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Chapter 1 : Antennas and Amplifiers for Long Distance Wireless Communications - Robots For Roboticists

Fresnel zone: D is the distance between the transmitter and the receiver; r is the radius of the first Fresnel zone (n=1) at point P. P is d1 away from the transmitter, and d2 away from the receiver.

Significance[edit] In any wave-propagated transmission between a transmitter and receiver, some amount of the radiated wave propagates off-axis not on the line-of-sight path between transmitter and receiver. This can then reflect off of objects and then radiate to the receiver. However, the direct-path wave and the reflected-path wave may be out of phase , leading to destructive interference when the phase difference is a half-integer multiple of the period. The nth Fresnel zone is defined as the locus of points in 3D space such that a 2-segment path from the transmitter to the receiver that reflects off a point on that surface will be n half-wavelengths out of phase with the straight-line path. These will be ellipsoids with foci at the transmitter and receiver. In order to ensure limited interference, such transmission paths are designed with a certain clearance distance determined by a Fresnel-zone analysis. The extreme variations of signal strength at the receiver can cause interruptions in the communications link, or even prevent a signal from being received at all. Fresnel zones are seen in optics , radio communications , electrodynamics , seismology , acoustics , gravitational radiation , and other situations involving the radiation of waves and multipath propagation. Fresnel zone computations are used to anticipate obstacle clearances required when designing highly directive systems such as microwave parabolic antenna systems. Although intuitively, line-of-sight between transmitter and receiver seems to be all that is required for a strong antenna system, because of to the complex nature of radio waves, obstructions within the first Fresnel zone can cause significant weakness, even if those obstructions are not blocking the line-of-sight signal path. For this reason, it is valuable to do a calculation of the size of the 1st, or primary, Fresnel zone for a given antenna system. Doing this will enable the antenna installer to decide if an obstacle, such as a tree, is going to make a significant impact on signal strength. Spatial structure[edit] First Fresnel zone avoidance Fresnel zones are confocal prolate ellipsoidal shaped regions in space e. The first region includes the ellipsoidal space which the direct line-of-sight signal passes through. The effect regarding phase-shift alone will be minimal. Therefore, this bounced signal can potentially result in having a positive impact on the receiver, as it is receiving a stronger signal than it would have without the deflection, and the additional signal will potentially be mostly in-phase. However, the positive attributes of this deflection also depends on the polarization of the signal relative to the object see the section on polarization below. The 2nd region surrounds the 1st region but excludes the first region. Generally this is unfavorable. But again, this depends on polarization explained below. The 3rd region surrounds the 2nd region and deflected waves captured by the receiver will have the same effect as a wave in the 1st region. A wave deflected from this region has the potential to be shifted precisely one wavelength so that it is exactly in sync with the line-of-sight wave when it arrives at the receiving antenna. The 4th region surrounds the 3rd region and is similar to the 2nd region. If unobstructed and in a perfect environment, radio waves will travel in a relatively straight line from the transmitter to the receiver. But if there are reflective surfaces that interact with a stray transmitted wave, such as bodies of water, smooth terrain, roof tops, sides of buildings, etc. Sometimes this results in the counter-intuitive finding that reducing the height of an antenna increases the signal-to-noise ratio at the receiver. Although radio waves generally travel in a straight line, fog and even humidity can cause some of the signal in certain frequencies to scatter or bend before reaching the receiver. This means that objects that are clear of the line of sight path will still potentially block parts of the signal. To maximize signal strength, one needs to minimize the effect of obstruction loss by removing obstacles from both the direct radio frequency