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Enhancing Rain Fade Mitigation through Site Diversity Techniques in the Southern Tropical Region of India

S. Harika1*, S. Nagarjuna1, T.V. Naveen1, G. Sanjay Harshanth1 K.Ch. Sri Kavya2, Sarat K. Kotamraju2,

Koneru Lakshmaiah Education Foundation (KLEF), Vaddeswaram 522302, Andhra Pradesh, India

Abstract

In the pursuit of establishing a reliable microwave link connecting the Earth to satellites, especially in tropical regions and specific frequency bands, the persistent challenges posed by multipath propagation often give rise to fading phenomena. Fading, in this context, refers to the fluctuations in signal attenuation caused by various factors, including temporal variations, geographic positioning, and radio frequencies. As radio waves travel through the Earth's atmosphere, they encounter attenuation due to the presence of atmospheric constituents such as water vapor, raindrops, and ice particles. These elements absorb and scatter the radio waves, leading to the degradation of microwave link performance and a potential loss of signal strength. To address these issues, the Site Diversity Technique emerges as a promising solution among various Fade Mitigation Techniques.

Introduction

The transmission of radio waves through the Earth's atmosphere encounters a phenomenon known as attenuation, which stems from the presence of atmospheric particles, particularly moisture and raindrops. These particles absorb radio waves, leading to degradation in the performance of microwave links. To counteract these unwanted distortions and signal attenuation, various fade mitigation techniques are employed. These techniques offer a means to regulate the impact of attenuation on the system, ultimately preserving the quality of the communication link. A classification based on multipath parameters gives rise to the concept of Fade Mitigation techniques. These techniques are designed to minimize signal attenuation, thereby enhancing the overall performance of the communication system. This approach stands as a robust methodology, progressively reducing blurring and contributing to the advancement of high-rate information transmission. Fade mitigation techniques find application in multimedia services and aid in the effective management of congestion within traditional frequency bands like X, C, and Ku. Moreover, this approach holds significance for the execution and enhancement of connectivity within the Ka and V frequency bands. Along Earth-space paths, the propagation loss relative to free space loss encompasses not only attenuation from atmospheric gases but also the influence of raindrops, different forms of precipitation, and cloud cover. As the elevation angle surpasses 10 degrees, the gaseous components and rainfall have discernible effects on propagation characteristics. This comprehensive approach sheds light on the intricate interplay between atmospheric

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conditions, attenuation, and the deployment of fade mitigation techniques, enhancing our understanding of radio wave propagation in diverse scenarios."

Fade Mitigation Techniques

Frequency Diversity

Frequency diversity is the process of receiving a radio signal or components of a radio signal on multiple channels different frequencies or over a wide radio channel wide frequency band to reduce the effects of radio signal distortions such as signal fading that occur on one frequency component but do not occur or not as severe on another frequency component[1]. The signal is transmittedusing several frequency channels or spread over a wide spectrum that is affected by frequency-selective fading. Replicas sent in bands separated by at least the coherence bandwidth uncorrelated channels as two or more different frequencies experience different fading [2], at least one will have strong signal. Frequency diversity consumes extra bandwidth and sending information symbol each L symbol times. Only one symbol can be transmitted every delay spread [3]. When one tries to transmit images more as often as possible than the intelligence data transmission, entomb image impedance (ISI) happens. To attain least correlated carrier frequencies are separated by more than the one coherence bandwidth of the channel [4]. The goal is to create those carrier frequencies uncorrelated to each other so that there will not experience same fades. Certainly, if the channels are uncorrelated then the probability of simultaneous fading will be the product of individual fading probabilities.

Antenna diversity

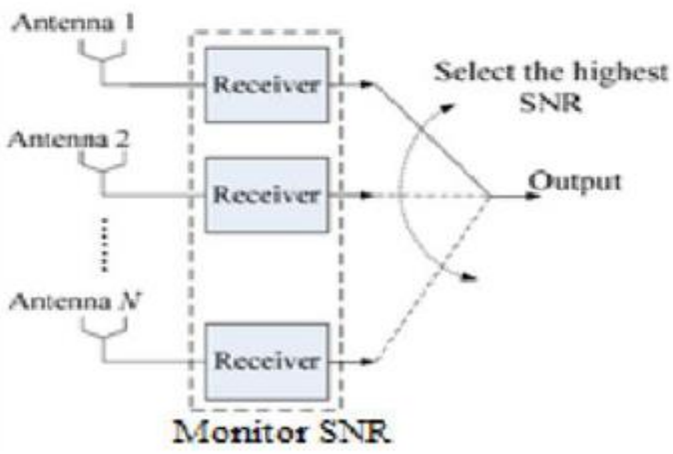

Fig. 1: Equal Gain Combining Technique

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2. Diversity Gain

The prediction of diversity gain (dB) in simplified method between the pair of sites can be calculated with the empirical expression [ITURP.618].

