

WIRELESS AND MOBILE COMMUNICATION
IMPLEMENTATION AND ANALYSIS OF
FEEDBACK DIVERSITY USING MATLAB
SIMULINK

CONTENTS

1. Introduction
2. Theoretical Background
 - 2.1. Fundamentals
 - 2.2. Channel Impairments
 - 2.3. Diversity Techniques
 - 2.4. Feedback Diversity
 - 2.5. SISO Systems
 - 2.6. Quantization
 - 2.7. Moving Average Filter
3. Design and Implementation
4. Results and Analysis
5. Discussion and Conclusion

1. INTRODUCTION

Wireless communication systems face numerous challenges, including multipath fading, noise, and interference which can degrade signal quality and reliability. This feedback diversity is one of the technique to address this issues.

This report presents the implementation and analysis of a feedback diversity using MATLAB Simulink.

2. THEORETICAL BACKGROUND

2.1 FUNDAMENTALS

Wireless communications systems transmit information through the space using electromagnetic waves. This system includes basic components to transmit information. Such as,

1. Transmitter – generates and modulates the signal
2. Channel – the medium through which the signal propagates
3. Receiver – detects and demodulates the received signal

During the transmission process, signals are subjected to various impairments that can affect their quality and reliability.

2.2 CHANNEL IMPAIRMENTS

1. Multipath fading

Multipath fading occurs when a signal takes multiple paths from the transmitter to the receiver due to reflection, refraction, and scattering. It will result in multiple copies of the signal arriving at the receiver with different delays, amplitudes, and phases. The Rayleigh fading model is used to describe multipath fading in environments where there is no line-of-sight path between the transmitter and receiver.

2.Additive White Gaussian Noise (AWGN)

It's a noise model. It adds white noise with a constant spectral density and a Gaussian distribution of amplitude to the signal passing through the signal.

2.3 DIVERSITY TECHNIQUES

Diversity techniques aim to improve signal quality and reliability of a system by using two or more communication channels with different characteristics.

Common diversity techniques

1. Spatial diversity – using multiple antennas
2. Time diversity – transmitting same information at different time intervals
3. Frequency diversity – transmitting same information on different frequency bands.
4. Polarization diversity – using different polarizations of electromagnetic waves.

2.4 FEEDBACK DIVERSITY

Feedback diversity is a one of the reception methods of spatial diversity. It's an adaptive technique where the information about the channel conditions back to the transmitter. The transmitter then uses this feedback to adjust its transmission parameters.

Advantages:

- Improved signal quality
- Enhanced spectral efficiency
- Reduced power consumption
- Increased system capacity
- Simple to implement

2.5 SISO SYSTEMS

SISO systems use one transmit antenna and one receive antenna. While simpler to implement, SISO systems are more susceptible to fading and interference compared to multiple antenna systems.

2.6 QUANTIZATION

It involves converting a continuous amplitude signal to a discrete amplitude signal. This process is essential for digital communication but here it introduces quantization noise.

2.7 MOVING AVERAGE FILTER

It's a simple low pass filter used for smoothing time series data. It operates by creating a series of averages of different subsets of the full data set, helping to reduce the impact of random variations in the signal.

3.DESIGN AND IMPLEMENTATION

The feedback diversity system was implemented using MATLAB Simulink.

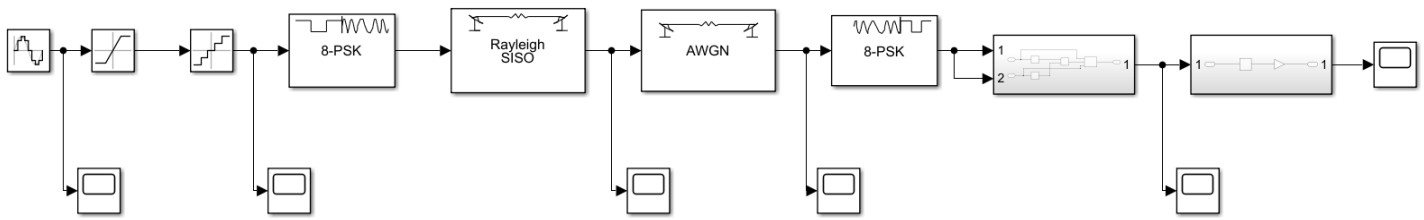


Figure 01: Simulink model for Feedback Diversity

The model consists of the following main components.

