Unit-2

3) (a) Prove that k=7 cell patterns didn't provide a sufficient frequency reuse distance, even when an ideal condition of flat terrain is assumed?

Ans:- The worst case is at the location where the mobile unit would receive the weakest signal from its own cell site but strong interference from all other interfering cell sites. In the worst case, the mobile unit is at the cell boundary R and the distances from all six cochannel interfering sites is two distances of D-R, two distances of D, and two distances of D+R. We already know that in the mobile Radio environment,

$$C \propto R^{-4}$$

$$I \propto D^{-4}$$

Then, the carrier to interference ratio is

$$\frac{C}{I} = \frac{R^{-4}}{2(D-R)^{-4} + 2D^{-4} + 2(D+R)^{-4}} \quad -(1)$$

$$= \frac{1}{2(q-1)^{-4} + 2q^{-4} + 2(q+1)^{-4}}$$

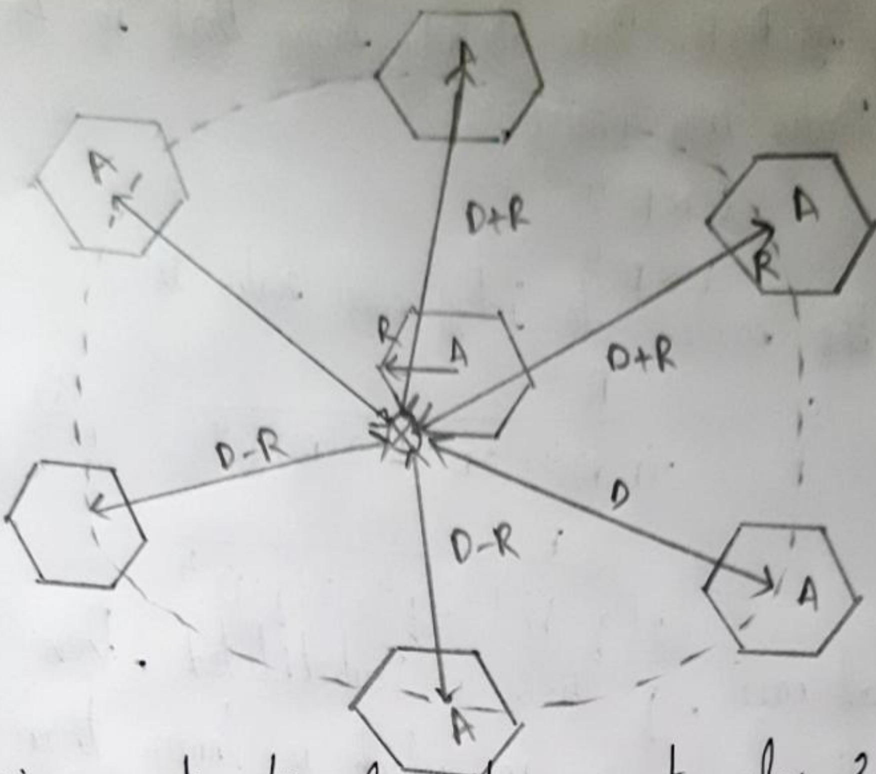
In normal case, $q = 4.6$ is substituted, then

$\frac{C}{I} = 54$ or 17 dB, which is lower than 18 dB.

For worst case, we may use the shortest distance D-R for all six interference, then the equation is replaced by,

$$\frac{C}{I} = \frac{R^{-4}}{6(D-R)^{-4}} = \frac{1}{6(q-1)^{-4}} = 28 = 14.47 \text{ dB}.$$

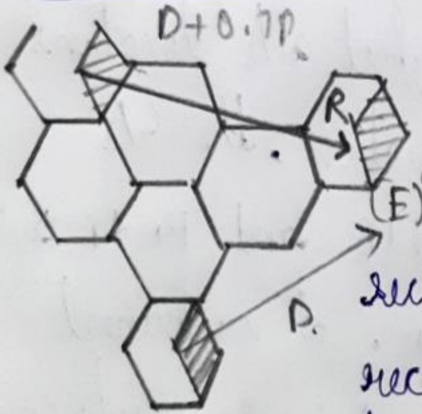
In reality, because of the imperfect site locations & rolling nature of terrain configuration, the C/I received is always worse than 17 dB and 14 dB a lower in a heavy traffic situation. A cochannel interference reduction factor of $q = 4.6$ is insufficient.



(b). Design a directional antenna system for 3 sector and 6 sector case when k=7, k=4.

