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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

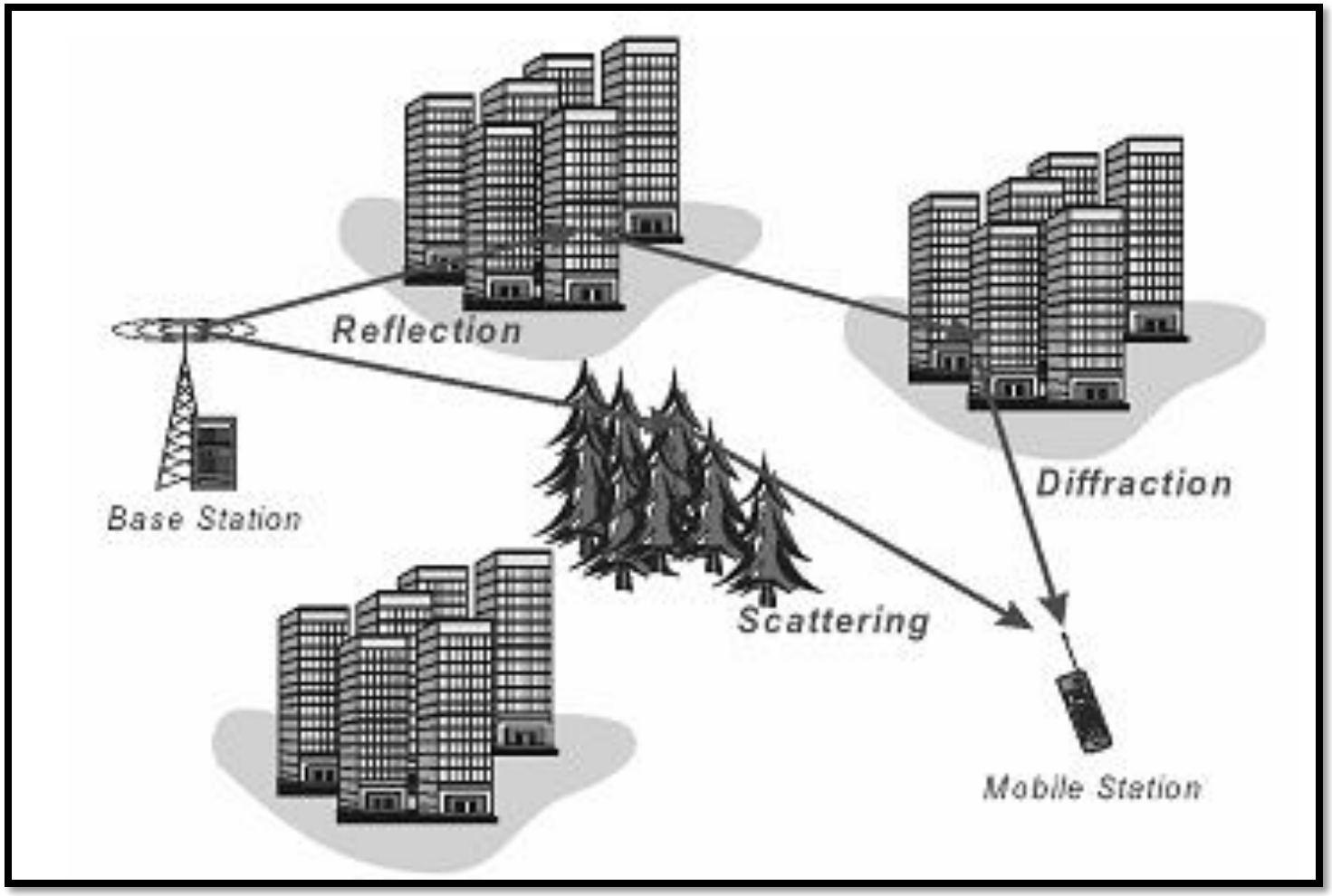
16EC401 / Wireless Communication

IV ECE/ VII SEMESTER

Unit IV - **MULTIPATH MITIGATION TECHNIQUES**

Topic 4,5 : Diversity-Micro diversity, Macro diversity

DIVERSITY TECHNIQUES



OUTLINE OF PRESENTATION

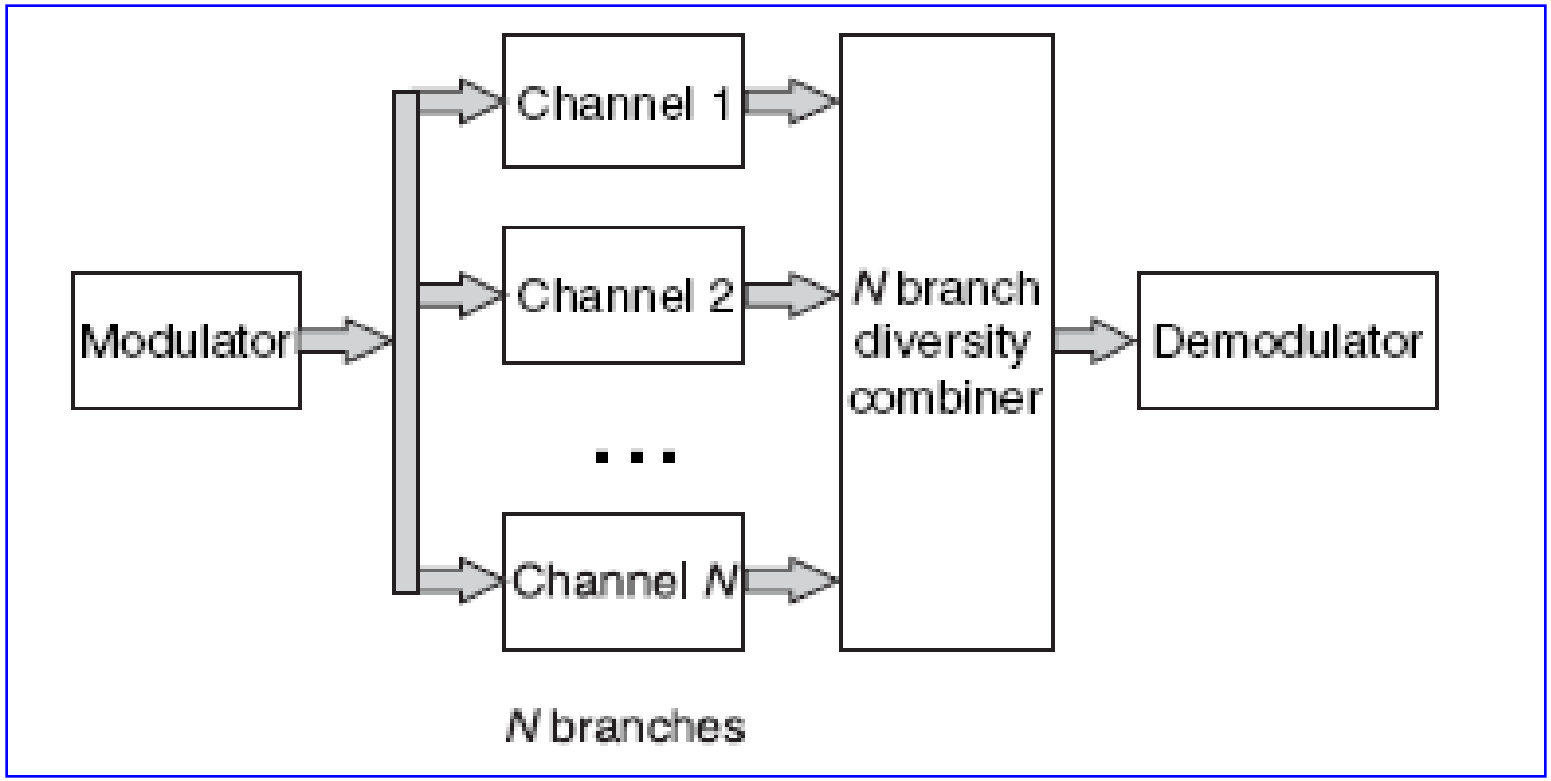
- Introduction.
- Need of Diversity.
- Classification of Diversity.
- Diversity Techniques.
- Frequency diversity.
- Time Diversity.

INTRODUCTION

- **Diversity-** is a powerful communication technique that provides wireless link improvements at relatively low cost.
- Diversity exploits the random nature of radio propagation by finding independent signal path for communication.
- These independent paths are highly uncorrelated.

NEED OF DIVERSITY

- If one radio path undergoes a deep fade another independent path may have a strong signal.



DIVERSITY- IMPORTANT CRITERIA

Two criteria are necessary to obtain a high degree of improvement from a diversity system are :

- First, the fading in individual branches should have low cross-correlation or highly uncorrelated.
- Second, the mean power available from each branch should be almost equal.