1. **Signal generation**

A sine wave generator was used as the input signal source. This simple waveform allows for easy visualization and analysis of the system's effects on the signal.

2. **Quantization**

The continuous sine wave was passed through a quantizer to convert it into discrete levels. This step simulates analog to digital conversion process in digital communication systems.

3. **Channel modeling**

Two channel models were implemented to simulate here.

I. **Rayleigh SISO Channel**

This block simulates the effects of multipath fading in a SISO system. It applies Rayleigh fading to the signal, causing variations in amplitude and phase over time.

II. **AWGN Channel**

This block adds white Gaussian noise to the signal, simulating random noise present in wireless channels.

4. **Feedback Diversity Logic**

A custom Simulink block was created to implement the feedback diversity logic. This block analysis the channel conditions based on the received signal generates appropriate feedback to the transmitter.

5. **Moving Average Filter**

A moving average filter was applied to the output signal to smooth out rapid fluctuations of the overall signal.

4.RESULTS AND ANALYSIS

RESULTS FROM MATLAB SIMULINK

The system's performance was analyzed using multiple scope outputs at different stages.

1. **Sine wave output**

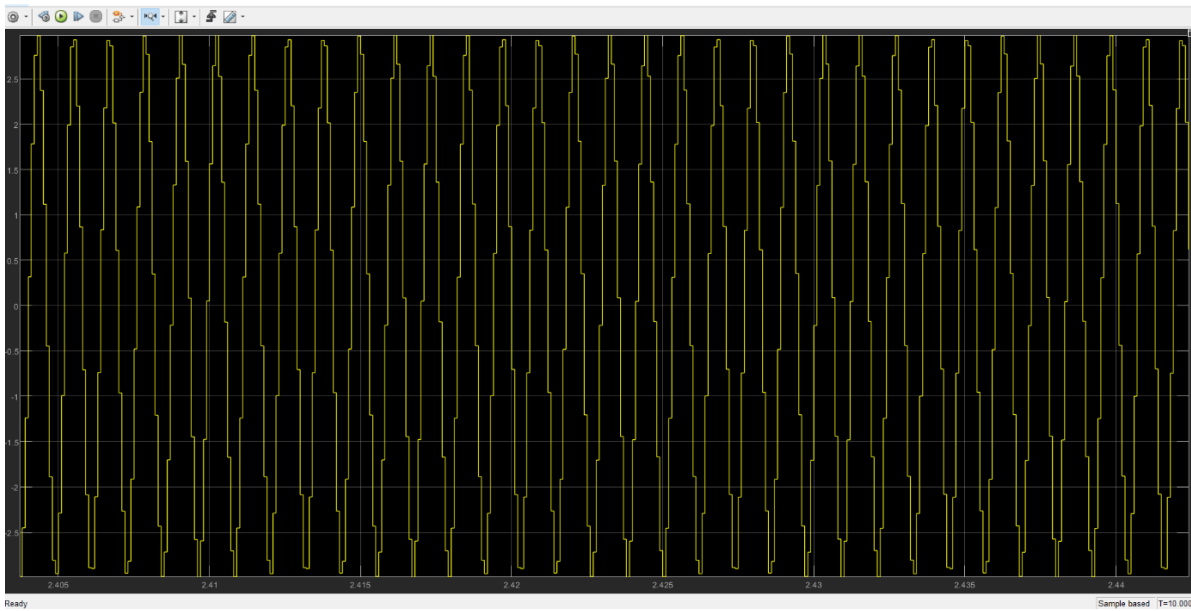


Figure 02: Output from sine wave input signal

- Output shows a input signal of sine wave
2. Quantizer output

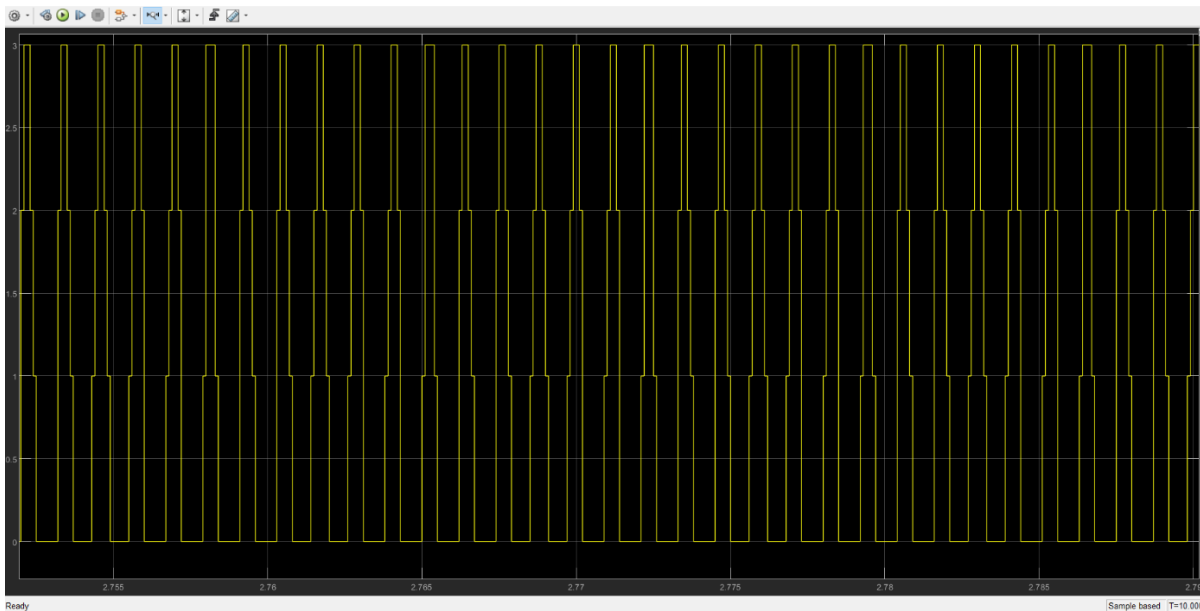


Figure 03: Output from Quantizer

- Output shows a stepped waveform, representing the quantized version of the input sine wave. This output demonstrates the discretization of the continuous input signal into distinct levels. The quantization process introduces some distortion to the original sine wave, visible as the stepped nature of the waveform.

