DESIGN AND SIMULATION OF 2x2 MIMO SYSTEM AND ANTENNA USING MATLAB

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Abstract - *Transmission of radio signal through the air is the basic form of wireless communication, but the noise present in the medium through which the signal is transmitted cause serious damage to the signal and results in errors in the transmitted signal. Noise is universal, it cannot be eliminated but can be avoided up to some extent. By using the MIMO system we can achieve a better form of communication, which has lower BER.*

As a part of our project, we have designed and simulation the MIMO system using MATLAB. In this project we came to know that MIMO has lower BER (Bit Error Rate) compared to other systems. We also designed the diverse antenna and studied its radiation patterns, correlation coefficients, active Impedance, etc. In this paper, we are going to explaining the design and simulation of the MIMO system and Antenna

***Key Words*: MIMO (Multiple Inputs and Multiple Outputs), SISO (Single Input and Single Output), SIMO (Single Input and Multiple Outputs), MISO (Multiple Inputs and Single Output), Multipath Propagation, Signal Fading, Spatial multiplexing, Correlation, Channel, Alamouti Code, Space Time Block Code (STBC), Bit Error Rate(BER), Signal to Noise ratio(SNR), Constructive Interference, Destructive Interference, Errors, Antenna, Diverse of Antennas, Dipole Antenna, Patch Antenna, Radiation Pattern, Impedance.**

1. INTRODUCTION

1.1 Wireless Communication Errors

Wireless Communication has become a critical part of human life and made most of the electronic devices used for communication portable by replacing the old wire set up with an antenna system that ensures wireless communication. In the wired communication, the transmitted signal will not be affected by the noise as compared to wireless communication, because additional noise sources become exponentially greater in wireless communication. The major noise sources in wireless communications are Unwanted Signal interference, Human interference, and Multipath propagation caused by signal Scattering.

Multipath propagation is a phenomenon where the signal travels along multiple different paths from a transmitter to reach the receiver antenna. The main reason for multipath propagation is the reflection, refraction, and scattering of the radio signal from various objects like buildings and mountains.

The multipath propagation of radio signal has various components (let's say radio echoes) as shown in the figure below. It has a direct signal and a reflected signal (reflected from the different objects). These various components interfere at the receivers at different phases (May also be in the same phase), this phase change is caused by different propagation paths. Such inference of different phase radio signal results in the fading of signal.

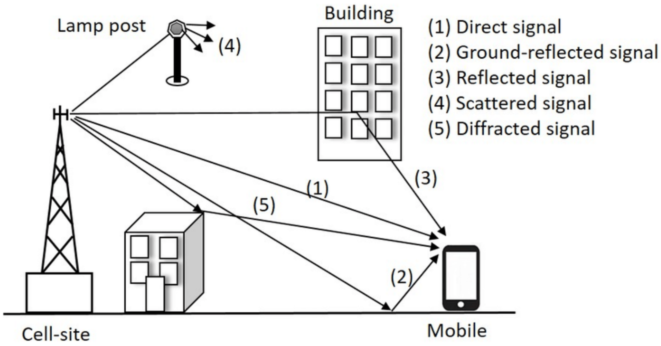

Fig 1: Multipath propagation

The multipath propagation results in various interference of signal, like constructive interference and destructive interference. If the multipath signal has reached the receiver at the same phase (both signals are in phase) this leads to the addition of signal strength which results in amplification of signal strength, this phenomenon is called constructive interference, this is the most desired form of interference, but this phenomenon has less possibility of occurrence due to random nature of multipath propagation of the signal. Most of the radio components reach the receiver at different phases this leads to suppression of amplitude of the resulting signal which causes the degradation of the signal strength and finally signal Fading, this phenomenon is called Destructive interference. Destructive interference is the most undesired form of interference this causes the main problem in the communication system. This problem can be reduced by the MIMO system.