line of sight RF LoS line and also the area around it within the primary Fresnel zone. The strongest signals are on the direct line between transmitter and receiver and always lie in the first Fresnel zone. In the early 19th century, French scientist Augustin-Jean Fresnel discovered a method to calculate where the zones are â€” that is, whether a given obstacle will cause mostly in-phase or mostly out-of-phase deflections between the transmitter and the receiver. Polarization[edit] As explained earlier, the Fresnel zone can be used to determine whether the bounced signal will be received in-phase or out-of-phase, but the transmitted polarization of a radio-frequency RF signal can greatly influence what actually happens at the receiving end of the transmission. Regarding polarization, an RF signal can be transmitted in different ways. Linear polarization â€" the sine wave moves on a plane Vertical polarization â€" the sine wave moves on a vertical plane Horizontal polarization â€" the sine wave moves on a horizontal plane Circular polarization â€" the sine wave moves in a tight three-dimensional helix as it leaves the transmitting antenna RHCP right-hand circular polarization â€" the sine wave moves clockwise as it leaves the transmitter LHCP left-hand circular polarization â€" the sine wave moves counter-clockwise If a signal is vertically polarized and it deflects off a horizontal object such as a flat roof, and then bounces up to a receiving antenna, and if the roof is within the 1st region of the Fresnel zone, the resulting signal will be inverted relative to the original signal. This means the high points of the sine wave are now low points, and vice versa. Hence, even though one would expect minimal change in phase in the first Fresnel region, the bounced signal will arrive out-of-phase, which will weaken the received signal. So, the installer of the antenna system must take this into consideration and either move the transmitting antenna, receiving antenna, or both, to minimize or remove the interfering roof-deflected phase-shifted signal. Or, the installer can increase the height of either one or both the transmitting and receiving antenna so that the object roof that is deflecting the signal is in the 2nd region rather than the 1st the inverted signal would behave as if it was right side up by the time it reached the receiver because of to the half-wave phase shift in region 2. Or, the installer can simply change the polarization to horizontal. If a signal is horizontally polarized and it deflects off a horizontal object such as a flat roof, and then bounces up to a receiving antenna, and if the roof is within the 1st region of the Fresnel zone, the resulting signal will be received favorably - as it will be in-phase. The left and right extremes of the sine wave will not be negatively impacted by the deflection of the roof. In fact, this will result in a stronger signal than if there was no deflection. For an analogy to more easily understand the differences in deflected vertically and horizontally polarized signals, place a mirror on the floor in the middle of a room. Have somebody hold a flashlight on the other side of the room. The flashlight represents a signal and your eyes are the receiver. The mirror represents a flat roof within region 1 of the Fresnel zone. Have the flashlight move up and down representing vertical polarization. Note that in the mirror, the flashlight moves in the opposite direction, that is, it moves down and up rather than up and down. Now have the flashlight move to the left and right representing horizontal polarization. If you look in the mirror, the reflected image of the flashlight moves exactly in tandem with the actual flashlight. Left is left, right is right. For example, a RHCP signal that hits a street, or a wall, or anything else, then becomes a LHCP signal, and is therefore invisible to the RHCP receiving antenna, regardless of whether it arrives at the receiver in-phase or out-of-phase. But the same logic regarding polarization and its effects applies to the 2nd region, 3rd region, and so forth. Fresnel zone clearance[edit] Several examples of how Fresnel zones can be disrupted Fresnel Zone clearance is in regards to the natural bending of waves, rather than the deflection of waves as discussed above. Although the waves are bending rather than bouncing, the impact upon the receiving antenna can be severe enough that it requires the consideration of the Fresnel Zones. 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.