For the calculation of diversity gain the following parameters are required such as:

d: separation of two sites (km)

A: path change for a single site (dB)

f: frequency (GHz)

theta: elevation angle (degrees) .

ψ: azimuthal angle

Step 1: In step1 the calculation of gain by the spatial separation is obtained.

$Gd=a(1-e^{-bd})$

where:

a = 0 78 *A – 1 94 *(1 – e–0 11 *A)

b = 0 59 * (1 – e–0 1 *A)

Step 2: In step2 the calculation of gain which is contributed by frequency dependent is obtained from the equation shown. Gf = e–0 025 *f

Step 3: In step3 the calculation of gain in which elevation angle is shown.

G(theta) = 1 + 0 006 (theta)

Step 4: In step4 the calculation of gain term which base line dependent is obtained from the equation has shown.

Γψ= 1 + 0 002 (chi)

Step 5: Finally, In step5 the overall net diversity gain as the product is computed and that can be obtained from the equation shown, hence the diversity gain is calculated.

G = Gd * Gf * G(theta) * G(chi)dB

Therefore, this equation which is used to implement Gain diversity by initializing the input parameters and resultant is discussed in the results with proper specifications.

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Results

Table 1: Plotting Distance (km) and Gain Diversity (dB)

S.No	Distance (km)	Gain diversity
1	3	31.9
2	6	37.8
3	9	38.9
4	12	39.16
5	15	39.204
6	18	39.2116

Table 2: Plotting frequency (GHz) and Gain diversity (dB)

S.No	Frequency (GHz)	Gain diversity
1	25	39.2
2	30	46.4
3	35	53.6
4	40	60.3
5	45	67.5
6	50	74.45

Table 3: Plotting angle of elevation (degrees) and Gain diversity

S.No	Angle of Elevation (degrees)	Gain diversity
1	60	37.5
2	70	39.5
3	80	40.86
4	90	42.517
5	100	44.17
6	110	45.83

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Table 4: Plotting attenuation (dB) and Gain diversity (dB)

S.No	Attenuation (dB)	Gain diversity
1	30	39.2
2	35	46.4
3	40	53.6
4	45	60.6
5	50	67.57
6	55	74.4

3.1. The resultant graph is shown between Distance vs Gain Diversity:

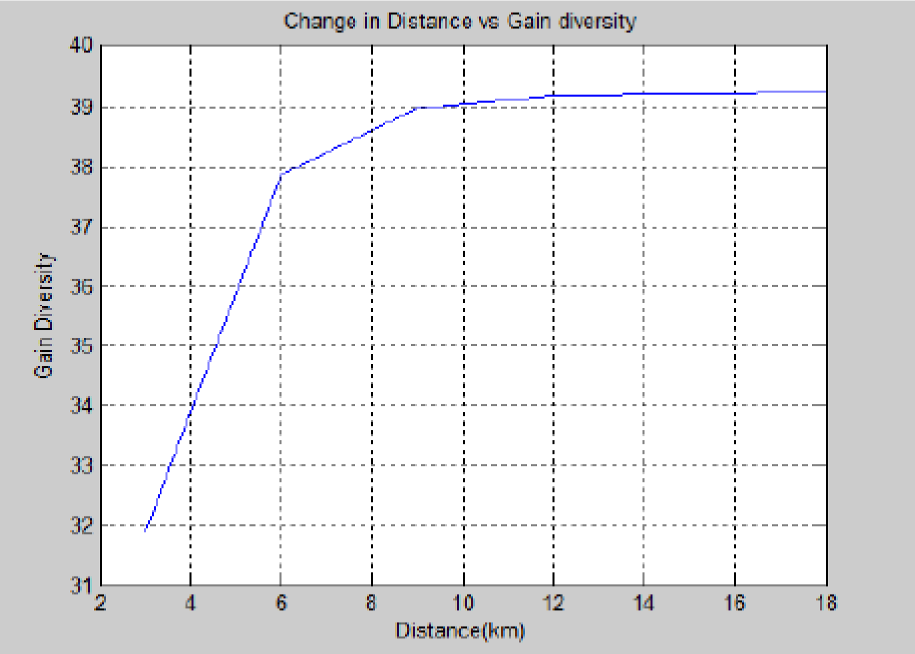

Fig. 2: Change in Distance (km) (i.e., from 3km to 18km) vs Gain Diversity (dB)