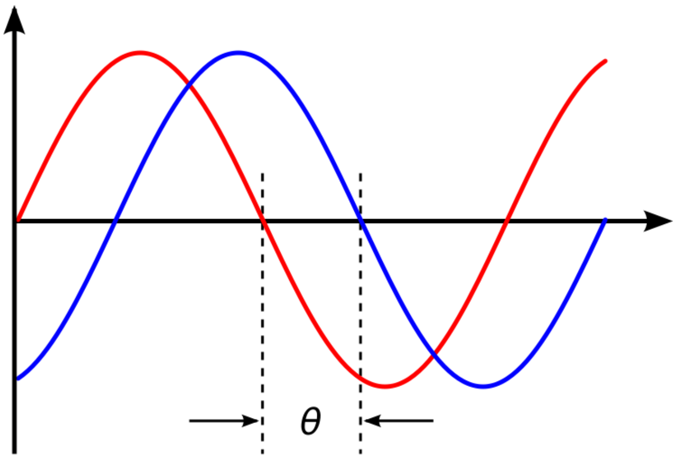

Fig 2: Interference of Signal

1.2 MIMO System

The main problem of wireless communication i.e., multipath propagation can be reduced by using the diversity of an antenna (multiple antenna or array of antenna) at either sides of communication (transmitter and receiver).

Let us consider the example of mobile phones, when we have a weak mobile signal, someone nearby can have a good mobile signal and that's because of different environment experiences, different fading characteristics (different radio echoes). So this is why moving our phones around will result in better signal strength.

Now consider placing another antenna at the receiver (R2) along with the initial receiver antenna (R1) which is separated by some distance. Consider R1 experiences, the fading coefficient H11, and R2 experience, the fading coefficient H12. If any one of the fading coefficients is 0(let's say H11=0), then R1 receives no signal, but still, R2 receives the signal, this means, to receive the signal at the receiver end, any one of the systems needs to be good. So this is how the fading of the signal can be eliminated, and this kind of system is called "SIMO" (Single Input and Multiple Outputs). If we increase the number of antennas then the fading can be eliminated.

But placing the multiple antenna at the receiver, will be much complex for the small portable devices. So consider the same case at the transmitter end, placing the multiple antennas at the transmitter i.e., T1 and T2, can results in nearly the same characteristics as that of SIMO. Multiple antennas at the "Base Station" (Transmitter) radiate the signal in different paths and each signal experiences different fading coefficients, now at the receiver, the signal can be received efficiently if any one of the transmitted signal experiences complete fading. This system is called "MISO" (Multiple Inputs and single Output). If we place multiple antennas at both receiver and transmitter end this will give more efficient reception of the signal, which leads to the MIMO system. The MIMO system is the combination of these both systems (SIMO and MISO), where we place multiple antennas at both receiver and transmitter end. This gives the combined effect of both SIMO and MISO systems. In the MIMO system the system can have MxN (M = No. Of transmitter antenna, N = No. of receiver antenna) combinations of fading coefficients, this leads to better reception of the signal and also ensure special multiplexing of the signal.

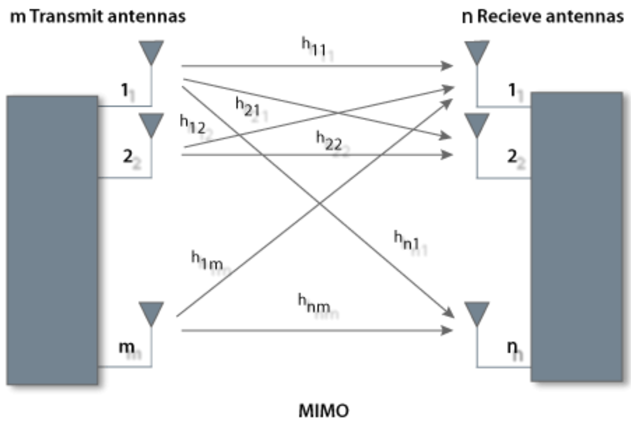

Fig 3: MxN MIMO system

2. SIMULATION OF 2x2 MIMO & ANTENNA

Simulation of comparisons of the different systems BER values is performed in MATLAB. In this work, we use two transmitter antenna and 2 receiver antenna, and to analyze the system BER to SNR graph, we generated a random binary signal and modulated it with BPSK (Binary phase shift keying) modulation scheme, this is achieved by the MATLAB inbuilt object. We encoded the signal by Space-Time Block Code, after that we created an AWNG channel and we transmitted the signal through it. Here the transmission of a signal refers to the multiplication of signal to channel variable. At the receiver end, we did the inverse function i.e., the demodulation and decoding of signal and then we compared it with the ideal signal.

We know that as the Signal to Noise ratio (SNR) increases when Bit Error Rate (BER) decreases. The below graph is the comparison of different systems.

