UNIT IV (A)

CELLSITE AND MOBILE ANTENNAS

SPACES-DIVERSITY ANTENNAS

Two-branch space-diversity antennas are used at the cell site to receive the same signal with different fading envelopes, one at each antenna. The degree of correlation between two fading envelopes is determined by the degree of separation between two receiving antennas. When the two fading envelopes are combined, the degree of fading is reduced. Here the antenna setup is shown in Fig. 5a.

Equation is presented as an example for the designer to use.

$\eta = h/D = 11$ (8.13-1)

Where h is the antenna height and D is the antenna separation. From Eq., the separation $d \geq 8\lambda$ is needed for an antenna height of 100 ft (30 m) and the separation $d \geq 14\lambda$ is needed for an antenna height of 150 ft (50 m). In any Omni cell system, the two space-diversity antennas should be aligned with the terrain, which should have a U shape as shown in Fig.5b. Space-diversity antennas can separate only horizontally, not vertically; thus, there is no advantage in using a vertical separation in the design.

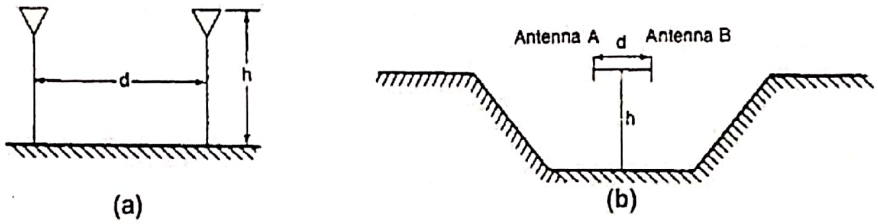


Fig.6.10.Diversity antenna spacing at cell site: (a) n=h/d (b) Proper arrangement with two antennas

UMBRELLAS-PATTERN ANTENNAS

In certain situations, umbrella-pattern antennas should be used for the cell-site antennas.

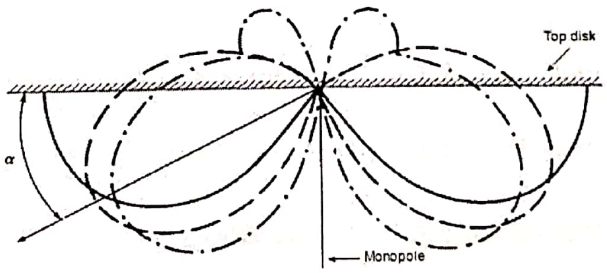


Fig. Vertical-plane patterns of quarter-wavelength stub antenna on infinite ground plane (solid) and on finite ground planes several wavelengths in diameter (dashed line) and about one wavelength in diameter (dotted line).

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i) NORMAL UMBRELLA-PATTERN ANTENNA:

For controlling the energy in a confined area, the umbrella-pattern antenna can be developed by using a monopole with a top disk (top-loading) as shown in Fig. The size of the disk determines the tilting angle of the pattern. The smaller the disk, the larger the tilting angle of the umbrella pattern.

ii) BROADBAND UMBRELLA-PATTERN ANTENNA:

The parameters of a Discone antenna (a bio conical antenna in which one of the cones is extended to 180° to form a disk) are shown in Fig. The diameter of the disk, the length of the cone, and the opening of the cone can be adjusted to create an umbrella-pattern antenna.

iii) INTERFERENCE REDUCTION ANTENNA:

A design for an antenna configuration that reduces interference in two critical directions (areas) is shown in Fig.6.3. The parasitic (insulation) element is about 1.05 times longer than the active element.

iv) HIGH-GAIN BROADBAND UMBRELLA-PATTERN ANTENNA:

A high-gain antenna can be constructed by vertically stacking a number of umbrella-pattern antennas as shown in Fig.

$$E_0 = \frac{\sin[(Nd/2\lambda)\cos\phi]}{\sin[(d/2\lambda)\cos\phi]} \cdot (\text{individual umbrella pattern})$$

where ϕ = direction of wave travel
N = number of elements
d = spacing between two adjacent elements

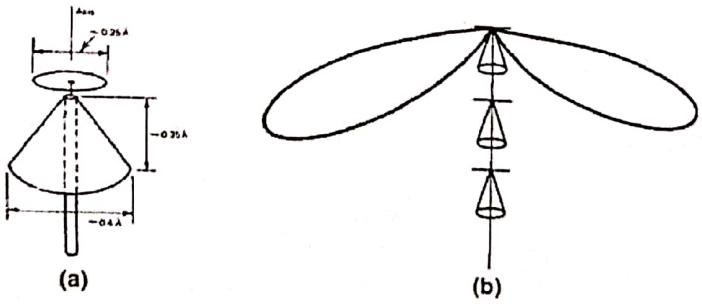


Fig. Discone antennas (a) Single antenna; (b) An array of antenna

MINIMUM SEPARATION OF CELL-SITE RECEIVING ANTENNAS

Separation between two transmitting antennas should be minimized to avoid the inter modulation. The minimum separation between a transmitting antenna and a receiving antenna is necessary to avoid receiver

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desensitization. Here we are describing a minimum separation between two receiving antennas to reduce the antenna pattern ripple effects. The two receiving antennas are used for a space-diversity receiver.

