Beamforming

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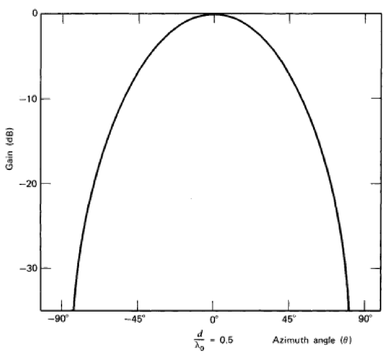
Abstract

Beamforming is a versatile processing technique for transmitting or receipting of a desired signal on an array of antenna elements. This is an attempt to have a better result of antenna connection then the latest version of beamforming. This performance beamforming is to simulate a large antenna that can be electrically steered using a set of smaller antennas. This is a better way of getting faster connection and sending more data in faster speed. This project is going to include the observation angel, single isolated element, and hamming. With this project we are going to use MATLAB to show the results we get in this project.

Introduction

Beamforming works when an access point antenna transmits to a group of subscribers it generates a beam in a specific shape to cover those subscribers. The shape of the beam is determined by the amount of gain the access point antenna has in various directions. The higher the gain the further the beam reaches in that direction. Signal energy is sent from the access point to the antenna in this shape. Access point to the antenna in this shape with all subscribers within the shape receiving signal energy from the access point antenna. The subscribers use narrower beam widths to transmit signals to the access point. When the access point antenna is receiving data from the subscribers it is listening for signals within the same beam shape as when it is transmitting. When the beams of the subscriber and access point intersect the access point can hear the subscriber receiving its data. This means that signals at the same frequency as the access point and subscribers that enter the access point antenna beam shape can interfere with signals from subscribers causing data loss. For beamforming, we use a lot of formulas to get the result for the overall array. To achieve beamforming, we need to use sensors to activate the array. When the array is activated, you will see a graph like shown bellow of how the beamforming of 1 sensors will be showing.



Background

Antenna beamforming is a type of radio frequency (RF) management in which a wireless signal is directed toward a specific receiving device. This helps transfer information with reducing latency on the internet. With this project we are going to use MATLAB program to learn how to use the Beamforming and we are also going to add simulation with graphs to see the response.

Problem

The focus of the project is to make the beamforming more efficient without downstream. When the beams of the subscriber and access point intersect the access point can hear the subscriber receiving its data. This means that signals at the same frequency as the access point and subscribers that enter the access point antenna beam shape can interfere with signals from subscribers causing data loss.

Methodology

Under the assumption that all element patterns are identical, the array radiation pattern in the far field can be found by using the pattern multiplication principle,

$$E(\theta) = E_0(\theta)F_A(\theta) \quad (1)$$

$$F_{A(\theta)=\sum_{n=1}^{N} V_n^{inc}(\delta)e^{jnkdsin\theta}} \quad (2)$$

where

$$V_n^{inc}(\delta) = a_n e^{-jnkdsin\theta_0} = a_n e^{-jn\delta} \quad (3)$$

As follows from (2), for arbitrary array scanning angle $\theta_U \in \theta$, the array factor maximum, $max\ F_A(\theta) = F_A(\theta_0)$, can be achieved by forming appropriate $V_N^{inc}(\delta), n = 1,2,\dots,N$,

$-90^{\theta} \geq \theta \geq 90^{\theta}$

Via adjusting corresponding weighting coefficients as

$$w_n(\delta) = e^{-jnkd\ sin\theta_0} \quad (4)$$

Substituting (3) to (2)

$$F_A(\theta) = \sum_{n=1}^{N} a_n e^{jnkd(u-u_0)} \quad (5)$$

Combining (1), and (2), the resulting array pattern.

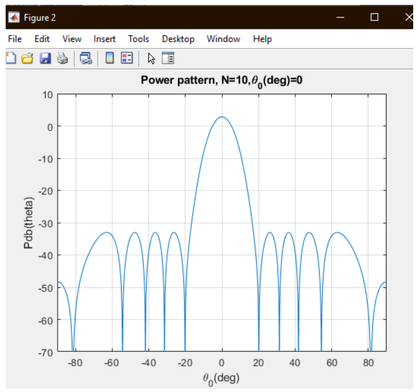
$$E(\theta) = E_0(\theta)\sum_{n=1}^{N} V_v^{inc}(\delta)e^{jnkdu} \quad (6)$$

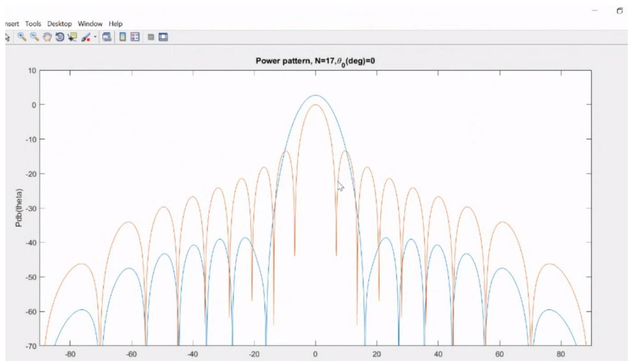
Therefore, substituting (7) in (1) and squaring the magnitudes of both sides yields the array power pattern.

$$|E(\theta)|^2 = E_0(\theta)xN^2\frac{sinc^2(\frac{Nkd(u-u_0)}{2})}{sinc^2(\frac{kdu}{2})} \quad (7)$$

Results and Discussion

This graph is a perfect example of beamforming. In the figure bellow you can see the plot of G(θ) for this two elements. There is a two-element array beam pattern shown in second graph shown bellow. This plot is made by adding this formula in MATLAB $G(\theta)(decibels) = 10log_{10}\{\frac{|A(\theta)|^2}{4}\}$. This formula will normalize the direction of pattern in decibels for the two elements. If you can see in all the figures there is a principal lobe having a beamwidth of 60 degrees off broadside. This occurs because at that sensor elements the direction of arrival has a signal wavefront must travel exactly in $\frac{2}{\gamma 0}$ between all the sensors. It is seen that as the number of elements increases the main lobe beamwidth decreases and the number of sidelobes and pattern nulls increases. To illustrate how elements spacing affects the directional pattern for a seven-element linear array in a azimuth plane. This is interesting because you will imagine that adding more elements will be better but is the opposite. The reason why this happens to antennas is because the beamwidth decreases and the signals that are sending will decrease and will not get far enough as it supposes to. That's why we implement more antennas in close range so the 5G connection will be better in every section of the location of the 5G antenna.





Conclusion

I figure out that beamforming is not just a simple calculation, and it will convert the entire process into the antenna, if not it will take multiple steps to end up making the antenna array as strong as it is in today's day. Beamforming will be better in the passing years when we would have better antennas and better technology. Without beamforming, we would have the internet speed that we have in today's life. I also notice that with antennas array between more sensors they are in the antenna the better the range of connection every device is going to have. You cannot implement 40 sensors to an antenna for the reason that it will not work out as it is supposed to. Because if you have multiple buildings in-between places you can not just implement one antenna array and have it jumping from one side to another. In conclusion, beamforming is bringing the future to a better place by implementing faster internet connection to the devices and getting everybody connected to each other.

Future Work

This project fulfilled the purpose of demonstrating that WP2, being the most secure of all network protocols, can be vulnerable and cracked. Most importantly, the results of this project serve as inspiration and open new opportunity in research and investigation in newer protocols being in develop like WP3 and that will be the new standard in a near future. We are living in a world that just one single vulnerability is all an attacker needs.

Acknowledgements

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