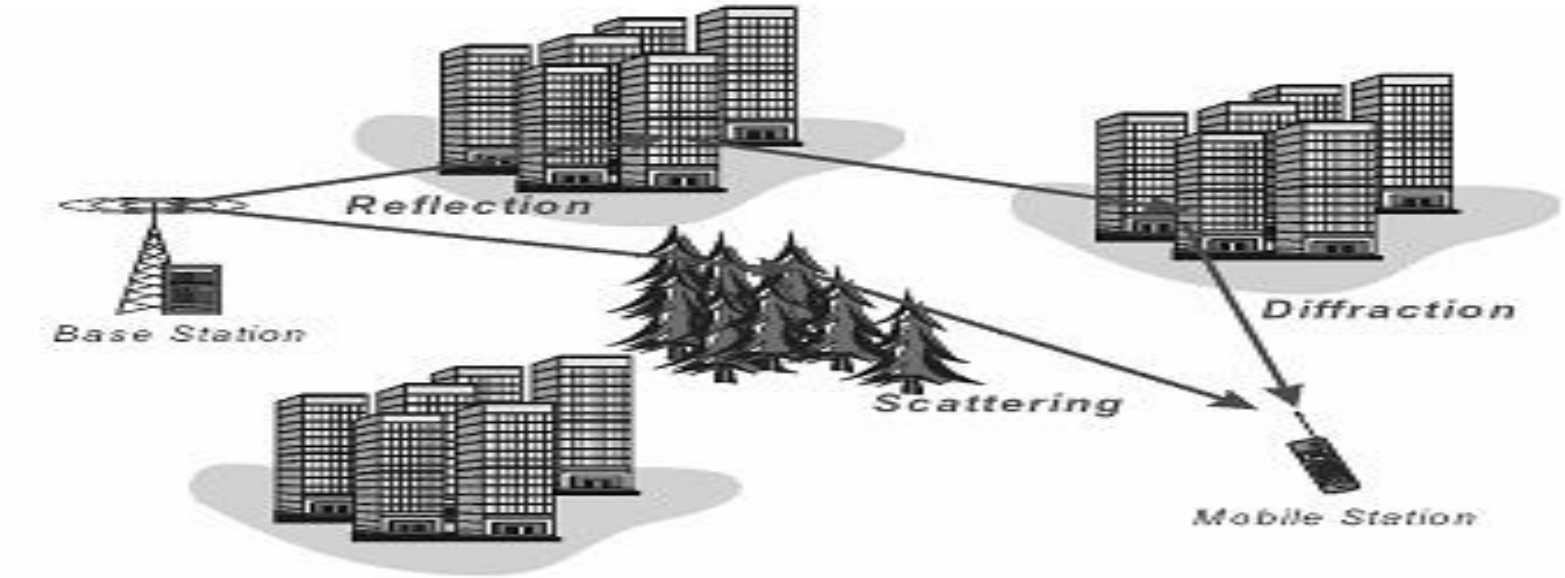
CLASSIFICATION OF DIVERSITY

- **Macro diversity:** provides a method to mitigate the effects of shadowing , as in case of Large scale fading.

- **Micro diversity:** provides a method to mitigate the effects of multi-path fading as in case of small scale fading.

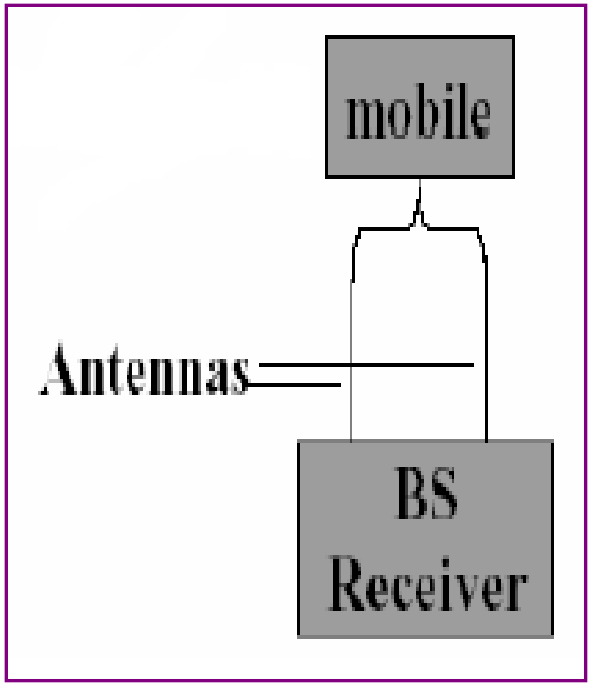
MACRO DIVERSITY

- Large scale fading is caused by shadowing due to the presence of fixed obstacles in the radio path
- Long term fading can be mitigated by macroscopic diversity (apply on separated antenna sites) like the diversity using two base stations



MICRO DIVERSITY

- Small scale fades are characterized by deep and rapid amplitude fluctuations
- which occur as the mobiles moves over distances of just a few wavelengths
- These fades are caused by multiple reflections from surroundings in the vicinity of the mobile



- Short term fading can be mitigated by the diversity using multiple antennas on the base station or mobile unit

Activity

- Imagine folding a paper in half once
- Then take the result and fold it in half again; and so on
- How many times can you do that?

DIVERSITY TECHNIQUES

- **Space Diversity:**

  Using antennas spaced enough (at Tx or Rx).

- **Polarization Diversity:**

  Using antennas with different polarizations.

