Jamming Diversity

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ABSTRACT

This project involves designing and creating a device that will interfere with enemy signals to trigger an improvised explosive device (IED) through the broadcasting of white noise. This jamming signal encounters Rayleigh fading which causes deep fades in the signal strength. The deep fades allow potential IED signals to get through. By using multiple antennas this system attempts to overcome the fading and also maintain a constant, strong jamming signal. Rayleigh fading is a model of how a signal propagates when there is no direct line of sight between the transmitter and receiver. While our results may have been inconclusive, the four antenna plot appears to have less fading characteristics than the others despite the number of level crossings. It shows potential for future effectiveness.

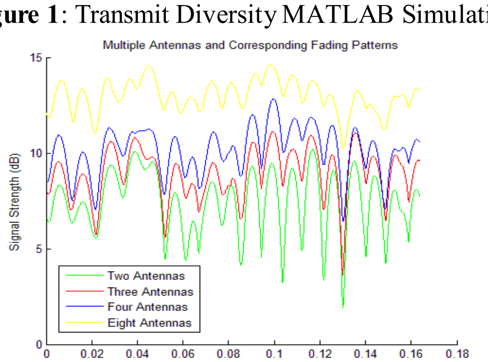
INTRODUCTION

A popular insurgent tactic in Iraq and Afghanistan is the employment of improvised explosive devices (IED). To combat this tactic, American forces utilize jamming to disrupt the trigger signal for the IED. The jamming signal must be emitted by the American vehicles while they travel. The jamming signal will naturally encounter fading in the form of Rayleigh fading. A way to prevent fading is needed to ensure successful jamming.

METHODOLOGY

We simulated using multiple antennas in MATLAB to gauge the impact on signal strength. We simulated using 1, 2, 3, and 4 antennas to determine if the number of antennas helped alleviate the signal strength. From the simulation we verified that more antennas helped the signal strength and we chose to use four antennas.

Figure 1: Transmit Diversity MATLAB Simulation



We had four antennas at an operating frequency of 900 MHz. The antennas were placed a certain distance apart based on their wavelength. Due to size constraints of the robot that we used as a test vehicle, the antennas were placed at the corners of a rectangular skirt, with dimensions 1 meter by 2 meters, mounted on the robot.

Figure 2: Robot with Mount with Antennas

First, we measured the signal strength radiated by each antenna. Each antenna emitted approximately 2 dBm, resulting in constant signal strength. After that we measured the received signal strength when the robot-mounted array was driven down a long hallway for 45 seconds. We attempted to drive in straight line and maintain the same speed. We initially placed the receiver at a point in the hallway where the robot was beyond line-of-sight. We obtained fading results using 1, 2, 3, and 4 antennas through the use of a spectrum analyzer. When using less than four antennas, we employed 50 Ohm dummy loads to prevent the emission of a signal from the inactive antenna.

RESULTS

The results that we obtained from our field tests were inconclusive. We predicted that the number of fades would decrease with an increase in the number of active antennas – illustrating the effects of transmit diversity. However, when analyzing our four plots, we discovered that despite our predictions, there were more fades present when the number of antennas was increased.