Ans:- Directional antennas in k=7 cell patterns

(a) 3 sector case:-



The mobile unit at position E will experience greater interference in the lower shaded cell sector than in the upper shaded cell sector because the mobile receiver receives the weakest signal from its own cell but fairly strong interference from the interfering cell.

→ In a 3 sector case, the interference is effective only in one direction because the front to back ratio of cell site directional antenna is atleast 10 dB or more in mobile radio environment.

→ Because of the use of directional antennas, the number of principal interferers is reduced from six to two, then the value of $\frac{C}{I}$ can be obtained by the following expression, $\frac{C}{I} = \frac{R^{-4}}{(D+0.7R)^{-4}+D^{-4}} = \frac{1}{(q+0.7)^{-4}+q^{-4}}$.

Let $q=4.6$, $\frac{C}{I} = 285$ (or) $24.5\,dB$

→ Here the C/I is received by mobile unit from the 120° directional antenna sector system greatly exceeds 18 dB in worst case.

Six sector case:- We have to divide a cell into six sectors by using 60° beam directional antennas. In this case only one instance of interference can occur in each sector $\frac{C}{I} = \frac{R^{-4}}{(D+0.7R)^{-4}} = (q+0.7)^{4}$

For $q = 4.6$ then $\frac{C}{I} = 794 \simeq 29\,dB$

which shows a further reduction of cochannel interference.

Directional antennas in k=4 cell patterns

Three sector case:- For $k=4$, $q=\sqrt{3k} \Rightarrow 3.46$

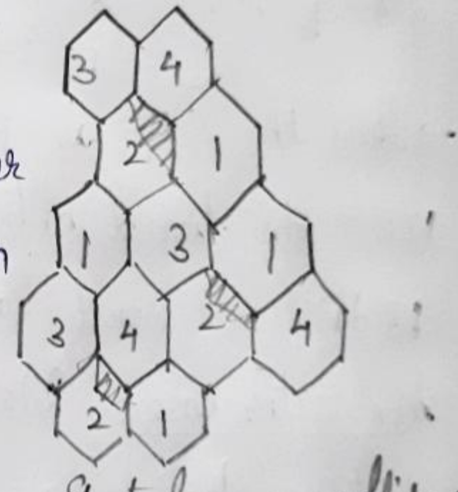
$$\frac{C}{I}\,(\text{Worst case}) = \frac{1}{(q+0.7)^{-4}+q^{-4}} = 97 = 20\,dB$$

If we subtract 6 dB, the remaining is unacceptable.

Six sector case:- There is only one interferer at a distance of D+R with $q=3.46$, then we obtain

$$\frac{C}{I}\,(\text{worst case}) = \frac{R^{-4}}{(D+R)^{-4}} = \frac{1}{(q+1)^{-4}} = 355 \simeq 26\,dB$$

If we subtract that 6 dB, the remaining 21 dB is adequate under heavy traffic conditions, we can use 60° sector at k=4 cell pattern.



Interference with k-4

4) (a) Discuss the effects of lowering antenna heights.

Ans:- It doesn't always reduce the cochannel interference but in some circumstances like fairly flat ground or in a valley situation, it will be very effective

in reducing cochannel and adjacent channel interference
→ There are three cases where lowering the antenna height may or may not effectively help to reduce the interference:-

(a) <u>On a high hill or high spot</u>:-

The effective antenna height, rather than the actual antenna height varies according to the location of mobile unit. When the antenna site is on a hill, then the effective antenna height is $h_1 + H$. If we reduce the actual antenna height to $0.5h_1$, then the new effective antenna height becomes $0.5h_1 + H$, Then the gain reduction is,

$$G = 20 \log \frac{0.5h_1 + H}{h_1 + H} = 20 \log \left[1 - \frac{0.5h_1}{h_1 + H}\right].$$

If $h_1 << H$, then $G = 20 \log_{10}(1) = 0\,dB$

This proves that the lowering antenna height on the hill doesn't reduce the received power at either cell site or the mobile unit.

(b) <u>In a valley</u>:-

→ The effective antenna height as seen from the mobile unit as h_e, which is less than actual antenna height h_1.

→ If $h_{e_1} = \frac{2}{3}h_1$ and the antenna is lowered to $\frac{1}{2}h_1$ then, the new effective antenna height is

$$h_{e_1}' = \frac{1}{2}h_1 - \left[h_1 - \frac{2}{3}h_1\right] = \frac{1}{6}h_1$$

→ Then the antenna gain is reduced by

$$G = 20 \log \frac{\frac{1}{6}h_1}{\frac{2}{3}h_1} = -12\,dB$$

This simply proves that the lower antenna height in a valley is very effective in reducing the radiated power. However in the area adjacent to the cell site antenna, the effective antenna is the same as actual antenna height.