Because of the near field disturbance due to the close spacing, ripples will form in the antenna patterns (Fig.). The difference in power reception between two antennas at different angles of arrival is shown in Fig. . If the antennas are located closer; the difference in power between two antennas at a given pointing angle increases. Although the power difference is confined to a small sector, it affects a large section of the street as shown in Fig. .

If the power difference is excessive, use of space diversity will have no effect reducing fading. At 850 MHz, the separation of eight wavelengths between two receiving antennas creates a power difference of ±2 dB, which is tolerable for the advantageous use of a diversity scheme.

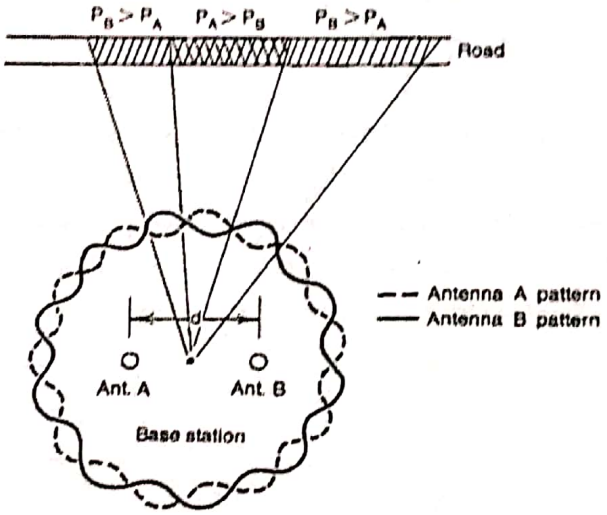


Fig. Antenna pattern ripple effect

MOBILE ANTENNAS

The requirement of a mobile (motor-vehicle–mounted) antenna is an Omni-directional antenna that can be located as high as possible from the point of reception. However, the physical limitation of antenna height on the vehicle restricts this requirement. Generally, the antenna should at least clear the top of the vehicle. Patterns for two types of mobile antenna are shown in Fig.

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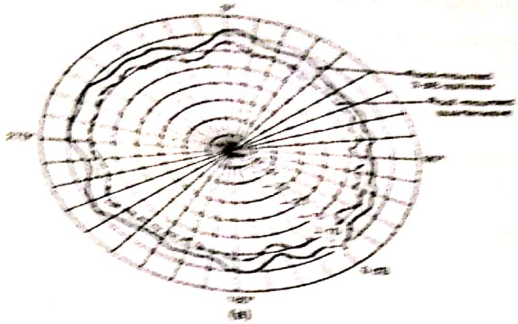


Fig. Mobile antenna patterns (a) Roof mounted 3-dB-gain collinear antenna versus roof-mounted quarter-wave antenna, (b) Window-mounted "on-glass" gain antenna versus roof-mounted quarter-wave antenna.

ROOF-MOUNTED ANTENNA:

The antenna pattern of a roof-mounted antenna is more or less uniformly distributed around the mobile unit when measured at an antenna range in free space as shown in Fig.9.2. The 3-dBhigh-gain antenna shows a 3-dBgain over the quarter-wave antenna. However, the gain of the antenna used at the mobile unit must be limited to 3 dB because the cell-site antenna is rarely as high as the broadcasting antenna and out-of-sight conditions often prevail. The mobile antenna with a gain of more than 3 dB can receive only a limited portion of the total multipath signal in the elevation as measured under the out-of-sight condition.