- **Frequency Diversity:**

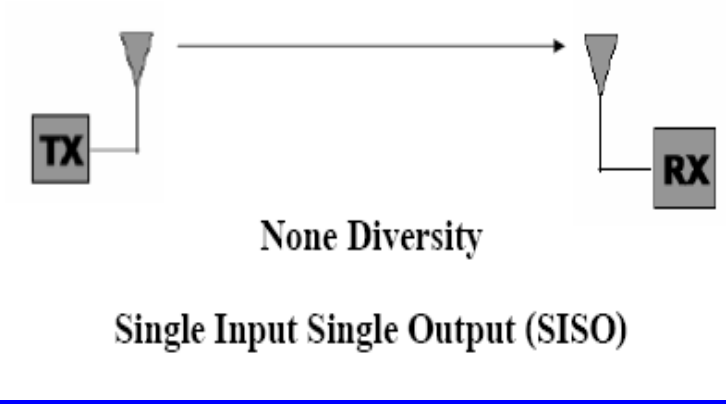
  Using frequency channels separated in frequency more than the channel coherence bandwidth.

- **Time Diversity:**

  Using time slots separated in time more than the channel coherence time.

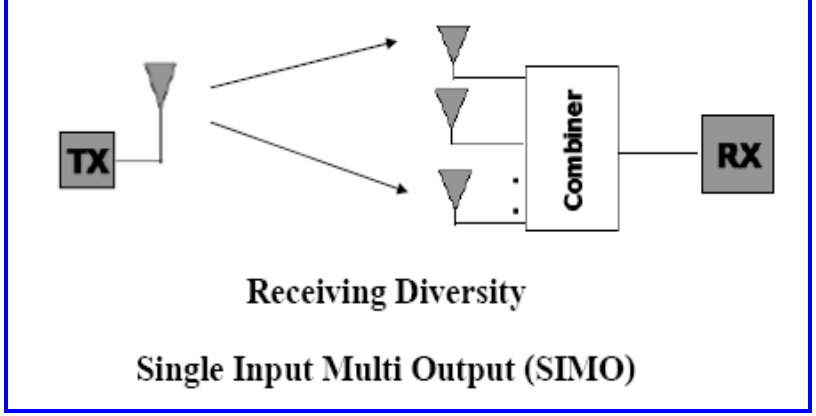
SPACE DIVERSITY

- Use more than one antenna to receive the signal



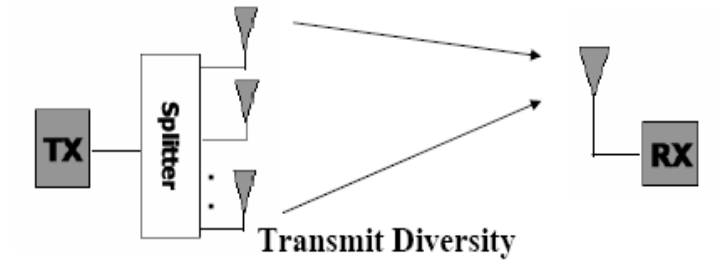
None Diversity

Single Input Single Output (SISO)



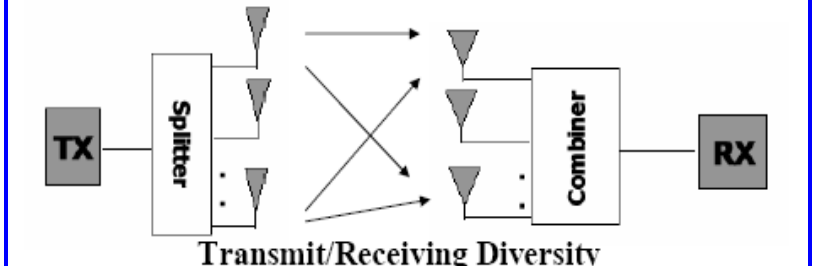
Receiving Diversity

Single Input Multi Output (SIMO)