3. Rayleigh SISO output

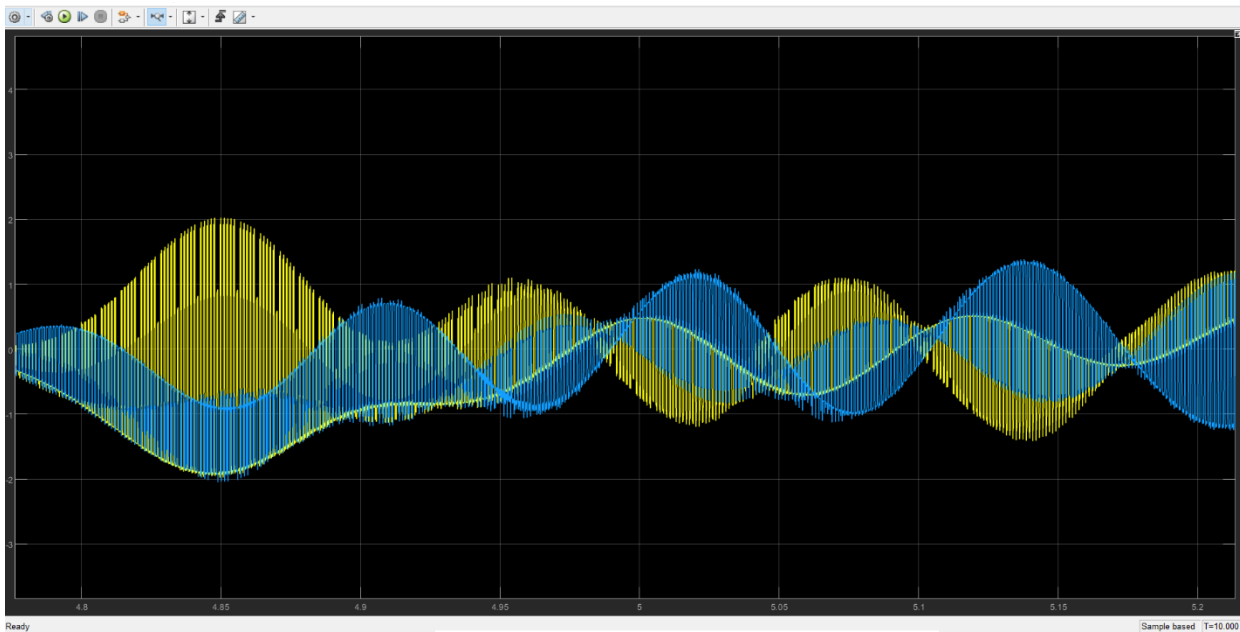


Figure 04: Output from Rayleigh SISO

- This scope output illustrates two overlapping sinusoidal waveforms with varying amplitudes. This output represents the signal before and after passing through the Rayleigh SISO channel, demonstrates the effects of multipath fading.