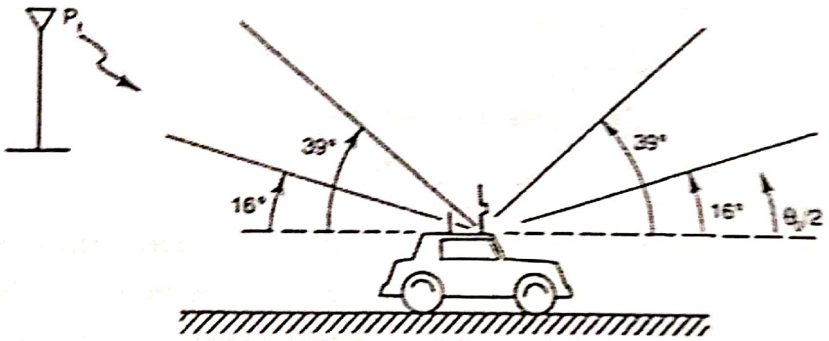


Fig. Vertical angle of signal arrival

GLASS-MOUNTED ANTENNAS:

There are many kinds of glass-mounted antennas. Energy is coupled through the glass; therefore, there is no need to drill a hole. However, some energy is dissipated on passage through the glass. The antenna gain range is 1 to 3 dB depending on the operating frequency. The position of the glass-mounted antenna is

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always lower than that of the roof-mounted antenna; generally there is a 3-dBdifference between these two types of antenna. Also, glass mounted antennas cannot be installed on the shaded glass found in some motor vehicles because this type of glass has a high metal content.

MOBILE HIGH-GAIN ANTENNAS:

A high-gain antenna used on a mobile unit has been studied. This type of high-gain antenna should be distinguished from the directional antenna. In the directional antenna, the antenna beam pattern is suppressed horizontally; in the high-gain antenna, the pattern is suppressed vertically.

To apply either a directional antenna or a high-gain antenna for reception in a radio environment, we must know the origin of the signal. If we point the directional antenna opposite to the transmitter site, we would in theory receive nothing. In a mobile radio environment, the scattered signals arrive at the mobile unit from every direction with equal probability. That is why an Omni directional antenna must be used.

The scattered signals also arrive from different elevation angles. Lee and Brandt used two types of antenna, one $\lambda/4$ whip antenna with elevation coverage of 39° and one 4-dB-gain antenna (4-dB gain with respect to the gain of a dipole) with elevation coverage of 16° and measured the angle of signal arrival in the suburban Keyport-Matawan area of New Jersey. There are two types of test: a line-of-sight condition and an out-of-sight condition. In Lee and Brandt's study, the transmitter was located at an elevation of approximately 100 m (300 ft) above sea level.

The measured areas were about 12 m (40 ft) above sea level and the path length about 3 mi. The received signal from the 4-dB-gain antenna was 4 dB stronger than that from the whip antenna under line-of-sight conditions. This is what we would expect.

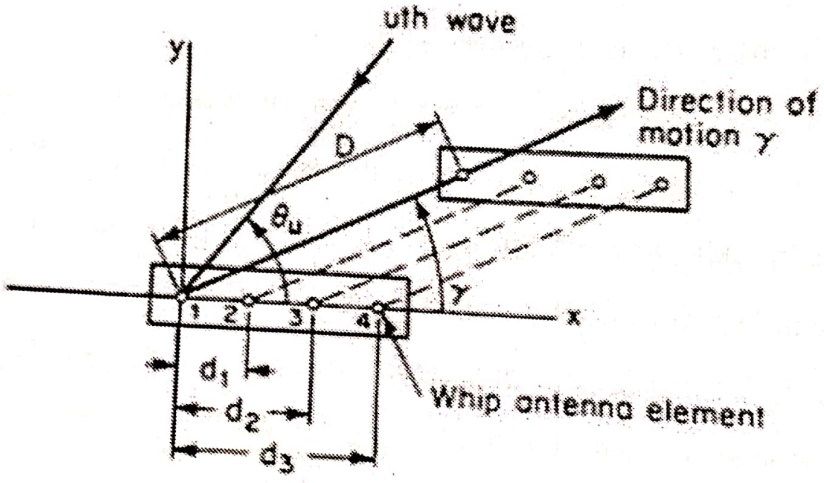
However, the received signal from the 4-dB-gain antenna was only about 2 dB stronger than that from the whip antenna under out-of-sight conditions. This is surprising. The reason for the latter observation is that the scattered signals arriving under out-of- sight conditions are spread over a wide elevation angle. A large portion of the signals outside the elevation angle of 16° cannot be received by the high-gain antenna. We may calculate the portion being received by the high-gain antenna from the measured beam width. For instance, suppose that a 4:1 gain (6 dBi) is expected from the high-gain antenna, but only 2.5:1 is received. Therefore, 63 percent of the signal is received by the 4-dB-gain antenna (i.e., 6 dBi) and 37 percent is felt in the region between 16 and 39°

Therefore, a 2- to 3-dB-gain antenna (4 to 5 dBi) should be adequate for general use. An antenna gain higher than 2 to 3 dB does not serve the purpose of enhancing reception level. Moreover, measurements reveal that the elevation angle for scattered signals received in urban areas is greater than that in suburban areas.