Figure 3: Fading Plot with One Antenna

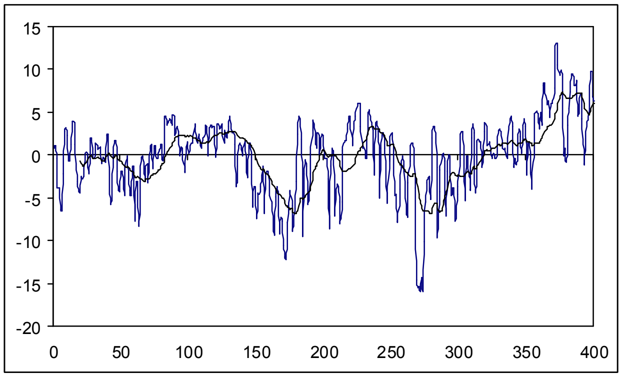


Figure 4: Fading Plot with Two Antennas

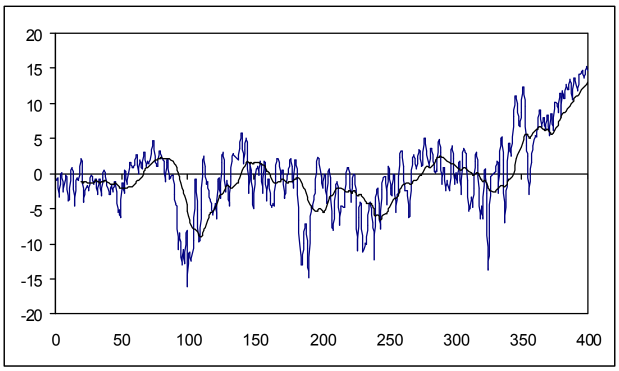


Figure 5: Fading Plot with Three Antennas

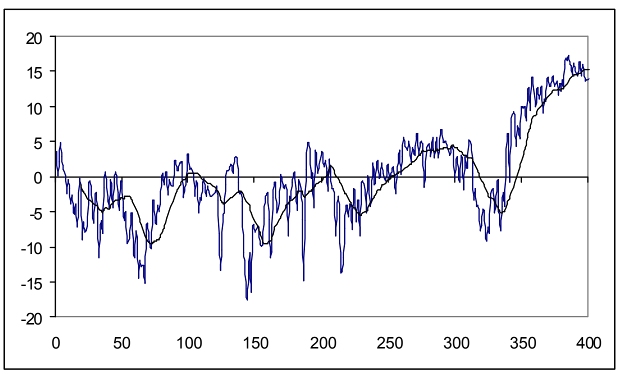


Figure 6: Fading Plot with Four Antennas

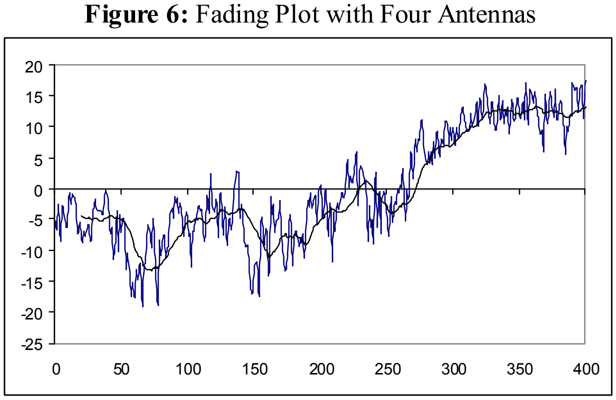


Table 1: Summary of Fading Results Below Thresholds

#Antennas	3dB	6dB	10dB
1	23	17	9
2	30	19	2
3	27	21	8
4	32	33	12

The number of fades below thresholds of 3dB, 6dB, and 10dB for each antenna scenario showed no trend or pattern, giving us no concrete conclusion. From comparing our fading patterns with their moving averages, we were able to see an overall trend and more constant signal strength when using four antennas.

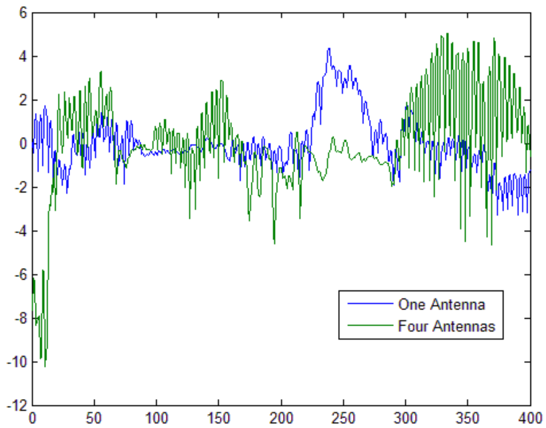
DISCUSSION

This error in outcome can be attributed to several factors:

- **Hallway Architecture**
  The hallway was not a good scattering environment, and there were objects in the hallway.
- **Human Interference**
  There were often other people walking around that we could control. These people could have affected the signal to an unknown degree.
- **Inability to Drive Straight**
  The exact performance of the robot could not be replicated for every trial. We tried to approximate the same course and speed, with varying results.
- **Distance**
  As the robot drove past the receiver, the distance constantly changed. Because of this, the signal strength gradually increased as distance lessened between the robot and the receiver, impacting our results.
- **Vibration**
  During testing, the mount vibrated impacting the received signal strength.

To assess the full effect of the vibration of the skirt when the robot was in motion, we simulated movement of the skirt and recorded the corresponding power losses. We took this data into account when recording our received power levels, noting that they were lower than predicted due to this vibration-induced power loss.

Figure 7: Effects of Vibration on Received Signal



For future research and testing, we would conduct further tests in a richer scattering environment where there would be fewer interruptions in our testing location. This would allow for better results. Another thing we would change is the frequency of our antennas, which would allow us to have them further apart on the mount. We would design a more stable mounting system to reduce vibration.

CONCLUSIONS

While our results may have been inconclusive, the four antenna plot appears to have less fading characteristics than the others despite the number of level crossings. These results show that given a better testing environment, the use of transmit diversity can help maintain signal strength. However, these inconclusive results require more controlled testing. This system could easily be employed in Iraq and Afghanistan. Antennas could be placed on a humvee or tank in order to take advantage of transmit diversity. Those vehicles would be large enough to potentially utilize more than four antennas.

ACKNOWLEDGMENTS

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REFERENCES

[1] T. Rappaport, *Wireless Commnications: Principles and Practice*, Prentice Hall, Upper Saddle River, NJ, 2002.