4. AWGN Channel output

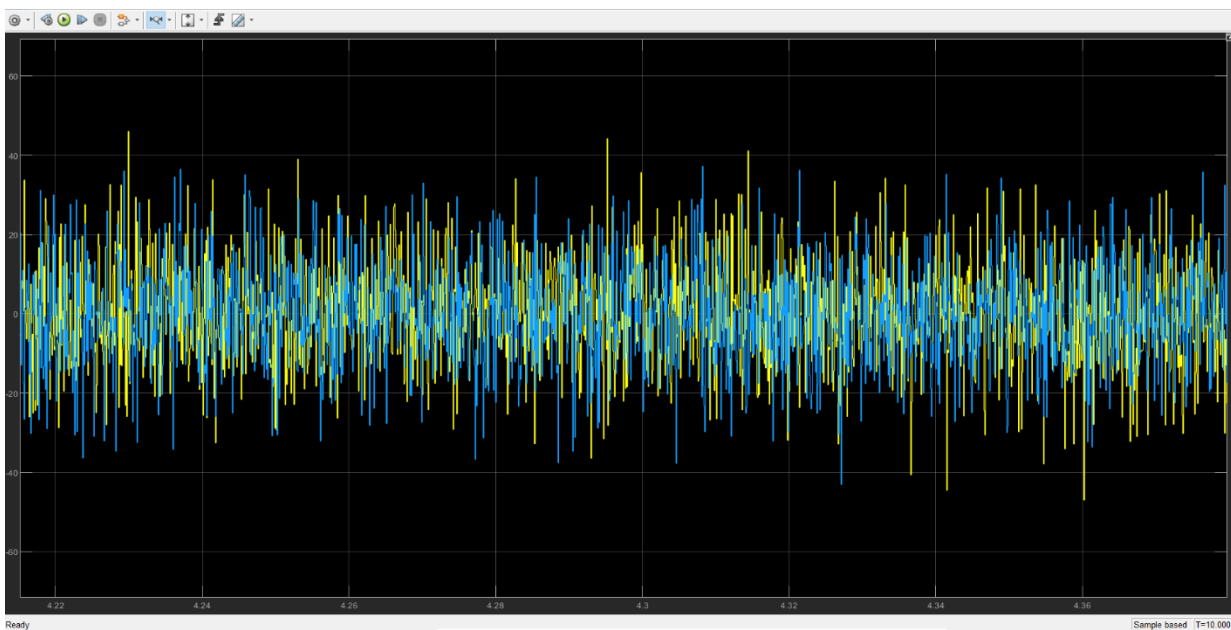


Figure 05: Output from AWGN channel

- This scope output shows a noisy, random signal with both positive and negative values. This output represents the signal after passing through the AWGN channel, demonstrating the added noise to the system.

5. Feedback diversity logic output

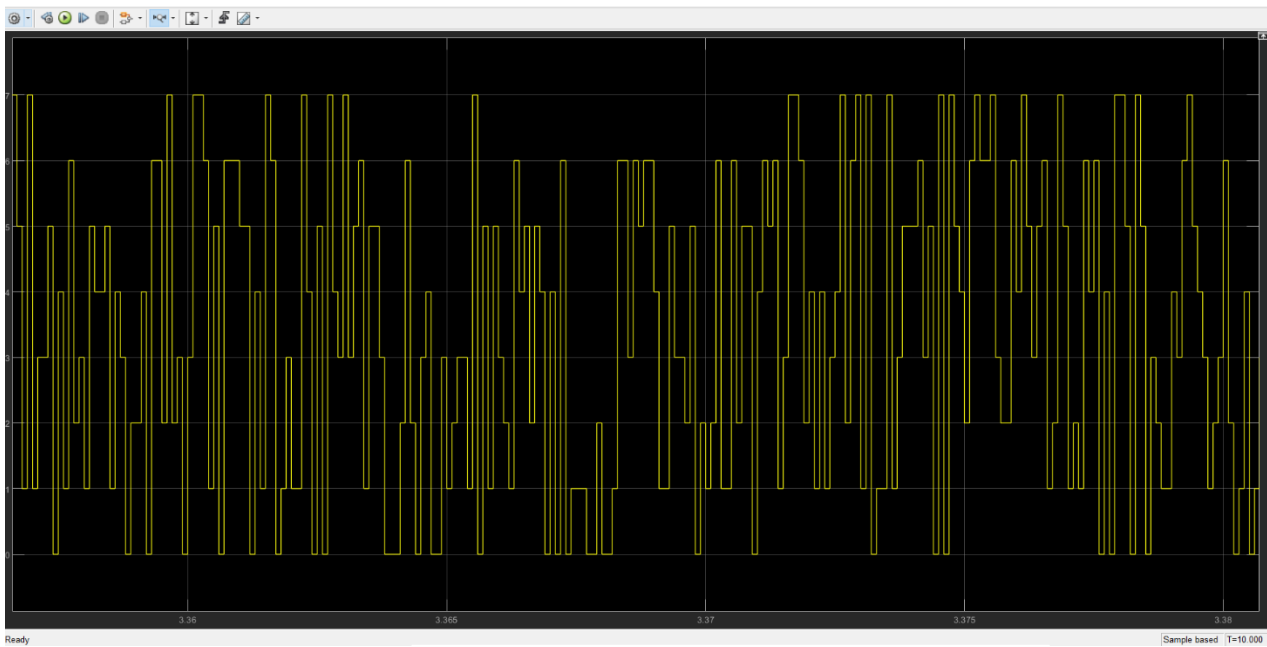


Figure 06: Output from feedback diversity logic

- This output shows a stepped waveform similar to the quantizer output, but with different characteristics. This represents the output of the feedback diversity logic, showing how the signal has been adjusted based on channel feedback.