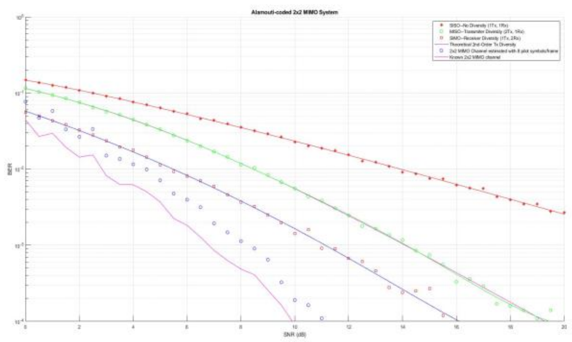

Fig 4: Comparison of BER to SNR of different system

In addition, we also design the antenna system for the MIMO system. We design the both Diverse Patch antenna and Diverse Dipole antenna and we compared them both.

The below figures shows the radiation pattern of the Diverse Dipole Antenna and Diverse Patch antenna along with their structures (Bottom left corner). The comparison of both antenna are also done, we came to know that the Dipole antenna has better gain compared to that of the Patch antenna. All the information is shown in the figures.

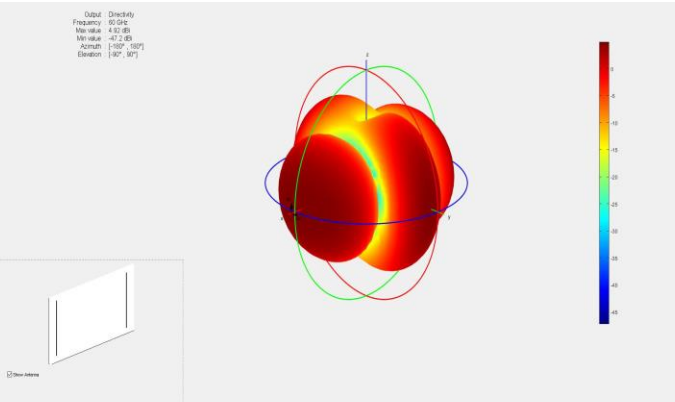

Fig 5: Radiation Pattern of Diverse Dipole Antenna

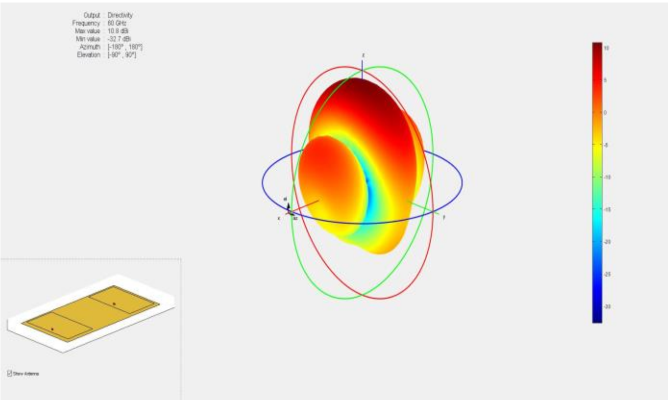

Fig 6: Radiation Pattern of Diverse Patch Antenna

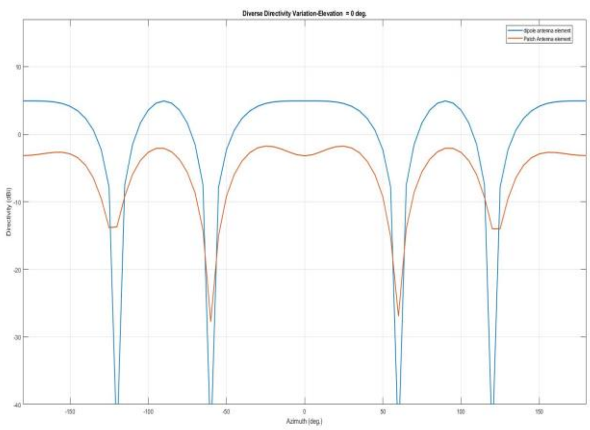

Fig 7: Comparison of Dipole and Patch antenna

Along with the radiation patterns, we also plotted the power transfer coefficient and reflection coefficient as a function of Frequency and also plotted correlation coefficient as a function of Polarization variation in the degree of one of the antenna. The power transfer coefficient shows how much power is radiated, and the frequency which we used is 60 GHz. At the centered frequency 60 GHz (with some error) the power transfer coefficient should be high for better transmission of the signal. We plotted the power transfer coefficient in the graph below, at the centered frequency the power transfer is high, but as the frequency changes the power transfer coefficient decreases. The reflection coefficient shows how much power is reflected back, this parameter should be low at the desired frequency for the best transmitter. As shown in the graph at centered frequency the reflection coefficient is low, and it climbs at the frequency changes.

