5.6 Mobile Antennas

The requirement of a mobile (motor-vehicle–mounted) antenna is an omnidirectional antenna which 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. 5.18.

5.6.1 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. 5.19. The 3-dB high-gain antenna shows a 3-dB gain 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.[19] This point is discussed in detail in Sec. 5.6.3.

5.6.2 Glass-mounted antennas[10,20]

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 always lower than that of the roof-mounted antenna; generally there is a 3-dB difference 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.

5.6.3 Mobile high-gain antennas

A high-gain antenna used on a mobile unit has been studied.[19] 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 omnidirectional antenna must be used. The scattered signals also arrive from different elevation angles. Lee and Brandt[19] used two types of antenna, one $\lambda/4$ whip antenna with an elevation coverage of 39° and one 4-dB-gain antenna (4-dB gain with respect to the gain of a

5.6.4 Horizontally oriented space-diversity antennas

A two-branch space-diversity receiver mounted on a motor vehicle has the advantage of reducing fading and thus can operate at a lower

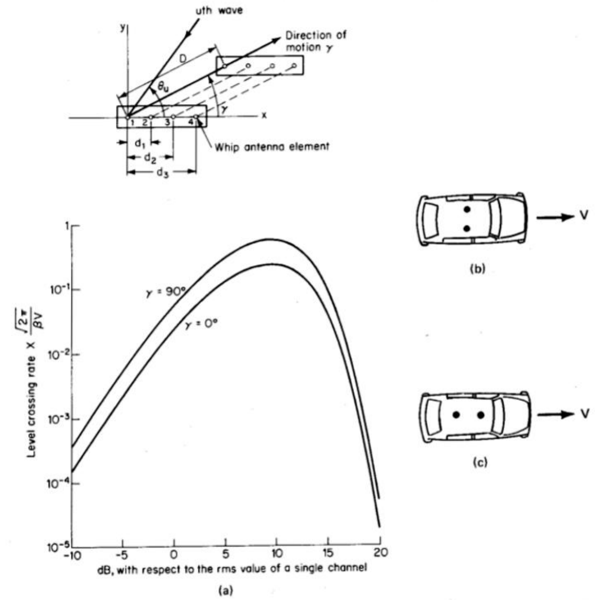

Figure 5.20 Horizontally spaced antennas. (*a*) Maximum difference in lcr of a four-branch equal-gain signal between α = 0 and α = 90° with antenna spacing of 0.15λ. (*b*) Not recommended. (*c*) Recommended.

reception level. The advantage of using a space-diversity receiver to reduce interference is discussed in Chap. 7. The discussion here concerns a space-diversity scheme in which two vehicle-mounted antennas separated horizontally by 0.5λ wavelength[21] (15 cm or 6 in) can achieve the advantage of diversity.

We must consider the following factor. The two antennas can be mounted either in line with or perpendicular to the motion of the vehicle. Theoretical analyses and measured data indicate that the in-line arrangement of the two antennas produces fewer level crossings, that is, less fading, than the perpendicular arrangement does. The level crossing rates of two signals received from different horizontally oriented space-diversity antennas are shown in Fig. 5.20.

5.6.5 Vertically oriented space-diversity antennas[22]

The vertical separation between two space-diversity antennas can be determined from the correlation between their received signals. The positions of two antennas X_1 and X_2 are shown in Fig. 5.21. The theoretical derivation of correlation is[23]

$$\rho\left(\frac{d}{\lambda}, \theta\right) = \frac{\sin[(\pi d/\lambda)\sin\theta]}{(\pi d/\lambda)\sin\theta} \tag{5.6-1}$$

Equation (5.6-1) is plotted in Fig. 5.22. A set of measured data was obtained by using two antennas vertically separated by 1.5λ wavelengths. The mean values of three groups of measured data are also shown in Fig. 5.22. In one group, in New York City, low correlation coefficients were observed. In two other groups, both in New Jersey, the average correlation coefficient for perpendicular streets was 0.35