3.2. The resultant graph is shown between Frequency vs Gain Diversity:

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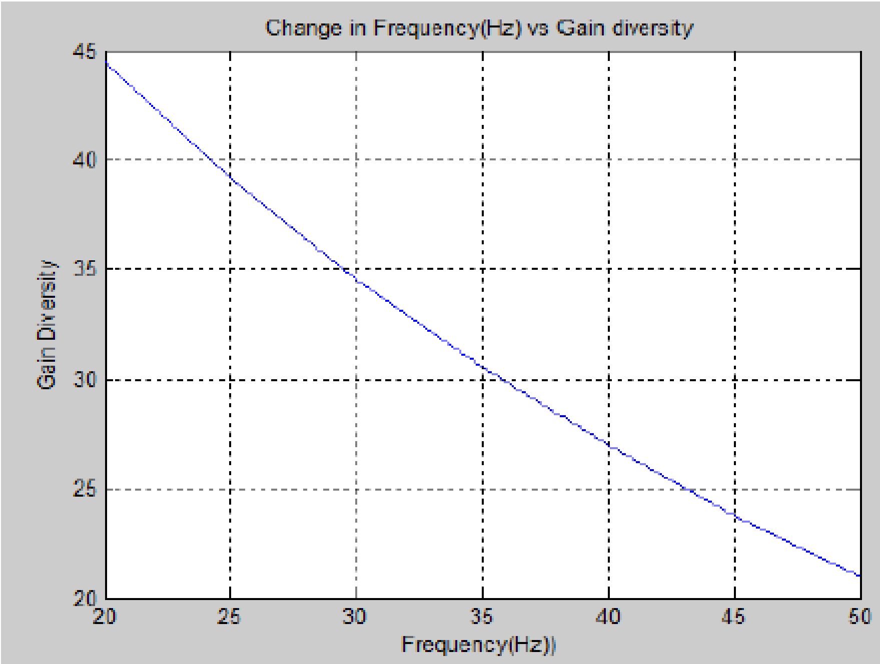

Fig. 3: Change in Frequency (GHz)(i.e., from 20GHz to50GHz) vs Gain Diversity(dB)

3.3. The resultant graph is shown between angle of elevation vs Gain Diversity:

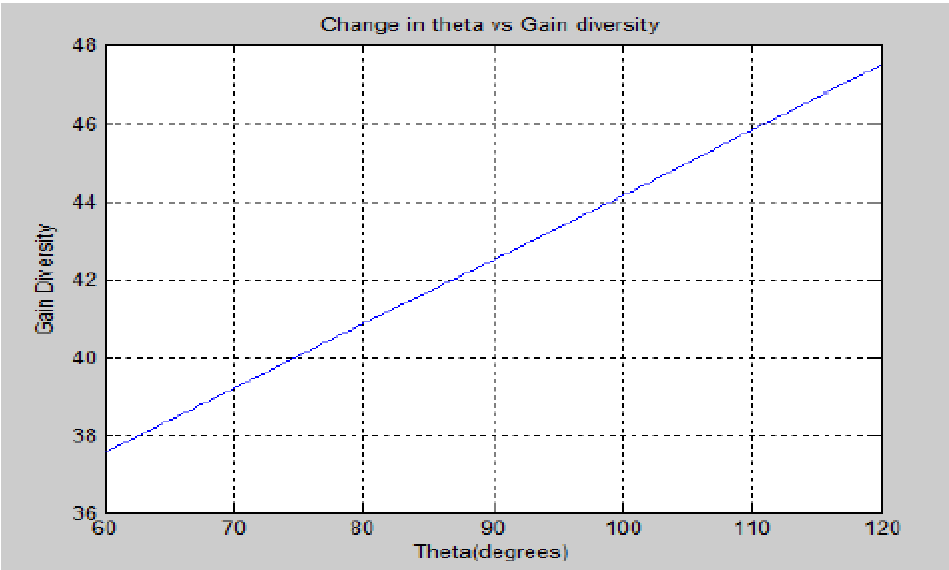

Fig. 4: Change in angle of elevation (degrees i.e., 60 degrees to 120 degrees) vs Gain Diversity (dB)

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3.4. The resultant graph is shown between attenuation (dB) vs Gain Diversity:

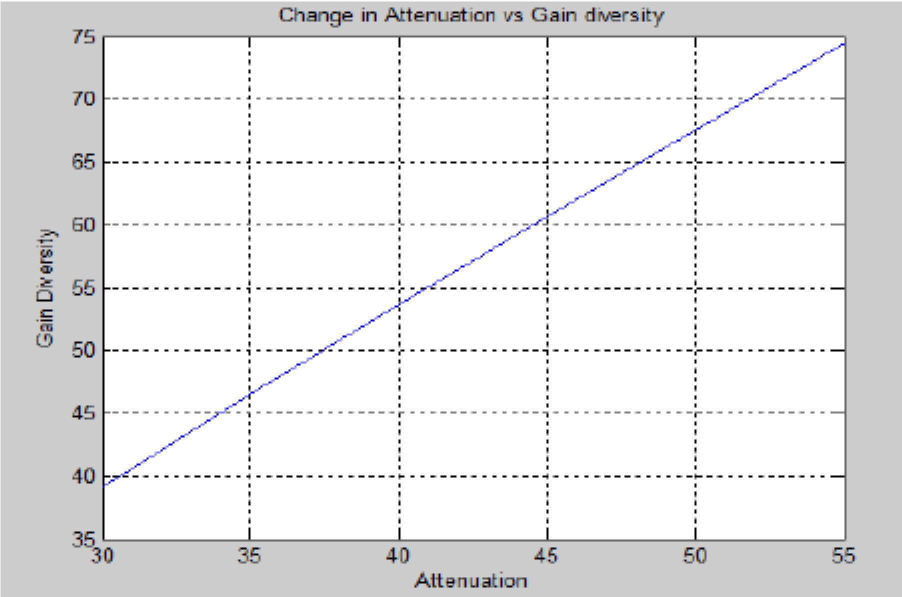

Fig. 5: Change in attenuation (dB i.e., 30dB to 55dB) vs Gain Diversity (dB)

3.5. Improving the signal strength by switching the location without any losses:

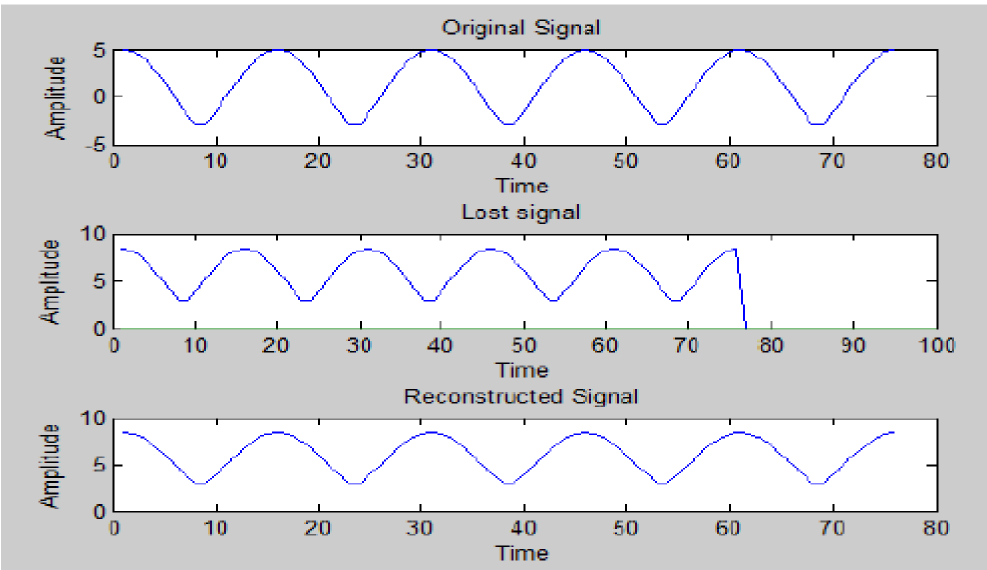

Fig. 6: Improving the signal strength by switching process

Conclusion

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To address these formidable challenges, we introduce an innovative approach that harnesses the inherent benefits of site diversity. Through agile location switching, we robustly fortify signal strength, facilitating seamless transitions without signal losses. What sets our methodology apart is its ability to reconstruct signals with exceptional precision by referencing the nearest unaffected location. This strategic maneuver serves as a potent countermeasure against the disruptive impact of raindrops and their attendant attenuation. In the realm of fade mitigation techniques, our rigorous evaluation firmly establishes site diversity as a frontrunner.

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