

# Diversity Effect of the Adaptive Antenna Using Blind Algorithm

#Sindhuja Patchaikani, Yoshihiko Kuwahara  
 Graduate School of Engineering, Shizuoka University  
 3-5-1 Johoku Naka-Ku Hamamatsu 432-8561,  
 tykuwab@ipc.shizuoka.ac.jp.

## Abstract

A design of phase diversity receiver for an ISDB-T is proposed in this paper. The objective is to improve the quality of the receiving signal by a simple hardware. The phase value of each receiving antennas are adjusted by named downhill simplex or amoeba algorithm, considering cross correlation between the head guard interval and the tail guard interval of the OFDM symbol as a cost function. We confirmed the BER improvement in the Rayleigh fading environment with several delay spreads by numerical simulation. The algorithm employed here has rapid convergence time to follow the Rayleigh fading.

**Keywords:** Diversity antenna, Simplex algorithm, ISDB-T, Rayleigh fading

## 1. Introduction

The explosive growth of wireless communications industry is creating a huge market opportunity. Wireless operators are currently looking for new technologies which would be implemented into the existing wireless communications systems to provide high quality signal transmission by overcoming the effect of many factors that are degrading the transmission quality.

As we know, in land mobile communication, there is no clear line of sight (LOS) between transmitter and receiver especially for moving systems. The LOS is often blocked by obstacles which will lead the signal to get reflected. The receiver might receive the reflected signals instead of the original signal. Thus the received signal is a combination of refracted signal, reflected signal and diffraction signal. This effect is known as multipath fading effects. Due to this effect the carrier to noise ratio (CNR) is degraded. Besides that, signal to interference plus noise ratio (SINR) is also degraded because of frequency selective fading in multipath fading effects. And hence the transmission quality is definitely degraded.

Sklar in [1] has introduced several techniques to mitigate the effects of multipath fading. In order to combat the distortion caused by frequency selective fading, Sklar has proposed a receiving scheme using adaptive equalization, spread spectrum, OFDM and pilot signal. He suggested several type of diversity to combat the loss caused by signal fading.

We proposed that phase diversity antenna of the phased array with a simple hardware is a candidate to overcome the multipath effects in the land scenario. Hence this receiving system can be employ in vehicles to receive the broadcasting signals.

## 2. Proposed Scheme of the Phase diversity antenna by amoeba algorithm:

### 2.1 Principle

The principle is the elimination of multipath signals at the receiver output by maximizing the correlation coefficient value between the Head Guard Interval (HGI) and Tail Guard Interval (TGI) of the received symbol  $y(t)$ , using simplex algorithm. As shown in Fig.3, when delayed signal by multipath is received at the same time, the correlation becomes low because the previous symbol is superposes at HGI while the same symbol superposes at TGI. The correlation value is calculated by the following expression.

$$\rho = \text{sum}(HGI \cdot \text{conjugate}(TGI))$$

Guard interval is an interval of end of symbol is attached to the head of the symbol to avoid Inter symbol interference (ISI) caused by multipath. Maximum cross correlation value will be achieved when HGI and TGI are the same signal.

## 2.2 Block Diagram

The configuration of the proposed phase diversity antenna receiver is shown in figure 1[2]. In this design, four antennas are arbitrary arranged to receive the faded OFDM signal. The each received signal is phase shifted by the analogue phase shifter and then combined. Head guard interval and tail guard interval of each receiving signal is extracted from the combined output  $y(t)$  and applied to the optimization algorithm. The phase shifters values are determined so as to maximize the correlation by the Simplex method.

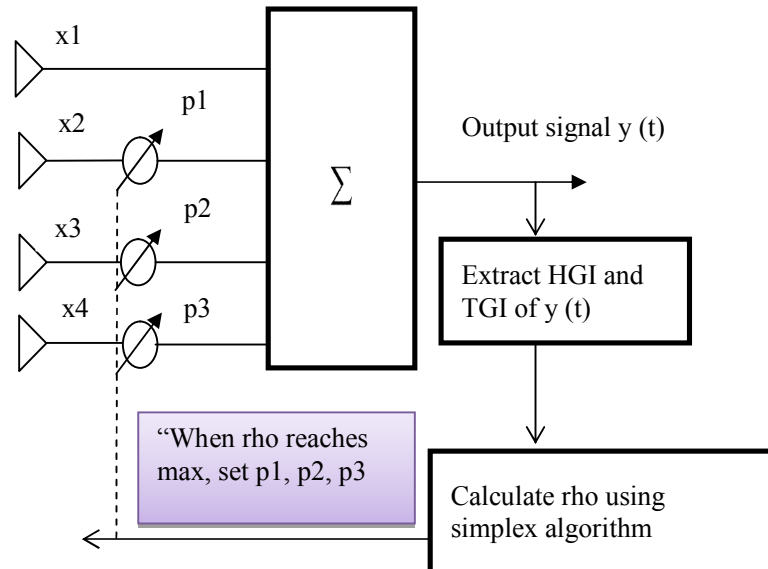


Figure 1:Block Diagram of Proposed Diversity Antenna

## 2.3 Algorithm Explanation

### a) Simplex Concept:

It is an iterative search technique to minimize a function that is nonlinear in parameters. This method is also known as Nelder-Mead method [2]. Simplex method can be used to solve N-dimensional geometry. Simplex is a geometrical figure consisting N dimensions of N+1 points and all interconnecting line segments and polygonal faces.