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	Gain, dBi	Linear ratio	$\theta_0/2$, degrees
Whip antenna (2 dB above isotropic)	2	1.58:1	39
High-gain antenna	6	4:1	16
Low-gain antenna	4	2.5:1	24



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UNIT-IV (B)

FREQUENCY MANAGEMENT AND CHANNEL ASSIGNMENT

The function of frequency management is to divide the total number of available channels into subsets which can be assigned to each cell either in a fixed fashion or dynamically (i.e., in response to any channel among the available channels). The terms —frequency management‖ and —channel assignment‖ often create some confusion. Frequency management refers to designating setup channels and voice channels (done by the FCC), numbering the channels (done by the FCC), and grouping the voice channels into subsets (done by each system according to its preference).

Channel assignment refers to the allocation of specific channels to cell sites and mobile units. A fixed channel set consisting of one more subsets is assigned to a cell site on a long-term basis. During a call, a particular channel is assigned to a mobile unit on a short- term basis. For a short-term assignment, one channel assignment per call is handled by the mobile telephone switching office (MTSO). Ideally channel assignment should be based on causing the least interference in the system. However, most cellular systems cannot perform this way.

4.1 NUMBERING THE RADIO CHANNELS

The total number of channels at present (January 1988) is 832. But most mobile units an systems are still operating on 666 channels. Therefore we describe the 666 channel numbering first. A channel consists of two frequency channel bandwidths, one in the low band and one in the high band. Two frequencies in channel 1 are 825.030 MHz (mobile transmit) 870.030 MHz (cell-site transmit). The two frequencies in channel 666 are 844.98 MHz (mobile transmit) and 898 MHz (cell-site transmit). The 666 channels are divided into two groups: block A system and block B system. Each market (i.e., each city) has two systems for a duopoly market policy. Each block has 333 channels, as shown in Fig.1.1.

The 42 set-up channels are assigned as follows.

Channels 313-333	block A
Channels 334-354	block B

The voice channels are assigned as follows.

Channels 1-312 (312 voice channels)	block A
Channels 355-666 (312 voice channels)	block B

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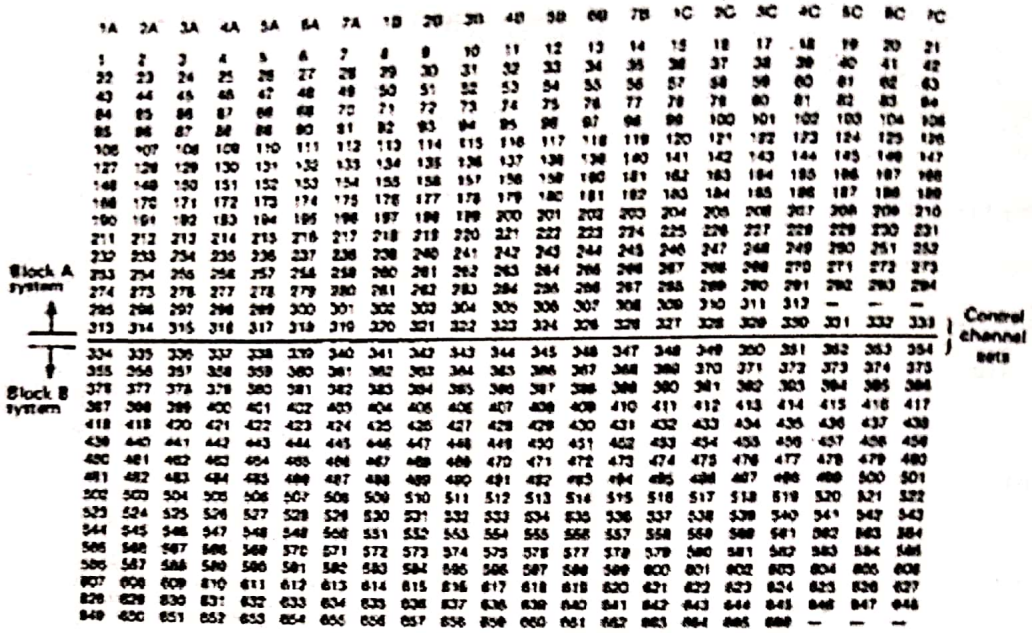


Fig.4.1. Frequency management chart

These 42 set-up channels are assigned in the middle of all the assigned channels to facilitate scanning of those channels by frequency synthesizers. In the new additional spectrum allocation of 10 MHz (sec Fig. 1.2.), an additional 166 channels are assigned. Since a 1 MHz is assigned below 825 MHz (or 870 MHz) in the future, additional channels will be numbered up to 849 MHz (or 894 MHz) and will then circle back. The last channel number is 1023. There are no Channels between channels 799 and 991.

