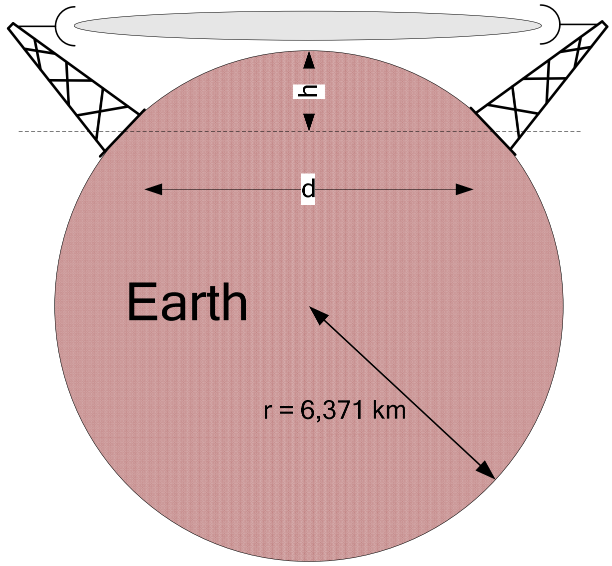
k Factor

Microwave design engineers commonly use a k factor equal 1.33. But, where does it come from? What is it?



The earth is round, not flat and supported by big elephants. Thus, over some distance there is a protuberance call the bulge of the earth. Its height (h) is calculated as follows:

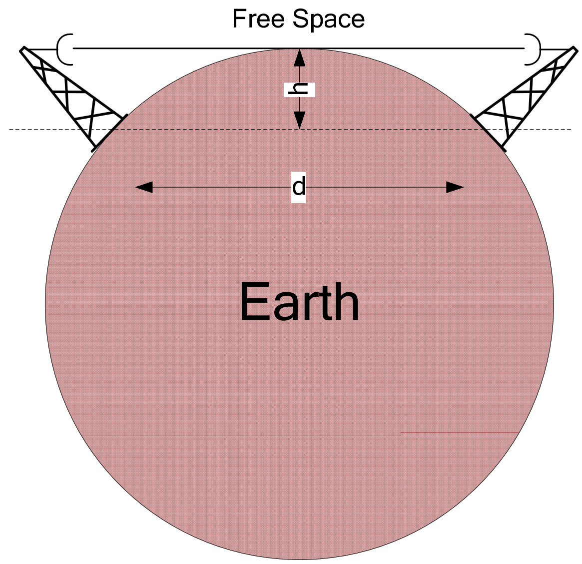
$$h = 0.02d^2 \text{ , h-meter, d-kilometers}$$

If the towers are too separated the bulge starts to block the First Fresnel Zone (FFZ). It is important to mention that the earth is not a perfect sphere. It tends to be flatter towards the poles. So, the bulge will be slightly less for a link in the poles compared to another one in the equator. The average earth radius is 6,371km.

Example1:

What would be the maximum distance that (2) two 30.5m (100 ft) towers can be separated without interfering the FFZ? The radius of the FFZ is 0m (a ray) and a free space medium is considered.

Let us represent the situation,



$$h = 0.02d^2$$

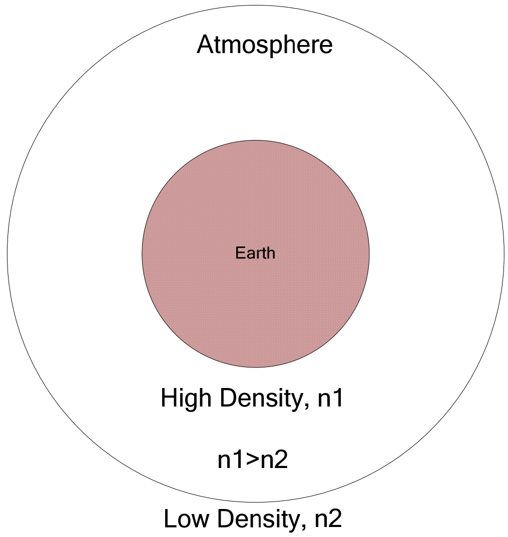
$$d = \sqrt{50\,h}$$

$$d = \sqrt{(50)(30.5)}$$

$$d = 39\ km = 24\ \ miles$$

Note: Towers can be considered to be parallel because their height (~h) is much smaller than d.

Is the previous result correct? Yes, in a way. Because it is known that earth surface microwave links can reach longer distances even when the towers are not in the line of sight (LOS). How does it happen? Well, the reason is that the medium where the microwave propagates is not the free space. It is the air. Air in the atmosphere change its density as represented below.



Thus, the refraction index (n) will also chance. As a consequence, a ray sent from one antenna tends to follow the earth surface. It is a very small variation, but sufficient to help microwave engineers to reach unseen sites. The end result is that the earth can be considered a little bit flatter. The bulge of the earth for a standard atmosphere can now be calculated:

$h = 0.015d^2$, h-meter, d-kilometers

Note: The phenomenon when k tends to zero is known as sub-refraction and when k tends to infinite is known as super-refraction.

Example2:

What would be the maximum distance that (2) two 30.5m (100 ft) towers can be separated without interfering the FFZ? The radius of the FFZ is 0m (a ray) and a standard atmosphere is considered.

$$h = 0.015d^2$$

$$d = \sqrt{66.66\,h}$$

$$d = \sqrt{(66.66)(30.5)}$$

$$d = 45\ km = 28\ \ miles$$

Now, the reach is longer thanks to the help of the atmosphere.

Ufff, I am almost done and not tell you where k=1.33 comes from. Well, that's because it is firstly important to understand what I explained up to this point. Let's get the famous number,

$$k = \frac{0.02}{0.015} = 1.33$$

Another way to interpret the k factor is imagining the earth radius 33% bigger. So, if the radius is bigger the earth looks flatter. A value of k tending to infinity means the earth looks flatter. A Value of k tending to zero means the earth looks rounder. It is very beneficial to have the k value for the area where the link is deployed to obtain the most accurate results. However, if it is not available k=1.33 (standard atmosphere) should be used.