Transmit Diversity

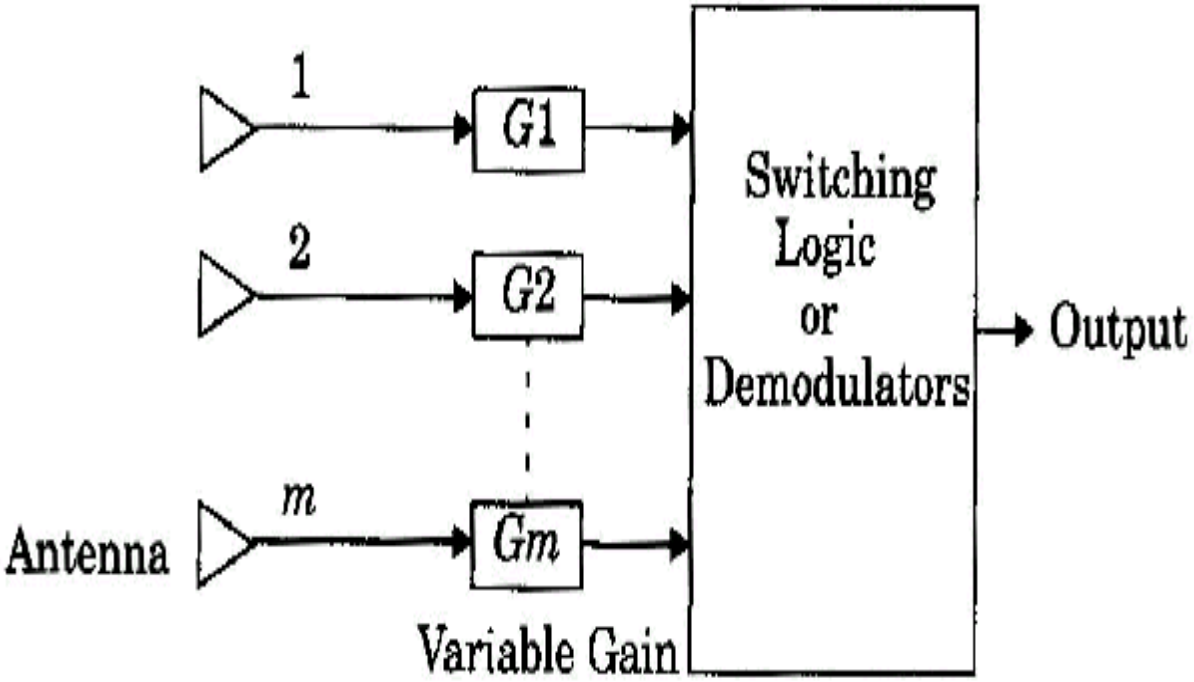
Multi Input Single Output (MISO)



Transmit/Receiving Diversity

Multi Input Multi Output (MIMO)

SPACE DIVERSITY



Generalized block diagram for space diversity

SPACE DIVERSITY TYPES

1. Selection diversity
2. Feedback diversity
3. Maximal ratio combining
4. Equal gain diversity

SELECTION DIVERSITY

1) Selection Diversity → simple & cheap

- Rx selects branch with highest **instantaneous** *SNR*
  - New selection made at a time that is the reciprocal of the fading rate
  - This will cause the system to stay with the current signal until it is likely the signal has faded
- *SNR* improvement :
  - $\bar{\gamma}$ is new avg. *SNR*
  - Γ : avg. *SNR* in each branch

SELECTION DIVERSITY

- A block diagram of this method is similar to space diversity
- m demodulators are used to provide m diversity branches
- whose gains are adjusted to provide the same average SNR for each branch.
- The receiver branch having the highest instantaneous SNR is connected to the demodulator.

$$\bar{\gamma} = \Gamma \sum_{k=1}^{m} \frac{1}{k} = \Gamma\left(1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \cdots + \frac{1}{m}\right) > \Gamma$$

SCANNING DIVERSITY

2) Scanning Diversity

- scan each antenna until a signal is found that is above predetermined threshold
- if signal drops below threshold → rescan
- only one Rx is required (since only receiving one signal at a time), so less costly → still need multiple antennas

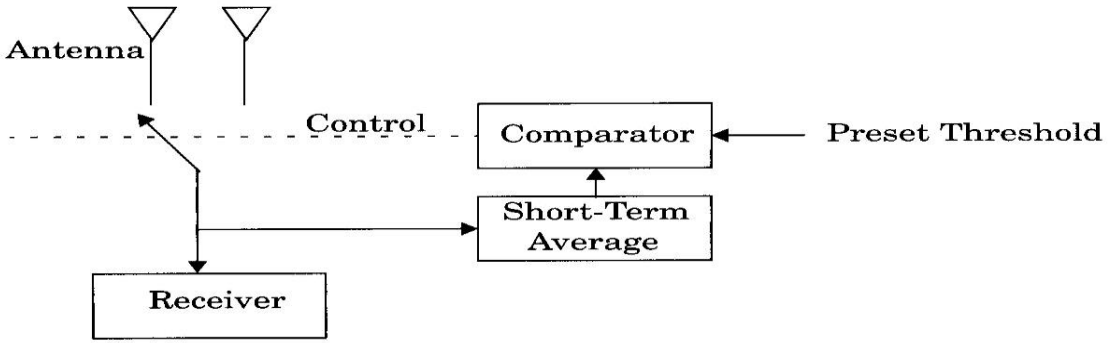


Figure 7.13 Basic form of scanning diversity.