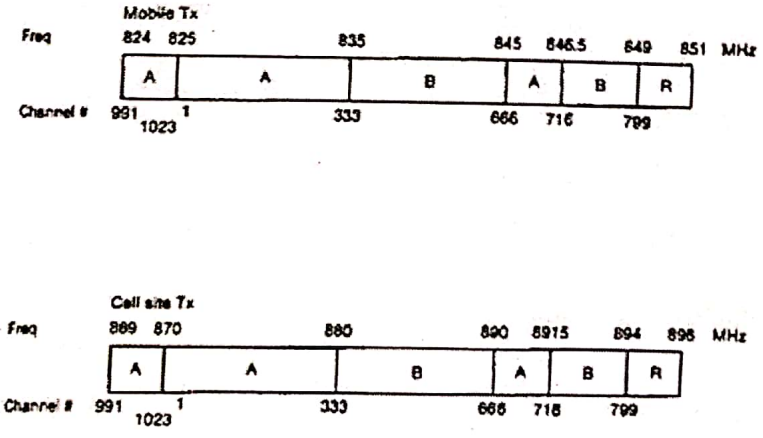


Fig.4.2. New additional spectrum allocation

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4.2 GROUPING INTO SUBSETS

The number of voice channels for each system is 312. We can group these into any number of subsets. Since there are 21 set-up channels for each system, it is logical to group the 312 channels into 21 subsets. Each subset then consists of 16 channels. In each set, the closest adjacent channel is 21 channels away, as shown in Fig.1.1. The 16 channels in each subset can be mounted on a frame and connected to a channel combiner. Wide separation between adjacent channels is required for meeting the requirement of minimum isolation. Each 16-channel subset is idealized for each 16-channel combiner. In a seven- cell frequency-reuse cell system each cell contains three subsets, iA+iB+iC, where i is an integer from 1 to 7. The total number of voice channels in a cell is about 45. The minimum separation between three subsets is 7 channels. If six subsets are equipped in an omnicell site, the minimum separation between two adjacent channels can be only three (21/6> 3) physical channel bandwidths.

For example,

1A+1B+1C+4A+4B

+4 C

Or

1A+1B+1C+5A+5B+5C

4.3 SET-UP CHANNELS

Set-up channels also called control channels are the channels designated to setup calls. We should not be confused by fact that a call always needs a set-up channel. A system can be operated without set-up channels. If we are choosing such a system all the 333 channels in each cellular system (block A or block B) can be voice channels; however each mobile unit must then scan 333 channels continuously and detect the signaling for its call. A customer who wants to initiate a call must scan all the channels and find an idle (unoccupied) one to use.

In a cellular system, we are implementing frequency-reuse concepts. In this case the set-up channels are acting as control channels. The 21 set-up channels are taken out from the total number of channels. The number 21 is derived from a seven-cell frequency-reuse pattern with three 120◦ sectors per cell, or a total of 21 sectors, which require 21 set-up channels. However, now only a few of the 21 setup channels are being used in each system. Theoretically, when cell size decreases the use of set-up channels should increase. Set-up channels can be classified by usage into two types: access channels and paging channels.

An access channel is used for the mobile-originating calls and paging channels for the land originating calls. For this reason, a set-up channel is sometimes called an ‗access channel' and sometimes called a ‗paging channel.' Every two- way channel contains two 30-kHz bandwidth.. Normally one set-up channel is also specified

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by two operations as a forward set-up channel (using the upper band) and a reverse set-up channel (using the lower band). In the most common types of cellular systems, one set-up channel is used for both access and paging. The forward set-up channel functions as the paging channel for responding to the mobile-originating calls. The reverse set-up channel functions as the access channel for the responder to the paging call. The forward set-up channel is transmitted at the cell site, and the reverse set-up channel is transmitted at the mobile unit. All set-up channels carry data information only.

4.3.1. ACCESS CHANNELS:

In mobile-originating calls, the mobile unit scans its 21 set-up channels and chooses the strongest one. Because each set-up channel is associated with one cell, the strongest set-up channel indicates which cell is to serve the mobile-originating calls. Th. mobile unit detects the system information transmitted from the cell site. Also, the mobile unit monitors the Busy/Idle status bits over the desired forward setup channel. When the idle bits are received, the mobile unit can use the corresponding reverse set-up channel to initiate a call.

Frequently only one system operates in a given city; for instance, block B system might be operating and the mobile unit could be set to —preferable A system.‖ When the mobile unit first scans the 21 set-up channels in block A, two conditions can occur.

1. If no set-up channels of block A are operational, the mobile unit automatically switches to block B.
2. If a strong set-up signal strength is received but no message can be detected, then the scanner chooses the second strongest set-up channel. If the message still cannot be detected, the mobile unit switches to block B and scans to block B set-up channels.