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Chapter 2 : Fresnel Zone Antennas - Y. Jay Guo, Stephen K. Barton - Google Books

Fresnel zone antennas are reflector antennas that focus the signal by using the phase shifting property of the antenna surface, rather than its shape. There are three type of Fresnel zone antennas, namely, Fresnel zone plate, offset Fresnel zone plate antennas and phase correcting reflective array or "Reflectarray" antennas.

Antennas and Amplifiers for Long Distance Wireless Communications by David Kohanbash on February 13, Hi all This is just a quick post on how to increase the range of your wireless communication system. There are several ways to do it and they mostly apply no matter what frequency you are using. We will discuss several ways to do this below. We will also discuss some of the legal limits for how powerful your system can be. You can use tools such as the Ubiquiti Airview or OmniWiFi to view how strong your signal is and what signals are in view. Or you can use less advanced software tools that use your computers wireless card. Ways to boost your signal Loss Reduction The simplest way is to reduce the loss in your system. This is often from two sources; the cables and the connectors. Cables â€" Try to use the lowest loss cable that you can use. Typically the lower the loss in the cable, the more it will cost, and the thicker and less flexible the cable will be. Connectors â€" Minimize the number of connectors that you use and avoid using adapters to change connector types. Each connector and adapter interface represents a signal loss called an insertion loss in the final output. A general rule is that every connection of the same type ex. Clean your connectors â€" A common problem that most people ignore is cleaning the threads and inside of the connectors. The best way to clean the connectors is with denatured alcohol isopropyl alcohol can also be used but it leaves a film behind which is not ideal and cotton swabs often called Qtips. Be careful not to bend any pins! Antenna The next way to increase your range, is to use an antenna with an increased gain. You can get omnidirectional antennas with different gains that transmit in a torus pattern they do not transmit directly above or below the antenna. As the gain increases the height of the torus transmission pattern decreases, however the range diameter of the torus increases. You can also consider a directional antenna for increased range. These antennas focus the RF energy in a specific direction to extend the range. As with the omnidirectional antennas as the gain increases the directionality of the antenna increases for a tighter window. If the directional antenna is not pointed perfectly in the right direction communications will suffer. The other thing that helps antennas a lot is increasing the height and avoiding obstacles in the line-of-site LOS path between the antennas. If you can increase the height and avoid breaking LOS you can get a much better signal. When you determine LOS you need to remember the Fresnel zone. The Fresnel zone is an area above and below the LOS line that should be clear for maximum radio transmission quality, however it is not always possible for that area to be completely free from obstruction. P is d1 away from the transmitter and d2 away from the receiver, lambda is the signal wavelength in meters from wikipedia. The easier way to figure out the center diameter of the fresnel zone for 2 aligned antennas is: This is often one of the most effective ways to increase power. The downside is that you need to provide more power for the amplification as opposed to just using an antenna with a higher gain. As a general rule as the operating frequency decreases, the range increases and you get better obstacle penetration. As the frequency increases you get a higher bandwidth more data , and a smaller antenna. Legal Limits There are also legal limits for how much power you can output and what frequencies you can operate on. Frequency Limits The standard frequencies for open use are known as the industrial, scientific and medical ISM bands. These bands can be used freely as long as you do not interfere with other devices. Some other parts of the world have spectrum put aside with similar performance.

Chapter 3 : Proxim Wireless -Calculations,Definition: Fresnel Clearance Zone

The Fresnel zone is a long ellipsoid that stretches between the two antennas. The first Fresnel zone is such that the difference between the direct path (AB in the figure below) and an indirect path that touches a single point on the border of the Fresnel zone (ACB) is half the wavelength.

Fresnel zone calculation This program is an applet for calculating the Fresnel zone. A particularly common problem with radio systems is communication errors. The occurrence of communication errors changes significantly depending on the method of placement of the radio equipment. With radio communication, it is important to ensure "line of sight" between the transceivers. When we can see the receiving antenna we use the expression "line of sight" without much thought, but with radio waves, it can be said that "line of sight" is only achieved when the Fresnel zone indicated below is established. With radio systems used at about 1. If operation of the equipment is unstable, it is necessary to consider whether the fixed station can be set up in a higher place. Viewed on a temporal basis, assessment of the receive data is performed in the middle position of the receive bit width, and in terms of level, the bit is determined to be 1 or 0 by whether the received voltage of the median value threshold value is bigger or smaller. This identified signal is the signal after FSK demodulation. Because the signal and noise are a composite waveform to begin with, if the difference between the signal level and noise level inside the receiver is low, with certain sampling timing, since the decision is made with a waveform in which the threshold value is exceeded due to noise, an error results. Therefore in general, the signal level is required to be about 20 dB times the voltage ratio greater than the level of noise. FSK radio equipment is immune to the influence of amplitude noise, but if there is an obstruction between the antennas the ground, buildings, natural objects and so on , the radio waves will be reflected resulting in multipath interference. At the receiving point, the composite wave incorporating the delayed radio waves is distorted in amplitude, resulting in an error. In addition, the ratio of the noise component of signals that enter the demodulation circuit in a location with weak electric field intensity is high in relation to the signal, and this causes errors. Of course, signals generated by the antenna due to external noise will also have an impact on amplitude and frequency. Fresnel zone In order for radio waves emitted from the transmitter to reach the receiver without attenuation of power, a certain amount of space is required. The energy cannot reach the receiver via one straight line in space. It is easy to understand for example that the waves will not get there through a hole the size of a needle in a concrete wall. The space required is a spheroid with its center along the shortest distance between antennas, and this is called the Fresnel zone. In fact this space expands indefinitely, but the part that principally contributes to communicating the energy is called the 1st Fresnel zone. If there are obstacles inside the Fresnel zone, insufficient energy is transmitted so that received field intensity becomes weak. If the received field intensity is weak, the probability that errors will occur becomes gradually higher. The receive sensitivity of the receiver is absolute, and propagation loss which depends on the distance traveled by the radio waves cannot be avoided. Therefore in order to prevent errors from occurring, it is important to ensure that the received radio waves are as close as possible to the theoretical value.