6. Moving average filter output

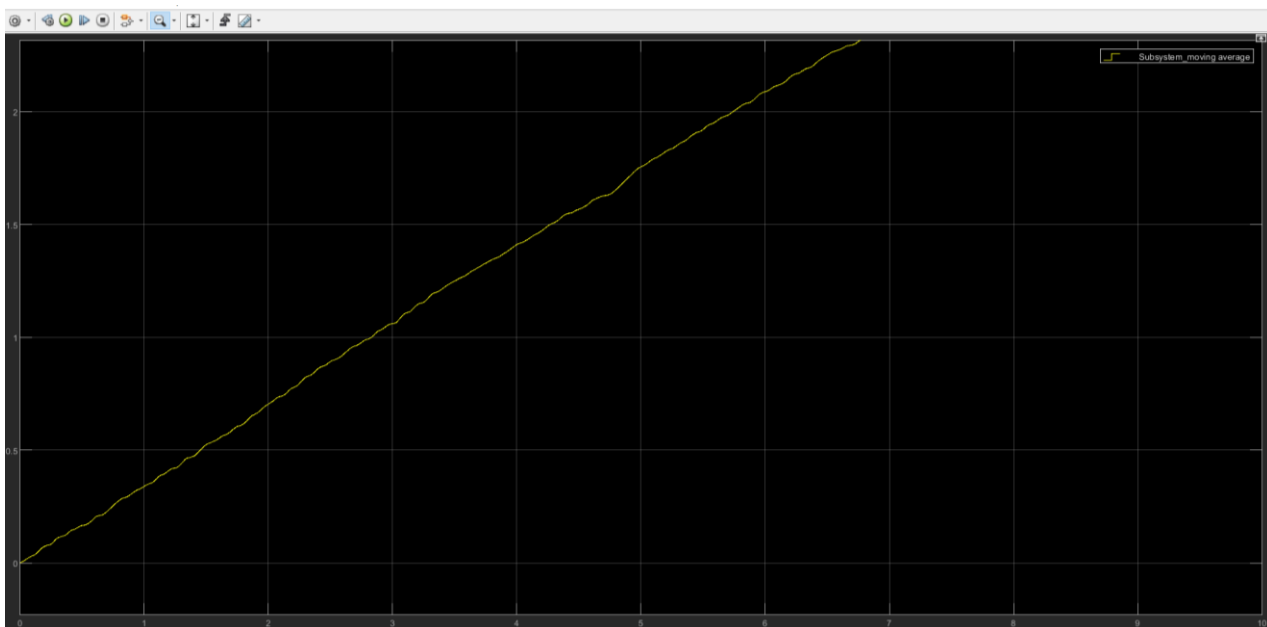


Figure 07: Output from Moving average filter

- The scope output shows increasing trend over time. The line is not perfectly smooth but exhibits small fluctuations, indicating some residual high frequency components.