In a Forested area:- In a forested area, the antenna height must be higher than all trees. because excessive alternuation of desired signal occur in the vicinity of the antenna and in its cell boundary if the antenna were below the top level.

(b) Explain the different types of Non cochannel interference.

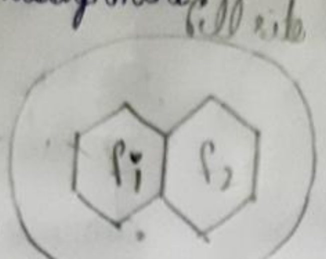
Ans:- The different types of non cochannel interference are listed below:-

1) Adjacent channel Interference:- It can be eliminated

by frequency assignment

$f_1 \rightarrow$ 800-850 MHz

$f_2 \rightarrow$ 851-890 MHz

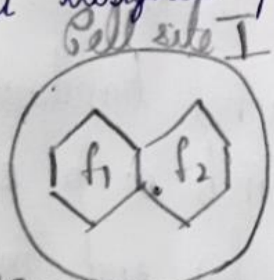


$f_1 \rightarrow$ 850 MHz

$f_2 \rightarrow$ 851 MHz

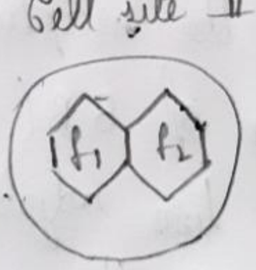
When the mobile wants to respond for f_1 of 850 MHz but because of interference and moving nature of mobile it will operate for f_2 of 851 MHz is called adjacent channel interference.

2) Next channel Interference:- Next channel interference affecting a particular mobile unit cannot be caused by transmitters in the common cell site, but must originate at several other cell sites, if the system is not designed properly.



f_1 = 850 MHz

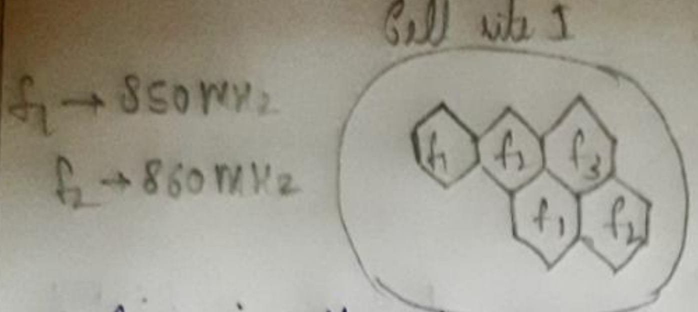
f_2 = 860 MHz



f_1 = 851 MHz

f_2 = 861 MHz

3) Neighbouring channel Interference:- The channels which are several channels away from the next channel will cause interference with the desired signal.

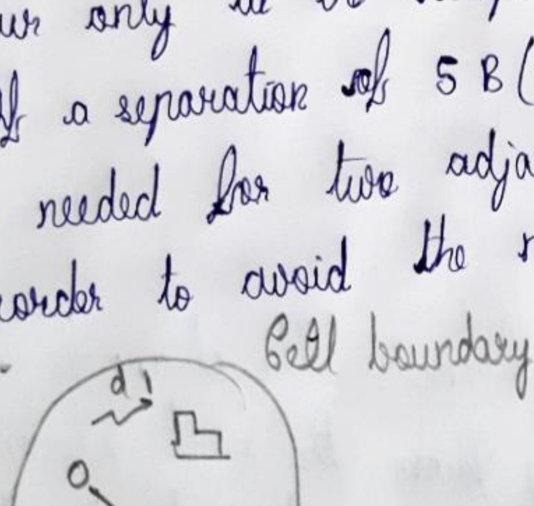


When the mobile operates for f_1, then if it will operate for f_2 of next channels will cause interference with the desired signal. i.e a fixed set of serving channels is assigned to each cell site.

Near End - Far end Interference:-

In one cell:- The mobiles in a given cell are usually moving some units are close to the cell site and some or not. The close in mobile unit has a strong signal which causes adjacent channel interference. At the situation, near end far end interference can occur only at the reception point in the cell site.

→ If a separation of 5 B (five channel bandwidths) is needed for two adjacent channels in a cell inorder to avoid the near end far end interference.



Similarly, this can be explained in cells of two systems.