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# MRC in Digital Troposcatter Communication System

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**ABSTRACT: This paper deals with the various diversity combining techniques used to overcome short–term fading in troposcatter communication. Superiority of Maximal-ratio combining technique over the others is established. Matlab simulation of dual and quadruple diversity using RLS filter is carried out at data rates of 20 Mbps. RLS filter is used as a forward filter for the purpose of co-phasing of individual branch signals and as well as for interference rejection in the forward direction. Performance is evaluated in terms of bit error rate plot. Modulation technique used is QPSK. The simulation results are compared with the theoretical results. The simulation results shows BER performance of quadruple diversity gives better performance than dual diversity at the data rate of 20Mbps.**

**Index Terms** – Troposcatter communication, Maximal –ratio combining (MRC), Bit Error Rate (BER)

## I. INTRODUCTION

Troposphere is the lowest layer of the atmosphere which extends up to 8-15 km. Troposcatter or Tropo is a beyond line- of-sight (LOS) communication system, in which scattering takes place Troposphere is the lowest layer of the atmosphere which takes place through the troposcatter. Troposphere has clouds, precipitation, humidity and active convection currents, which leads to variations in the refractive index of the troposphere. These refractive index variations enable forward scattering of transmitted signal. A Tropo link is established when terminals point to a common volume in the troposphere and energy transmitted from one terminal is scattered towards the other. Here the path loss is higher than normal line-of-sight (LOS) microwave communication, so this requires high gain antennas and high power amplifiers [1].

In Fig. 1, the common volume is the common area at the intersection of the transmitted and received beams of a troposcatter link.

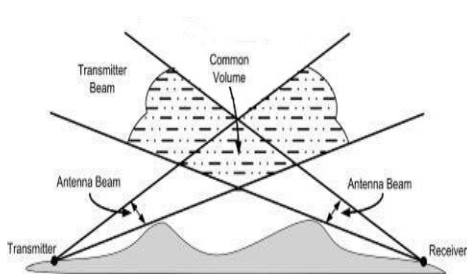


**Fig. 1**. Troposcatter Communication [1].

The common volume is the area where useful scattering takes place which is received by the far end of the link. Here $\theta$ is the scatter angle between a ray from receiving antenna and corresponding ray from far end transmit antenna [2].

Scatter angle in troposcatter communication is inversely proportional to the received signal level. If one or both antennas have large take-off angle, the common volume would be larger, so amount of Energy deflected towards receiver would be reduced as scatter angle becomes larger. Also as the altitude increases results in less scattering so received power decreases.

A troposcatter path can vary in length from about 100 to 150 km to almost 1000 km. Generally the systems these days use in between150 to 400 km. frequency range of communication is in between 2-5 GHz [3].

## II. KEY ISSUES

Troposcatter communication suffers from multipath delay spread and fading. Signal scatters from different points within the common volume and have different path delays. Thus the impulse response of the troposcatter channel has a time- varying multipath structure with delay spread. The multipath delay spread limits the channel capacity and causes the inter-symbol interference (ISI). Adaptive methods can be used to remove ISI and diversity techniques can improve the fading.

The time between the first arrival and the last arrival is the multipath delay spread. Fading is the variation in the refractive index of the troposphere causes fluctuations in each multipath received signal and phase of the received signals are continuously changing. This time-varying multipath characteristic produces alternately destructive and constructive interference which is known as fading, which produces complete loss of signal [4].

Fading can be classified as long term fading and short term fading. Long term fading is caused by the change of climate conditions and primarily caused by the change of temperature, pressure and humidity in the atmosphere. In long term fading variation in received signal is due to the large T-R separation. This type of fading characteristics obeys logarithmic distribution. Short term fading is caused by multipath transmission as different radio signals have different transmission path through troposphere. This type of fading characteristics obeys Rayleigh distribution [5].

Fading produces intervals long compared to a symbol interval where the signal power is very weak as a result error probability increases. For combat this effect, independent signals are transmitted over different channel for diversity protection [6].

## III. DIVERSITY TECHNIQUE

In troposcatter radio links the received signal through a tropo channel varies continuously and follows Rayleigh distribution. In order to overcome the deleterious effects of the continuous variability of the received signal diversity techniques such as space, frequency, polarization, angle, time etc. Most commonly used diversities are frequency and space.

## IV.DIVERSITY COMBINING

Diversity systems have been devised to combat the effect of fast fading and to smooth out the variability of the received signal. The signals transmitted through two or more independent channels are recombined at the reception. The equivalent circuit of diversity combiner is shown in Fig. 2.