MAXIMAL RATIO DIVERSITY

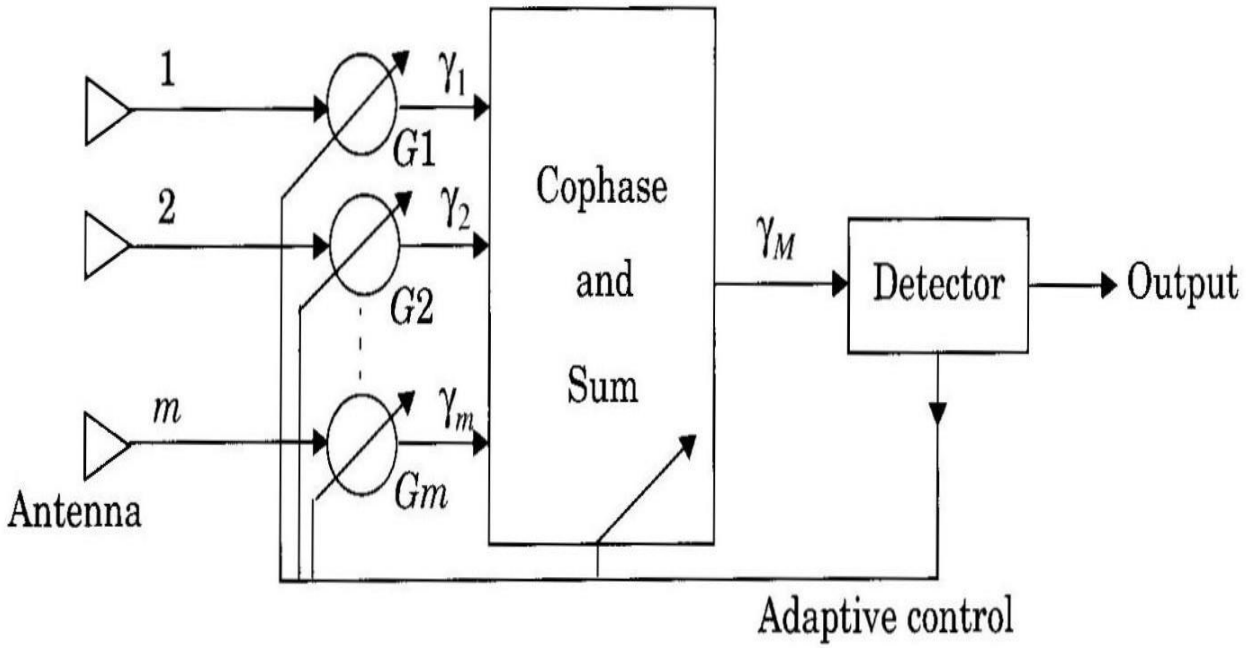


Figure 7.14 Maximal ratio combiner.

MAXIMAL RATIO DIVERSITY

3) Maximal Ratio Diversity

- signal amplitudes are weighted according to each *SNR*
- summed **in-phase**
- most complex of all types
- a complicated mechanism, but modern DSP makes this more practical → especially in the base station Rx where battery power to perform computations is not an issue