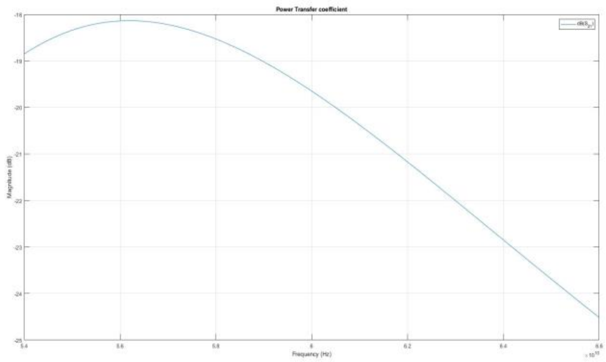

Fig 8: Power transfer coefficient variation with frequency

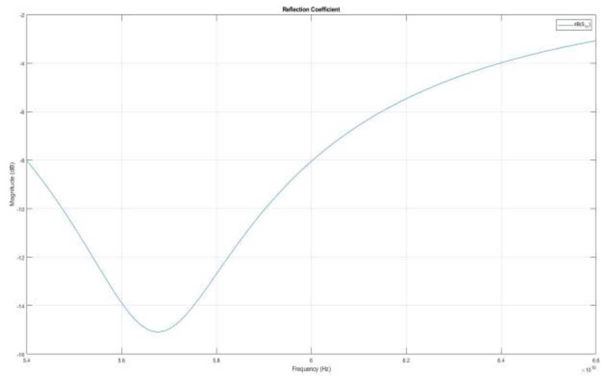

Fig 9: Reflection Coefficient variation with frequency

The Correlation coefficient is the relation between the radio signals input to the antenna ports in diverse antenna system. The graph shown below is the variation of the correlation coefficient as the function of the tilt in one of the dipole antenna. When both the antenna are in phase then we have a high correlation coefficient, but the angle varies the correlation decreases and finally, at 90 degrees the correlation is very minimum.

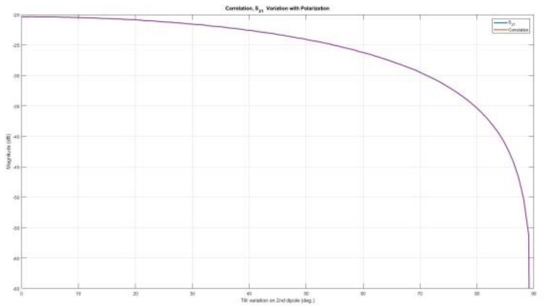

Fig 10: Correlation variation with tilt variation in the 2nd Dipole

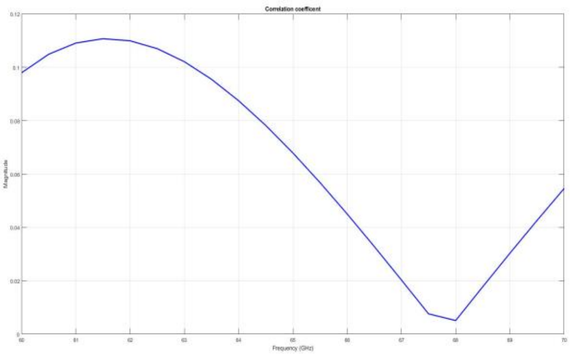

Fig 11: Correlation variation with Frequency

3. CONCLUSION

The MIMO system has better advantages over the traditional SISO system and other evolved SIMO and MISO systems. By using this system we can overcome the signal fading effects, along with that we can also achieve special multiplexing (transmission of multiple signals through the common channel). MIMO systems are currently in use, but in the case of portable devices, the system implant is a little complex. MIMO system will be a major step in 5G communications because of major signal fading problems associated with 5G communications.

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