Chapter 4 : Wireless Calculators | Radio Frequency Propagation | www.nxgvision.com

Radio frequency line of sight is defined by Fresnel Zones which are ellipse shaped areas between any two radio antennas. This calculator calculates the radius of the Fresnel Zone at its widest point. The distance between the two radio antennas and the frequency of operation are required to compute the radius of the Fresnel Zone.

This feature introduces some new problems to the analysis of offset Fresnel zone plate antennas. The formulae and algorithms for predicting the radiation pattern of an offset Fresnel lens antenna are presented in [4], where some experimental results are also reported. Although a simple Fresnel lens antenna has low efficiency, it serves as a very attractive indoor candidate when a large window or an electrically transparent wall is available. In the application of direct broadcasting services DBS , for example, an offset Fresnel lens can be produced by simply painting a zonal pattern on a window glass or a blind with conducting material. The satellite signal passing through the transparent zones is then collected by using an indoor feed. To increase the efficiency of Fresnel zone plate antennas, one can divide each Fresnel zone into several sub-zones, such as quarter-wave sub-zones, and provide an appropriate phase shift in each of them, thus resulting in a sub-zone phase correcting zone plate [5]. The problem with dielectric based zone plate lens antenna is that whilst a dielectric is providing a phase shift to the transmitted wave, it inevitably reflects some of the energy back, so the efficiency of such a lens is limited. However, the low efficiency problem for a zone plate reflector is less severe, as total reflection can achieved by using a conducting reflector behind the zone plate. Based on the focal field analysis, it is demonstrated that high efficiency zone plate reflectors can be obtained by employing the multilayer phase correcting technique, which is to use a number of dielectric slabs of low permittivity and print different metallic zonal patterns on the different interfaces. The design and experiments of circular and offset multilayer phase correcting zone plate reflectors were presented in [5]. A problem with the multilayer zone plate reflector is the complexity introduced, which might offset the advantage of using Fresnel zone plate antennas. One solution is to print an inhomogeneous array of conducting elements on a grounded dielectric plate, thus leading to the so-called single-layer printed flat reflector [2]. This configuration bears much in common with the printed array antenna but it requires the use of a feed antenna instead of a corporate feed network. In contract to the normal array antenna, the array elements are different and are arranged in a pseudo-periodic manner. The theory and design method of single layer printed flat reflectors incorporating conducting rings and experimental results on such an antenna operating in the X-band were given in [2]. Naturally, this leads to a more general antenna concept, the phase correcting reflective array. A phase correcting reflective array consists of an array of phase shifting elements illuminated by a feed placed at the focal point. The word "reflective" refers to the fact that each phase shifting element reflects back the energy in the incident wave with an appropriate phase shift. The phase shifting elements can be passive or active. Each phase shifting element can be designed to either produce a phase shift which is equal to that required at the element centre, or provide some quantised phase shifting values. Although the former does not seem to be commercially attractive, the latter proved to be practical antenna configuration. One potential advantage is that such an array can be reconfigured by changing the positions of the elements to produce different radiation patterns. A systematic theory of the phase efficiency of passive phase correcting array antennas and experimental results on an X-band prototype were reported in [3]. In recent years, it became common to call this type of antennas "reflectarrays". Reference phase modulation[edit] It has been shown that the phase of the main lobe of a zone plate follows its reference phase, a constant path length or phase added to the formula for the zones, but that the phase of the side lobes is much less sensitive.