THE OPERATIONAL FUNCTIONS ARE DESCRIBED AS FOLLOWS:

1.POWER OF A FORWARD SET-UP CHANNEL [OR FORWARD CONTROL CHANNEL (FOCC)]: The power of the set-up channel can be varied in order to control the number of incoming calls served by the cell. The number of mobile-originating calls is limited by the number of voice channels in each cell site, when the traffic is heavy, most voice channels are occupied and the power of the set-up channel should be reduced in order to reduce the coverage of the cell for the incoming calls originating from the mobile unit. This will force the mobile units to originate calls from other cell sites, assuming that all cells are adequately overlapped.

2. THE SET-UP CHANNEL RECEIVED LEVEL: The setup channel threshold level is determined in order to control the reception at the reverse control channel (RECC). If the received power level is greater than the given set-up threshold level, the call request will be taken.

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3. CHANGE POWER AT THE MOBILE UNIT: When the mobile unit monitors the strongest signal strength from all Set-up channels and selects that channel to receive the messages, there are three types of message.

A. MOBILE STATION CONTROL MESSAGE. This message is used for paging and consists of one, two, or four words -DCC, MIN, SCC and VMAX.

B. SYSTEM PARAMETER OVERHEAD MESSAGE. This message contains two words, including DCC, SID, CMAX, or CPA.

c. CONTROL-FILLER MESSAGE. This message may be sent with a system parameter overhead message, CMAC—a control mobile attenuation code (seven levels).

4. DIRECT CALLS RETRY. When a cell site has no available voice channels, it can send a direct call-retry message through the set-up channel. The mobile unit will initiate, the call from a neighboring cell which is on the list of neighboring cells in the direct call-retry message.

4.3.2. PAGING CHANNELS:

Each cell site has been allocated its own setup channel (control channel). The assigned forward set-up channel (FOCC) of each cell site is used to page the mobile unit with the same mobile station control message.

Because the same message is transmitted by the different set-up channels, no simulcast interference occurs in the system. The algorithm for paging & mobile unit can be performed in different ways. The simplest way is to page from all the cell sites. This can occupy a large amount of the traffic load. The other way is to page in an area corresponding to the mobile unit phone number. If there is no answer, the system tries to page in other areas. The drawback is that response time is sometimes too long.

When the mobile unit responds to the page on the reverse set-up channel, the cell site which receives the response checks the signal reception level and makes a decision regarding the voice channel assignment based on least interference in the selected sector or underlay-overlay region.

4.4 FIXED CHANNEL ASSIGNMENT

ADJACENT-CHANNEL ASSIGNMENT:

Adjacent-channel assignment includes neighboring-channel assignment and next-channel assignment. The near-end–far-end (ratio) interference can occur among the neighboring channels (four channels on each side of the desired channel). Therefore, within a cell we have to be sure to assign neighboring channels in an Omni-directional-cell system and in a directional-antenna-cell system properly.

In an Omni-directional-cell system, if one channel is assigned to the middle cell of seven cells, next channels cannot be assigned in the same cell. Also, no next channel (preferably including neighboring channels) should be assigned in the six neighboring sites in the same cell system area (Fig. 7.3a). In a directional-antenna-

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cell system, if one channel is assigned to a face, next channels cannot be assigned to the same face or to the other two faces in the same cell. Also, next channels cannot be assigned to the other two faces at the same cell site (Fig. 7.3b). Sometimes the next channels are assigned in the next sector of the same cell in order to increase capacity. Then performance can still be in the tolerance range if the design is proper.

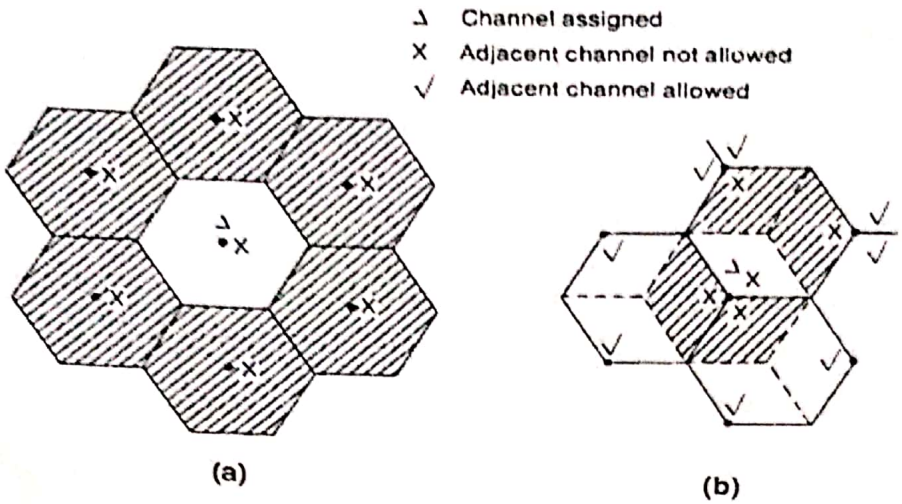


Fig.4.3 Adjacent channel assignment (a) Omni direction antenna cells; (b) Directional antenna cells