RESULTS USING MATLAB CODE

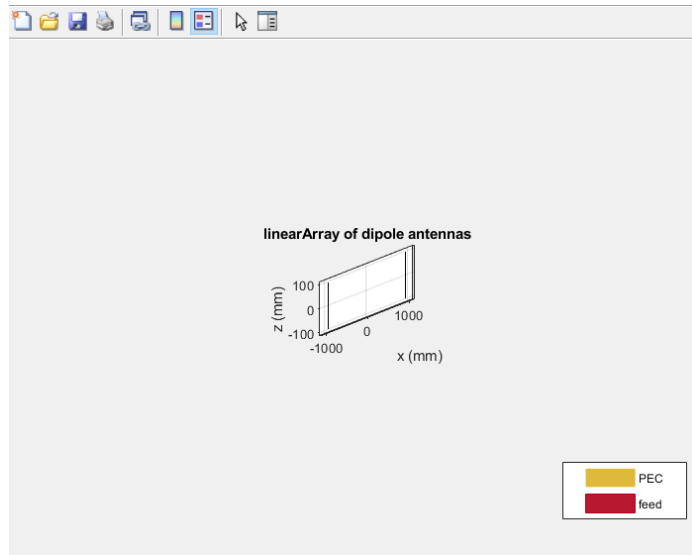


Figure 08: LinearArray of dipole antennas

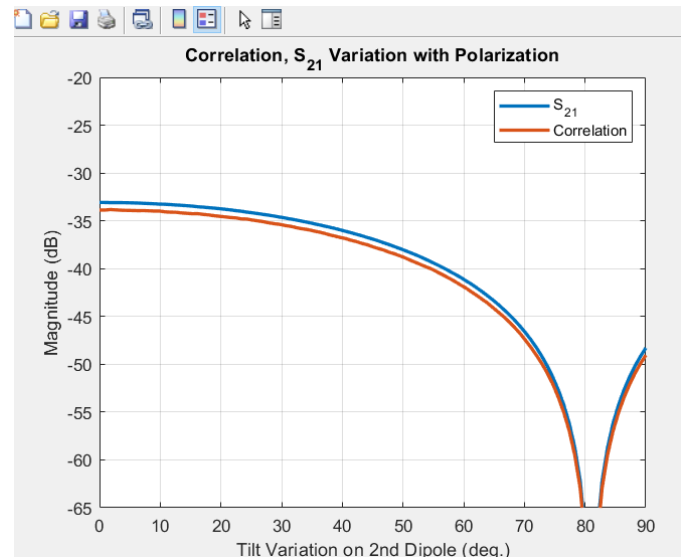


Figure 09: Correlation and S_{21} Vs Polarization

This image shows 3D representation of linear array of dipole antennas. This array is positioned in the x-z plane, spanning from -1000 to 1000 mm along the x-axis and -100 to 100 mm along the z-axis. This setup forms the basis of our diversity system.

Both S_{21} and correlation decrease as the tilt angle increases, indicating reduced coupling between antennas.

Optimal diversity is achieved at around 80 degrees tilt.

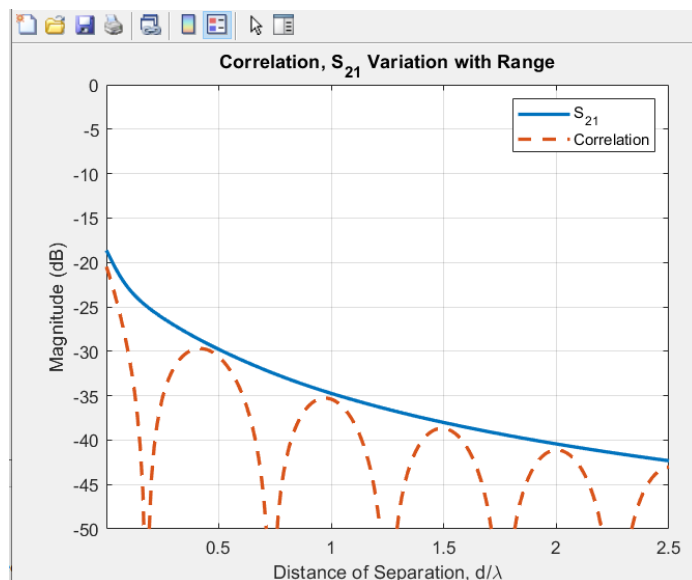


Figure 10: Correlation and S_{21} Vs Range

S_{21} steadily decreases with increased antenna separation.

Correlation oscillates but generally decreases with distance.

Periodic nulls in correlation indicate optimal separation distances.