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Chapter 5 : Fresnel Zones In Wireless Links Zone Plate Lenses And Antennas PDF

This This book book is is a a research research monograph monograph on on Fresnel Fresnel zone zone antennas. antennas. It It covers covers various various lens lens and and reflector reflector antennas antennas based based on on the the Fresnel Fresnel zone zone concept concept and and phase phase correction correction techniques. techniques.

We provide a free Fresnel Zone Calculator to assist with this section. When radio waves encounter an obstacle such as a tree, a building, or even a hill , some of the signal energy is lost trying to penetrate the object. Some will bounce, scattering seemingly at random. Worse, the effects of bounce may vary depending upon weather for example, wet leaves absorb more signal than dry leaves. Thus, if it all possible, it is desirable to have a clear line-of-sight between your transmitter and receiver. An easy way to judge line-of-sight is to stand at the location of the transmitter, and look towards the receiver. If you can see it â€" you have line-of-sight. Line-of-sight by itself is not enough! Radio waves do not leave the transmitter in a perfectly narrow beam, and are not received from a single tiny point. Rather, radio waves are emitted in a cone, and received across the surface of the antenna. The angle of the cone varies by transmitter and antenna. For example, the PowerBeam boasts a degree emission cone, as do the large Rocket Dishes in practice, the Rocket Dishes have the smaller cones; a good rule of thumb is that the larger the dish, the more focused the beam can be. NanoStations cover a degree cone. Sector antennas, by their very nature, can cover a degree or degree cone. Omnidirectional antennas are a special case, in that they are designed to beam in all directions at once: The result is two cones facing one another. We can ignore the portions that will completely miss the other end-point, and instead focus on the areas of useful signal. This results in a radio-signal pattern in the air that strongly resembles an airship: There are in fact multiple Fresnel zones surrounding any given link, referred to as the first, second, third, etc. You can calculate the diameter of a Fresnel zone for a given link as follows: Fresnel Zone Radius Function The rule-of-thumb for wireless links is that sixty percent of the first Fresnel zone must be clear of obstructions if a great link is to be established. Therefore, for a ten kilometer link at 5. The Fresnel formula also provides some interesting insight into frequencies, and their usefulness over long distances. If we plot the size of Fresnel zones for each of the major frequency bands, over a distance ranging from one to fifty kilometers, we get the following: This graph shows an interesting property of the Fresnel-zone: This is important to remember: The good news is that very few people calculate Fresnel zones by hand. Like most of the parts of this section, there are calculators online to assist you. Radio Mobile, covered in detail later in this book, also provides excellent assistance in determining if your links have sufficient Fresnel clearance. It is worth noting that Mhz Fresnel zones are enormous. It is very difficult to raise an antenna sufficiently to provide a clear Fresnel zone for a link in this frequency. The exact extent to which you need Fresnel-zone clearance is a topic of some debate amongst wireless operators. Theory helps, but occasionally Mother Nature still surprises even the smartest of us. If you like this book, please consider making a donation to the author, Herbert Wolverson.

Chapter 6 : Fresnel zone - Wikipedia

*Fresnel Zone Antennas [Y. Jay Guo, Stephen K. Barton] on www.nxgvision.com *FREE* shipping on qualifying offers. Written by leading experts in the field, this book is a research monograph on Fresnel zone antennas.*

Chapter 7 : Wireless Bridging and the Fresnel Zone

*The formula for determining the radius of the widest point of the fresnel zone (in feet) is: * square root of (d/4f) where d is the distance (in miles) between the two antennas and f is the frequency (in GHz) at which you are transmitting.*

Chapter 8 : Fresnel zone antenna - Wikipedia

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Abstract In this talk, we review the historic development of Fresnel zone antennas and reflectarrays. The strong relationships between these two antennas are discussed.

Chapter 9 : RF Fundaments Chapter 4: Fresnel Zones and Line-of-Sight

Thus the Fresnel zone pattern may result from illumination "by the Fresnel field of the signal source if the dimensions of the signal source are comparable to those of the antenna under test.