4.5 CHANNEL SHARING

Channel sharing is a short-term traffic-relief scheme. A scheme used for a seven-cell three-face system is shown in Fig. 7.2. There are 21 channel sets, with each set consisting of about 16 channels. Figure7.2 shows the channel set numbers. When a cell needs more channels, the channels of another face at the same cell site can be shared to handle the short-term overload. To obey the adjacent-channel assignment algorithm, the sharing is always cyclic. Sharing always increases the trunking efficiency of channels.

Since we cannot allow adjacent channels to share with the nominal channels in the same cell, channel sets 4 and 5 cannot both be shared with channel sets 12 and 18, a indicated by the grid mark. Many grid marks are indicated in Fig.7.2 for the same reason. However, the upper subset of set 4 can be shared with the lower subset of set 5 with no interference. In channel-sharing systems, the channel combiner should be flexible in order to combine up to 32 channels in one face in real time. An alternative method is to install a standby antenna.

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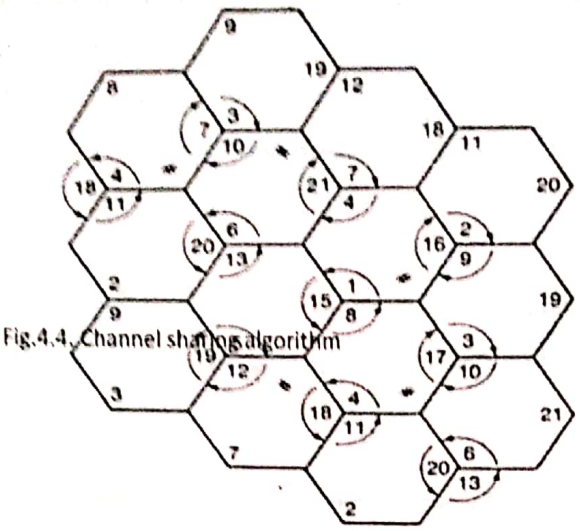


Fig.4.4. Channel sharing algorithm

4.6 CHANNEL BORROWING

Channel borrowing is usually handled on a long-term basis. The extent of borrowing more available channels from other cells depends on the traffic density in the area. Channel borrowing can be implemented from one cell-site face to another face at the same cell site. In addition, the central cell site can borrow channels from neighboring cells. The channel-borrowing scheme is used primarily for slowly-growing systems. It is often helpful in delaying cell splitting in peak traffic areas. Since cell splitting is costly, it should be implemented only as a last resort.

ADVANTAGE OF SECTORIZATION:

The total number of available channels can be divided into sets (subgroups) depending on the Sectorization of the cell configuration: the 120°-sector system, the 60°-sector system, and the 45°-sector system. In certain locations and special situations, the sector angle can be reduced (narrowed) in order to assign more channels in one sector without increasing neighboring-channel interference. Sectorization serves the same purpose as the channel-borrowing scheme in delaying cell splitting. In addition, channel coordination to avoid co-channel interference is much easier in sectorization than in cell splitting. Given the same number of channels, trunking efficiency decreases in Sectorization.

SECTORIZED CELLS: There are three basic types.

1. The 120°-sector cell is used for both transmitting and receiving Sectorization. Each sector has an assigned a number of frequencies. Changing sectors during a call requires handoffs.

2. The 60°-sector cell is used for both transmitting and receiving Sectorization. Changing sectors during a call requires handoffs. More handoffs are expected for a 60° sector than a 120° sector in areas close to cell sites (close-in areas).

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3. The 120° or 60°-sector cell is used for receiving Sectorization only. In this case, the transmitting antenna is Omni directional. The number of channels in this cell is not sub- divided for each sector. Therefore, no handoffs are required when changing sectors. This receiving-Sectorization-only configuration does not decrease interference or increase the D/R ratio; it only allows for a more accurate decision regarding handing off the calls to neighboring cells.

4.7 UNDERLAY-OVERLAY ARRANGEMENT

In actual cellular systems cell grids are seldom uniform because of varying traffic conditions in different areas and cell-site locations.