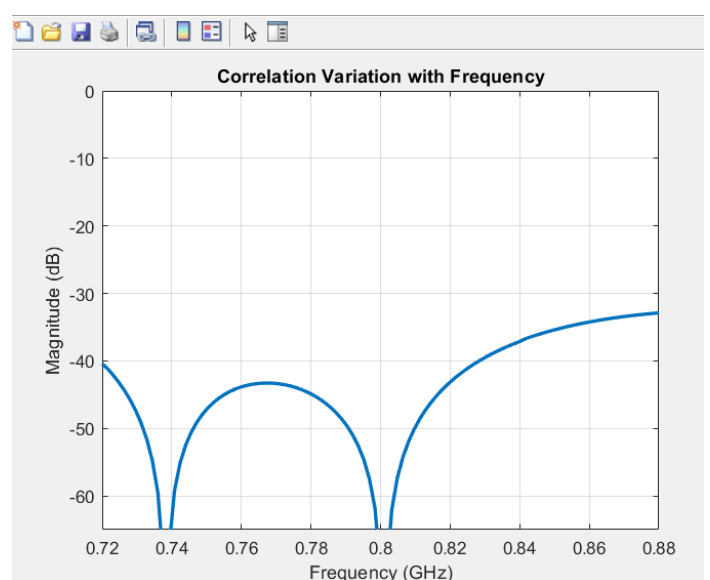
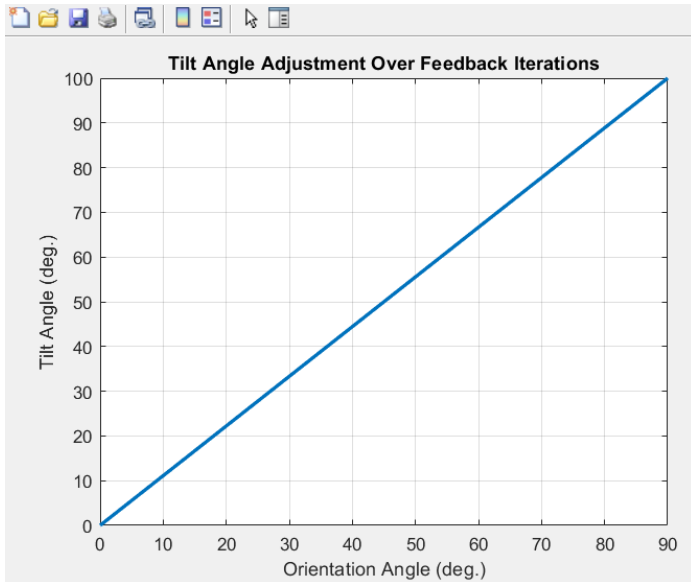


Figure 11: Correlation Vs Frequency

Two distinct nulls at approximately 0.74 GHz and 0.8 GHz, indicating frequencies of minimal correlation.



[Figure 12: Tilt angle adjustment over feedback iterations](#)

The tilt angle increases linearly from 0-100 degrees as the orientation angle increases from 0-90 degrees.

This suggests that our feedback system is adjusting the tilt angle proportionally to changes in orientation to maintain optimal diversity

5.DISCUSSION AND CONCLUSION

The feedback diversity system presented in this report leverages the spatial diversity of wireless channel to improve the overall system performance. By continuously monitoring channel conditions and adaptively selecting the optimal diversity branch, the system can maintain a more reliable and efficient.

the implemented Simulink model successfully demonstrates the concept and potential benefits of feedback diversity in wireless communication systems. By incorporating realistic channel impairments such as Rayleigh fading and AWGN, model provides challenges faced in wireless communication and how feedback diversity can help mitigate these issues.

The analysis of the scope outputs presents the effects of quantization, channel impairments, and the feedback diversity mechanism of the signal. The results show that feedback diversity is capable for improving signal quality and reliability.

From MATLAB code, results demonstrate that feedback diversity is effectively optimizing antenna parameters to minimize correlation and improve diversity performance. The linear adjustment of tilt angle in response to orientation changes indicates that feedback mechanism is working as intended, continuously adapting the array configuration to maintain diversity performance as conditions change.