EQUAL GAIN DIVERSITY

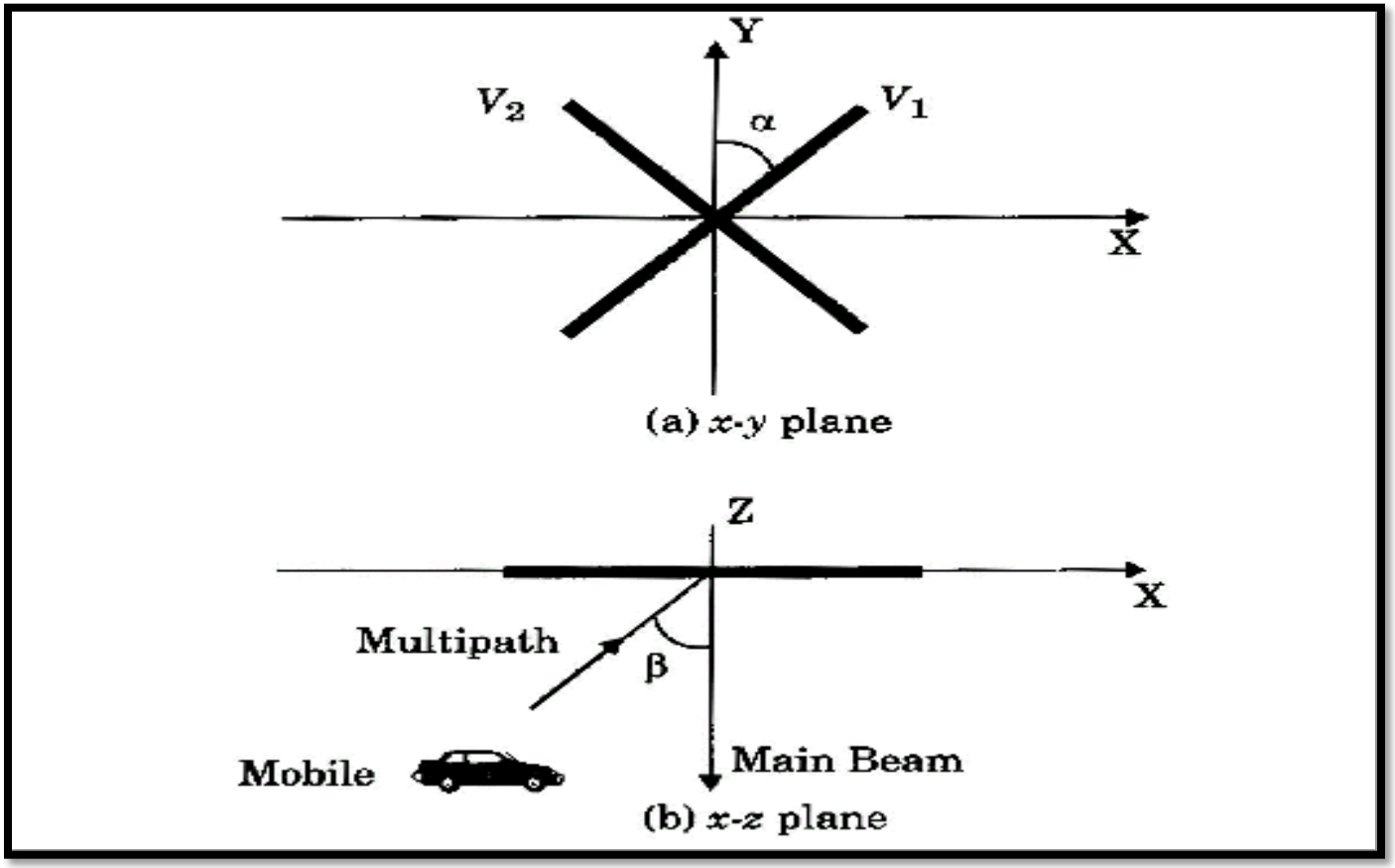
4) Equal Gain Diversity

- combine multiple signals into one
- $G = 1$, but the phase is adjusted for each received signal so that
  - The signal from each branch are co-phased
  - vectors add in-phase
- better performance than selection diversity

POLARIZATION DIVERSITY

- Polarization diversity uses antennas of different polarizations i.e. horizontal and vertical.
- The antennas take advantage of the multipath propagation characteristics to receive separate uncorrelated signals
- SNR is improved by up to 12 dB even in line-of-sight channels.

POLARIZATION DIVERSITY



Theoretical Model

POLARIZATION DIVERSITY

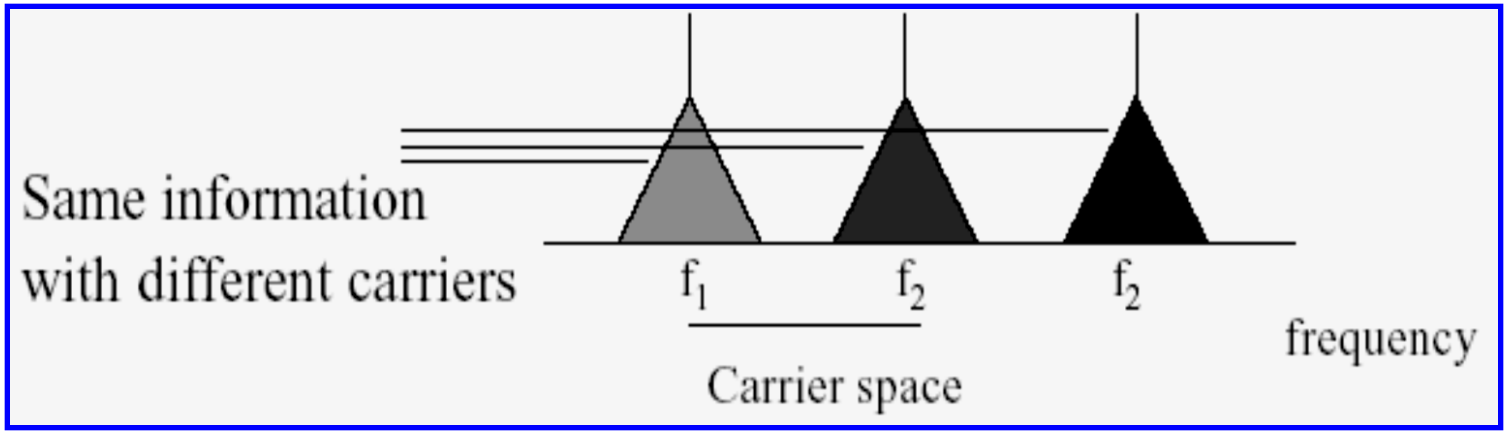
- A polarization diversity antenna is composed of two antenna elements V1 and V2
- which make a ±α angle (polarization angle) with the Y axis
- A mobile station is located in the direction of offset angle β from the main beam direction of the diversity antenna

FREQUENCY DIVERSITY

- Frequency diversity is implemented by transmitting same information on more than one carrier frequency.
- Our aim is to make these carrier frequency uncorrelated to each other, so that they will not experience the same fades.
- To make them least correlated, these carrier frequencies are separated by more than the coherence bandwidth of the channel.

