSK**, two phases (0° and 180°) are used.

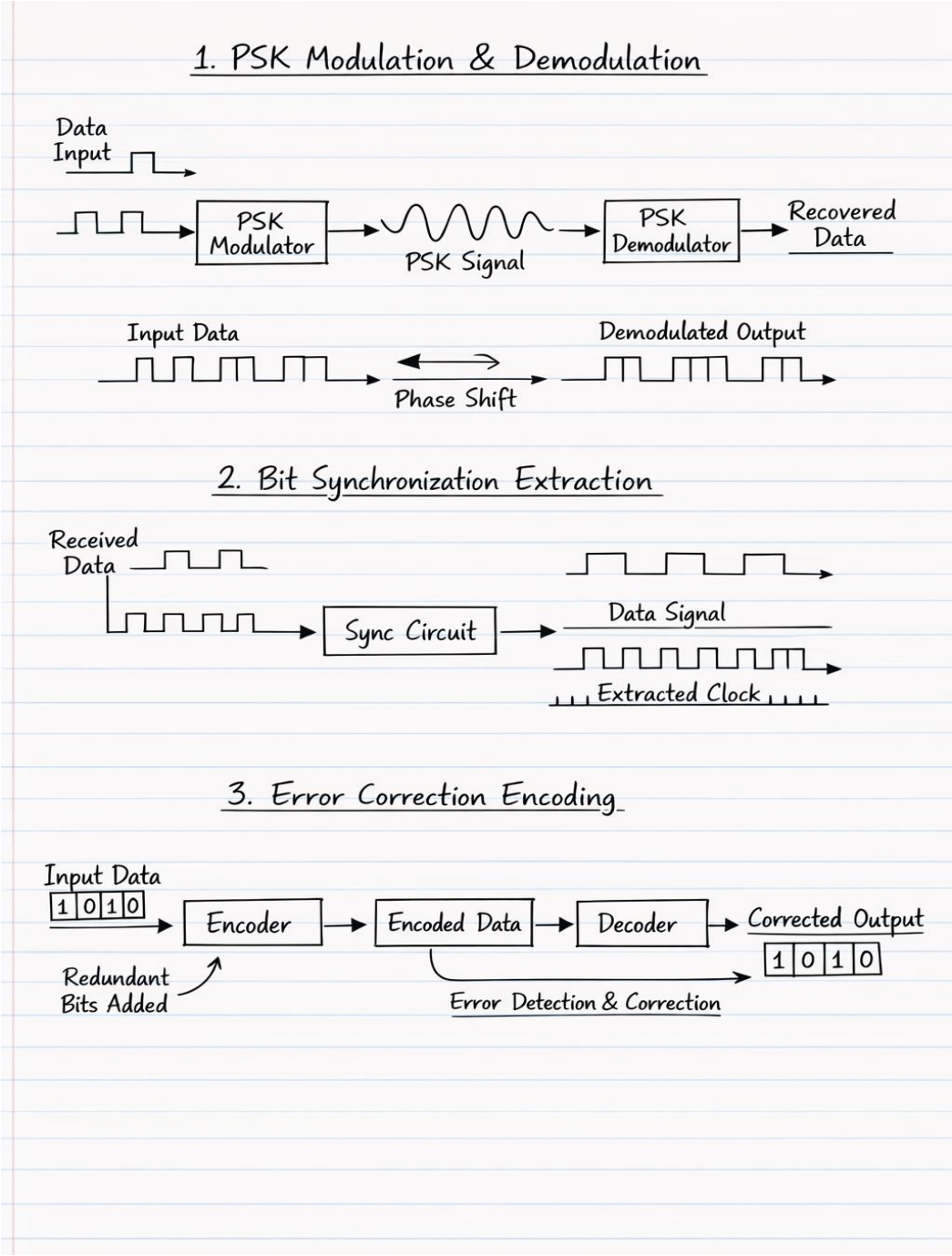
Procedure

1. Switch ON the CDMA trainer kit.
2. Select **PSK modulation mode**.
3. Apply digital input signal.
4. Observe modulated signal on CRO.
5. Connect demodulator section.
6. Observe recovered digital signal.
7. Compare input and output waveforms.

Observation

- Phase changes with input bits
- Output signal matches input data

- Carrier amplitude remains constant



Result

PSK modulation and demodulation were successfully performed and verified.

Experiment 2: Bit Synchronization Extraction

Aim

To extract clock signal using **Bit Synchronization** technique.

Apparatus Required

- CDMA Trainer Kit
- CRO
- Connecting wires

Theory

In digital communication, receiver must know **bit timing**.

 Bit synchronization extracts clock signal from received data to correctly interpret bits.

Procedure

1. Power ON the trainer kit.
2. Generate digital data signal.
3. Pass signal through synchronization circuit.
4. Observe extracted clock signal on CRO.
5. Compare input data and clock alignment.

Observation

- Clock pulses align with data bits
- Proper synchronization achieved

Result

Bit synchronization was successfully extracted from the received signal.

Experiment 3: Error Correction Encoding

Aim

To study **Error Correction Codes** using CDMA trainer kit.

Apparatus Required

- CDMA Trainer Kit
- CRO
- Connecting wires

Theory

Error correction adds **redundant bits** to detect and correct errors during transmission.

Common techniques:

- Hamming Code
- Parity Check

Procedure

1. Switch ON trainer kit.
2. Apply input binary data.
3. Enable encoding section.
4. Observe encoded output (extra bits added).
5. Introduce error (if possible).
6. Pass through decoder.
7. Observe corrected output.

Observation

- Encoded data contains extra bits
- Errors are detected and corrected
- Output matches original input

Result

Error correction encoding and decoding were successfully performed.