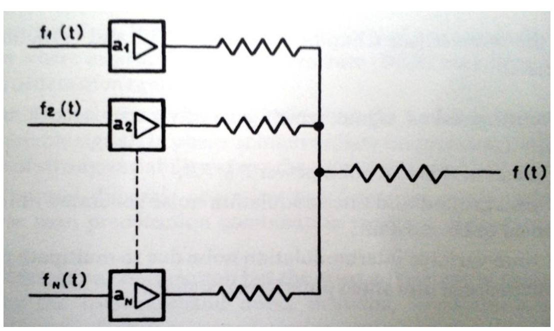


**Fig. 2.** Equivalent circuit of Diversity Combiner [7].

The process of combining N diversity signals from Fig.2 can be explained mathematically as:

$$f_i(t) = s_i(t) + n_i(t) = b_i.s(t) + n_i(t) \quad (4.1)$$

where $s_i(t)$the ith copy of the original signal is, $b_i(t)$ is the amplitude of the envelope and $n_i(t)$ is the noise added in the channel. The output signal is given by:

$$f(t) = a_1.f_1(t) + a_2.f_2(t) + \cdots + a_N.f_N(t) \quad (4.2)$$

$$f(t) = \sum_{i=1}^{N} a_i.s_i(t) + \sum_{i=1}^{N} a_i.n_i(t)) \quad (4.3)$$

$$f(t) = s_i(t) \sum_{i=1}^{N} a_i.b_i + \sum_{i=1}^{N} a_i.n_i(t) \quad (4.4)$$

Where $a_i$ are the gains of the respective channel. Fig.2 corresponds to eq.(4.4), which is composed of N branches, each consisting of an amplifier of gain $a_i$ with an input signal $f_i(t)$

There are three common techniques for diversity combining in wireless communication.

1. Selection Combining
2. Equal Gain Combining
3. Maximal-Ratio Combining

In Selection combining all coefficients $a_i$ of eq. (4.2) except the one corresponding to the best received signal are equal to zero at any given time.

In Equal gain combining all coefficients $a_i$ are made identical by using a common AGC for all channel. The combined signal becomes:

$$f(t) = a\{f_1(t) + f_2(t) + \cdots + f_N(t)\} \quad (4.5)$$

In Maximal-ratio combining (MRC) the coefficients $a_i$ are directly proportional to the amplitude of the envelope of the signal $b_i$ and inversely proportional to the noise power$p_i$. In pre detection combiners the control signal is taken from the AGC. There is a constant thermal noise power given by:

$$p_1 = p_2 = p_3 = \cdots = p_N = FKTB \quad (4.6)$$

Where F is the noise Figure of the receiver, K is the Boltzmann constant is the physical temperature and B is the receiver bandwidth. At the input of each receiver eq.(4.6) can be written as:

$$f(t) = \frac{1}{FKTB}(b_1 f_1 + b_2 f_2 + \cdots + b_N f_N) \quad (4.7)$$

Assume $b_i = f_i$, eq. (4.9) can be written as:

$$f(t) = \frac{1}{FKTB}(f_1^2 + f_2^2 + \cdots + f_N^2) \quad (4.8)$$

Above eq. (4.8) shows that maximal –ratio combining is obtained if each diversity branch has a quadratic amplifier, in which the input is $f_i$ and the output is $b_i f_i = f_i^2$. Comparison between above diversity combining techniques is shown in Fig.3. Here three curves represent three types of combining techniques and other curve represents Rayleigh fading which is without diversity.

Diversity gains for different combining techniques for various percentages of time with respect to median power level can taken from this it is concluded that in MRC we can get higher gain levels as compared to other combining techniques [7].

## V. SIMULATION OF MRC

Simulation model for MRC is based on reference [8]. Model is shown in Fig.3.

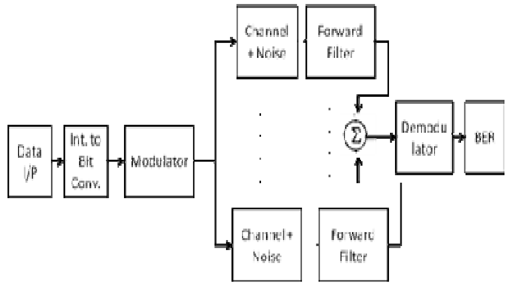


**Fig.3**.Simulation Model for MRC.

This model is simulated in Matlab Simulink. Here the source is generated by Random integer generator and the output of this source is converted to bit form by integer to bit convertor, and then passed to QPSK modulator. Channel is Rayleigh and then AWGN noise is added. In this model Forward filter is used as an Adaptive filter which adjusts its filter coefficients automatically. RLS algorithm is used as an adaptive algorithm, since it has fast convergence rate. Forward filter is used for co-phasing of individual branch signal as well as for interference rejection in the forward direction before summing. Filter length is taken as 3. Output of combined signal is passed through QPSK demodulator and then BER is calculated.

## VI. SIMULATION RESULTANALYSIS

Comparison of BER plot between dual branch and four branch MRC for 20Mbits/s is shown in Fig.4

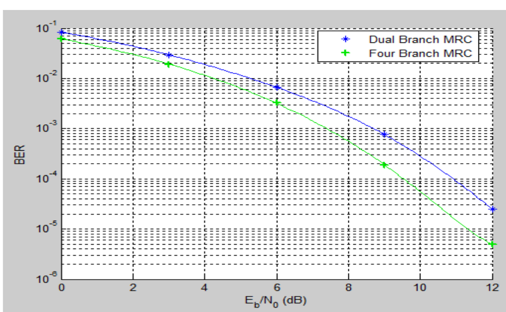


**Fig. 4.** Comparison of BER plot between dual and four branch MRC for 20Mbits/s.

## VII. CONCLUSION

According to the simulation result by using forward filter the BER performance is improve for four branch MRC as compared to the dual branch MRC. Further BER performance for the data rate of 10 Mbits/s is better than the 20Mbits/s as higher the data rate leading to higher ISI.

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