OVERLAID CELLS:

To permit the two groups to reuse the channels in two different cell-reuse patterns of the same size, an —under laid‖ small cell is sometimes established at the same cell site as the large cell (see Fig. 7.5a). The —doughnut‖ (large) and —hole‖ (small) cells are treated as two different cells. They are usually considered as —neighboring cells.‖

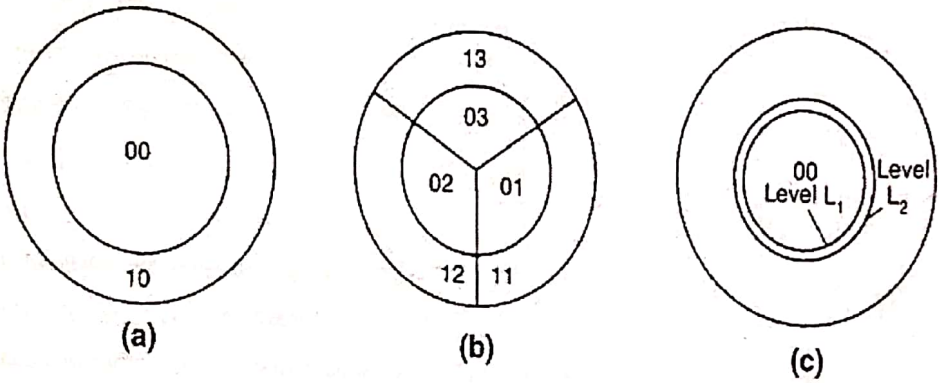


Fig.4.5.Under laid-overlaid cell arrangements. (a) Underlay-overlay in omnicell; (b) Underlay-overlay in Sectorized cell; (c) Two level handoff scheme

The use of either an Omni directional antenna at one site to create two sub ring areas or three directional antennas to create six subareas is illustrated in Fig. 4.5 b. As seen in Fig.4.5, a set of frequencies used in an overlay area will differ from a set of frequencies used in an underlay area in order to avoid adjacent-channel and co-channel interference.

The channels assigned to one combiner—say, 16 channels—can be used for overlay, and another combiner can be used for underlay.

IMPLEMENTATION:

The antenna of a set-up channel is usually Omni directional. When an incoming call is received by the set-up channel and its signal strength is higher than a level L, the under laid cell is assigned; otherwise, the overlaid cell is

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assigned. The handoffs are implemented between the under laid and overlaid cells. In order to avoid the unnecessary handoffs, we may choose two levels L1 and L2 and L1 > L2 as shown in Fig. 4.5 (c). When a mobile signal is higher than a level L1 the call is handed off to the under laid cell. When a signal is lower than a level L2 the call is handed off to the overlaid cell. The channels assigned in the under laid cell have more protection against co-channel interference.

4.8 NON FIXED CHANNEL ASSIGNMENT STRATEGY

1. FIXED CHANNEL ASSIGNMENT: The fixed channel assignment (FCA) algorithm is the most common algorithm adopted in many cellular systems. In this algorithm, each cell assigns its own radio channels to the vehicles within its cell.

2. DYNAMIC CHANNEL ASSIGNMENT: In dynamic channel assignment (DCA), no fixed channels are assigned to each cell. Therefore, any channel in a composite of N radio channels can be assigned to the mobile unit. This means that a channel is assigned directly to a mobile unit. On the basis of overall system performance, DCA can also be used during a call.

3. HYBRID CHANNEL ASSIGNMENT: Hybrid channel assignment (HCA) is a combination of FCA and DCA. A portion of the total frequency channels will use FCA and the rest will use DCA.

4. BORROWING CHANNEL ASSIGNMENT: Borrowing channel assignment (BCA) uses FCA as a normal assignment condition. When all the fixed channels are occupied, then the cell borrows channels from the neighboring cells.

5. FORCIBLE-BORROWING CHANNEL ASSIGNMENT: In forcible-borrowing channel assignment (FBCA), if a channel is in operation and the situation warrants it, channels must be borrowed from the neighboring cells and at the same time, another voice channel will be assigned to continue the call in the neighboring cell. There are many different ways of implementing FBCA. In a general sense, FBCA can also be applied while accounting for the forcible borrowing of the channels within a fixed channel set to reduce the chance of co-channel assignment in a reuse cell pattern. The FBCA algorithms based on assigning a channel dynamically but obeying the rule of reuse distance.

The distance between the two cells is reuse distance, which is the minimum distance at which no co-channel interference would occur. Very infrequently, no channel can be borrowed in the neighboring cells. Even those channels currently in operation can be forcibly borrowed and will be replaced by a new channel in the neighboring cell or the neighboring cell of the neighboring cell. If all the channels in the neighboring cells cannot be borrowed because of interference problems, the FBCA stops.

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