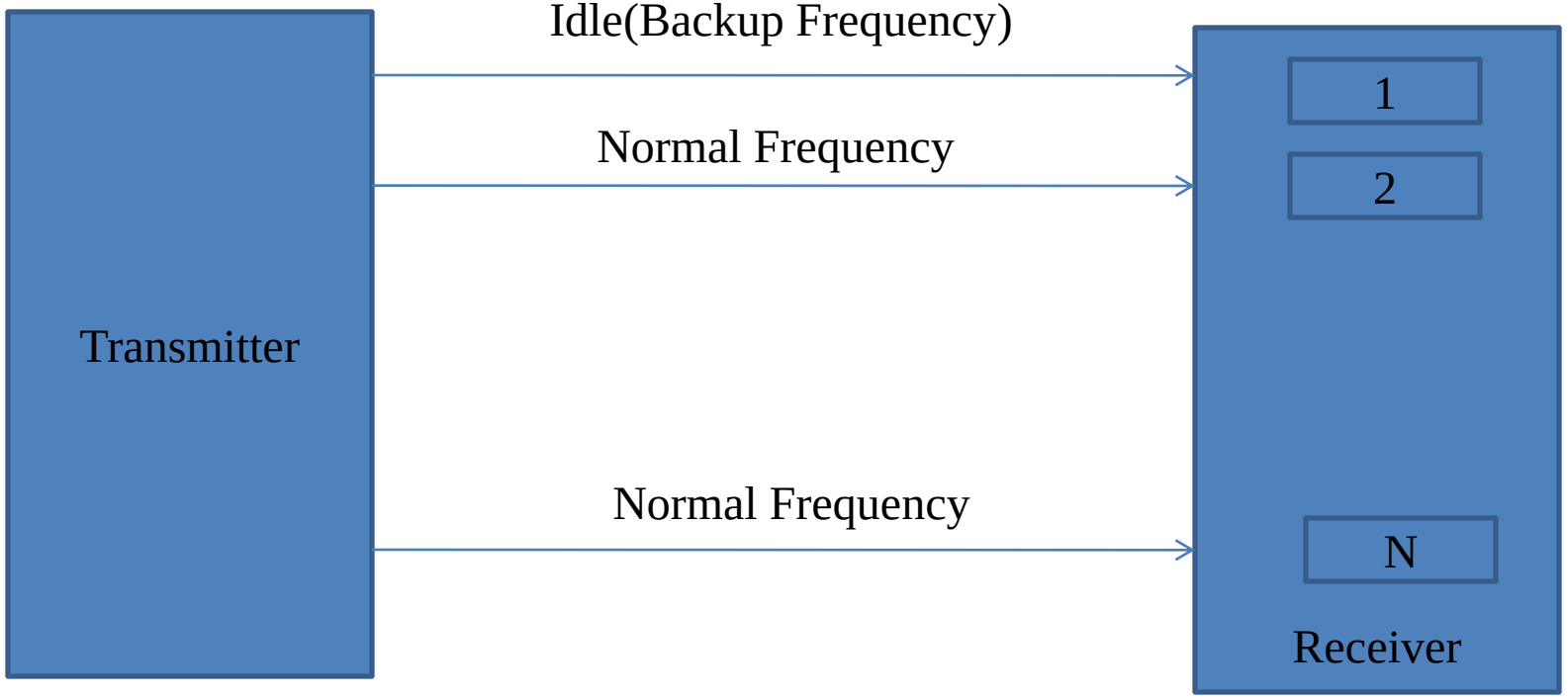
FREQUENCY DIVERSITY

- Theoretically if the channels are uncorrelated , then the probability of simultaneous fading will be the product of the individual fading probabilities
- Frequency diversity is often employed in microwave line –of-sight links
- These links uses Frequency division multiplexing mode(FDM).



FREQUENCY DIVERSITY

- In Practice 1:N protection switching is used as shown below.



FREQUENCY DIVERSITY

- Protection switching is provided by a radio licensee.
- In this case one frequency is nominally idle but is available on a stand by basis to provide frequency diversity switching for any one of the other N carrier.
- When diversity is needed , the appropriate traffic is simply switched to backup frequency.

Assessment

- **1. Diversity technique is used for combating**
  a) Fading
  b) Error bursts
  c) Co-channel interference
  d) All of the mentioned
- **2. Diversity technique is applied at**
  a) Base station
  b) Mobile receiver
  c) Both of the mentioned
  d) None of the mentioned
- 3. **Which is more effective and commonly preferred technique?**
  a) Time diversity
  b) Spatial diversity
  c) Frequency diversity
  d) None of the mentioned