

FRESNEL ZONE

If unobstructed, radio waves will travel in a straight line from the transmitter to the receiver. But if there are obstacles near the path, the radio waves reflecting off those objects may arrive out of phase with the signals that travel directly and reduce the power of the received signal. On the other hand, the reflection can enhance the power of the received signal if the reflection and the direct signals arrive in phase. Sometimes this results in the counterintuitive finding that reducing the height of an antenna increases the S+N/N ratio. Fresnel provided a means to calculate where the zones are where obstacles will cause mostly in phase and mostly out of phase reflections between the transmitter and the receiver. Obstacles in the first Fresnel will create signals that will be 0 to 90 degrees out of phase, in the second zone they will be 90 to 270 degrees out of phase, in third zone, they will be 270 to 450 degrees out of phase and so on. Odd numbered zones are constructive and even numbered zones are destructive. The concept of Fresnel zone clearance may be used to analyze interference by obstacles near the path of a radio beam. The first zone must be kept largely free from obstructions to avoid interfering with the radio reception. However, some obstruction of the Fresnel zones can often be tolerated, as a rule of thumb the maximum obstruction allowable is 40%, but the recommended obstruction is 20% or less.

For establishing Fresnel zones, first determine the RF Line of Sight (RF LoS), which in simple terms is a straight line between the transmitting and receiving antennas. Now the zone surrounding the RF LoS is said to be the Fresnel zone.

The general equation for calculating the Fresnel zone radius at any point P in the middle of the link is the following:

$$F_n = \sqrt{\frac{n\lambda d_1 d_2}{d_1 + d_2}}$$

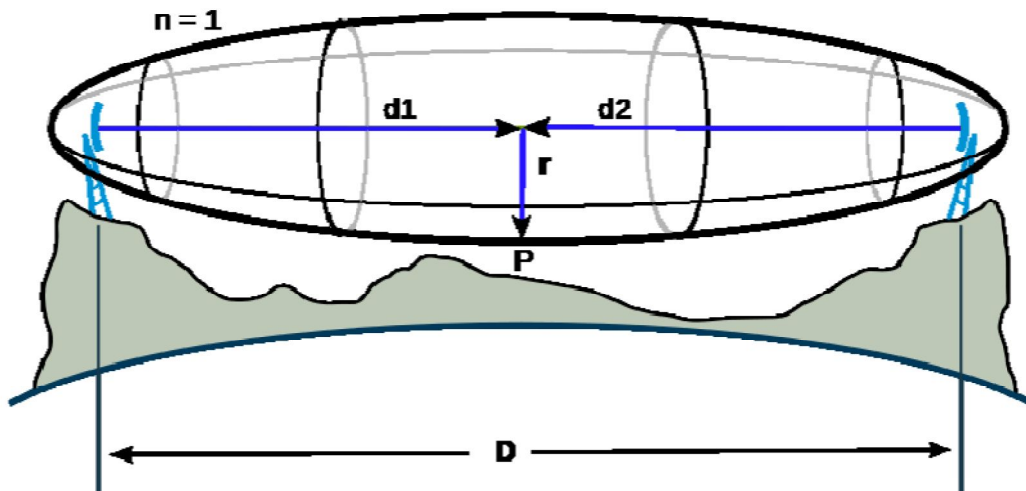
where,

F_n = The nth Fresnel Zone radius in metres

d_1 = The distance of P from one end in metres

d_2 = The distance of P from the other end in metres

λ = The wavelength of the transmitted signal in metres



Frequency Reuse

Frequency reuse is a technique of reusing frequencies and channels within a communications system to improve capacity and spectral efficiency. Frequency reuse is one of the fundamental concepts on which commercial wireless systems are based that involves the partitioning of an RF radiating area (cell) into segments of a cell. One segment of the cell uses a frequency that is far enough away from the frequency in the bordering segment that it does not provide interference problems. Frequency re-use in mobile cellular systems means that each cell has a frequency that is far enough away from the frequency in the bordering cell that it does not provide interference problems. The same frequency is used at least two cells apart from each other. This practice enables cellular providers to have many times more customers for a given site license.

The key characteristic of a cellular network is the ability to re-use frequencies to increase both coverage and capacity. As described above, adjacent cells must use different frequencies, however there is no problem with two cells sufficiently far apart operating on the same frequency. The elements that determine frequency reuse are the reuse distance and the reuse factor.

The reuse distance, D is calculated as

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

where R is the cell radius and N is the number of cells per cluster. Cells may vary in radius in the ranges (1 km to 30 km). The boundaries of the cells can also overlap between adjacent cells and large cells can be divided into smaller cells.

The frequency reuse factor is the rate at which the same frequency can be used in the network. It is $1/K$ (or K according to some books) where K is the number of cells which cannot use the same frequencies for transmission.

Common values for the frequency reuse factor are $1/3$, $1/4$, $1/7$, $1/9$ and $1/12$ (or 3, 4, 7, 9 and 12 depending on notation).

In case of N sector antennas on the same base station site, each with different direction, the base station site can serve N different sectors. N is typically 3. A **reuse pattern** of N/K denotes a further division in frequency among N sector antennas per site. Some current and historical reuse patterns are $3/7$ (North American AMPS), $6/4$ (Motorola NAMPS), and $3/4$ (GSM).

If the total available bandwidth is B , each cell can only use a number of frequency channels corresponding to a bandwidth of B/K , and each sector can use a bandwidth of B/NK .

Code division multiple access-based systems use a wider frequency band to achieve the same rate of transmission as FDMA, but this is compensated for by the ability to use a frequency reuse factor of 1, for example using a reuse pattern of $1/1$. In other words, adjacent base station sites use the same frequencies, and the different base stations and users are separated by codes rather than frequencies. While N is shown as 1 in this example, that does not mean the CDMA cell has only one sector, but rather that the entire cell bandwidth is also available to each sector individually.

Depending on the size of the city, a taxi system may not have any frequency-reuse in its own city, but certainly in other nearby cities, the same frequency can be used. In a big city, on the other hand, frequency-reuse could certainly be in use.

Recently also orthogonal frequency-division multiple access based systems such as LTE are being deployed with a frequency reuse of 1. Since such systems do not spread the signal across the frequency band, inter-cell radio resource management is important to coordinate resource allocation between different cell sites and to limit the inter-cell interference. There are various means of Inter-cell Interference Coordination (ICIC) already defined in the standard. Coordinated scheduling, multi-site MIMO or multi-site beam forming is other examples for inter-cell radio resource management that might be standardized in the future.

Source : <http://msk1986.files.wordpress.com/2013/09/wlc-unit2.pdf>