Simplex method starts with defining,  $P_0$  which consists of N+1 points. After that all points in  $P_0$  will be classified to highest point ( $x_h$ ), second highest point ( $x_{sh}$ ) and lowest point ( $x_l$ ). Simplex method has involve in several possible steps such as reflection, expansion, contraction and multiple contractions in order to find the best combination of ( $x_h$ ), ( $x_{sh}$ ), ( $x_l$ ) at which the function attains its minimum [3].

### b) Implementation of Simplex in Phase diversity antenna:

Initially the array output  $y(t)$  is calculated by randomly choosing the phase values ( $p_1, p_2, p_3$ ). After extracting the HGI and TGI of  $y(t)$ , the cross correlation value ( $\rho$ ) is calculated. By use of Simplex algorithm, it iterates till the “ $\rho$ ” value reaches its minimum. Since ordinary simplex search is used for minimization, the obtained “ $\rho$ ” value is taken as negative in order to find the maximum value of the cost function. Once the “ $\rho$ ” value reaches its maximum, the current set of phase values are noted and set to the phase shifter [4].

## 3 Simulation Conditions:

### 3.1 Numerical Simulation Procedure

The objective of this simulation is to evaluate the diversity effect of phased array antenna in the Rayleigh fading phenomenon using blind algorithm. Simulation conditions are shown in table1. The frequency used is 473MHz. Fading signals are randomly generated for each element, in which the

Table 1 Data used in Numerical Simulation

|                                |               |
|--------------------------------|---------------|
| Modulation Scheme              | OFDM          |
| Carrier Modulation             | 64 QAM        |
| Number of Transmitting symbol  | 200           |
| Number of Carrier symbol       | 5617          |
| IFFT point                     | 8192          |
| Guard Length                   | 1024          |
| Number of Pilot signal         | 469           |
| Number of Receiver antenna     | 4             |
| Number of Delay spread channel | 5             |
| Doppler frequency used         | 50Hz,25Hz,5Hz |

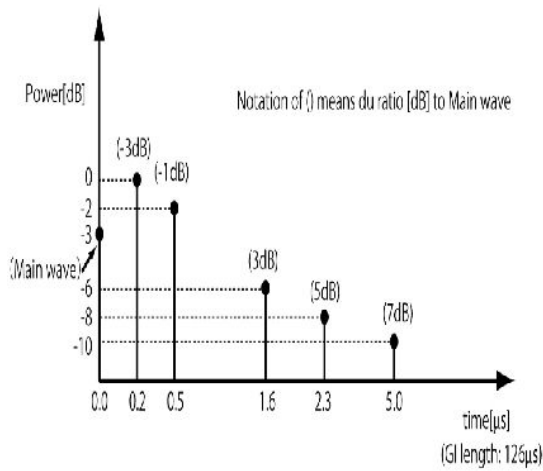


Figure 2: Delay Spread Profile

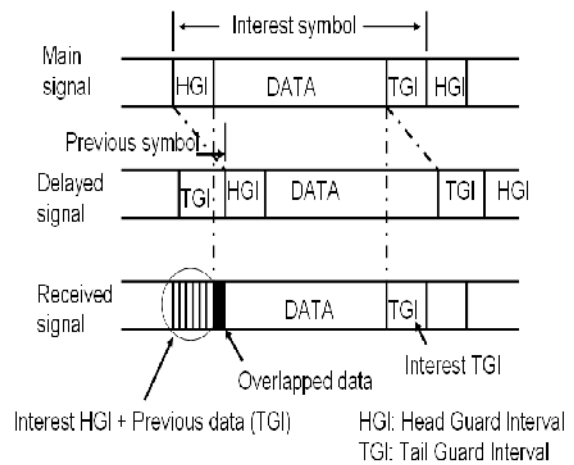


Figure 3: OFDM Signal in multipath

spatial correlation corresponds with 0. We assume 5 delay spread shown as Fig.2. This model is based on COST 207[5]. The du ratio is given as,

$$du = 10 \log_{10} \left\{ \frac{\text{Power of main wave}}{\text{Power of delay wave}} \right\}.$$

Then, we start OFDM signal generation and transmission process. 64QAM modulation scheme is performed. Scattered pilot symbols are inserted to estimate the propagation channel. Additive white Gaussian noise signals are generated and added. After calculating each antenna's received signal, they are combined.

Once the output signal is calculated, extract the guard intervals and starts simplex process. Finally the desired high gain output, with the rejection of multipath signal is obtained. After demodulation, BER is calculated. In this simulation, BER for single antenna and proposed array antenna is plotted.

### 3.2 Simulation Results

BER vs CNR(db) plots are compared between single antenna receiving system and proposed adaptive array antenna receiving system. The Doppler frequency is set to 5, 25, and 50Hz. The results are shown in figure 4. It is confirmed that the phased array with analogue phase shifters can operate as the phase diversity in the Rayleigh fading environment by use of simplex algorithm.

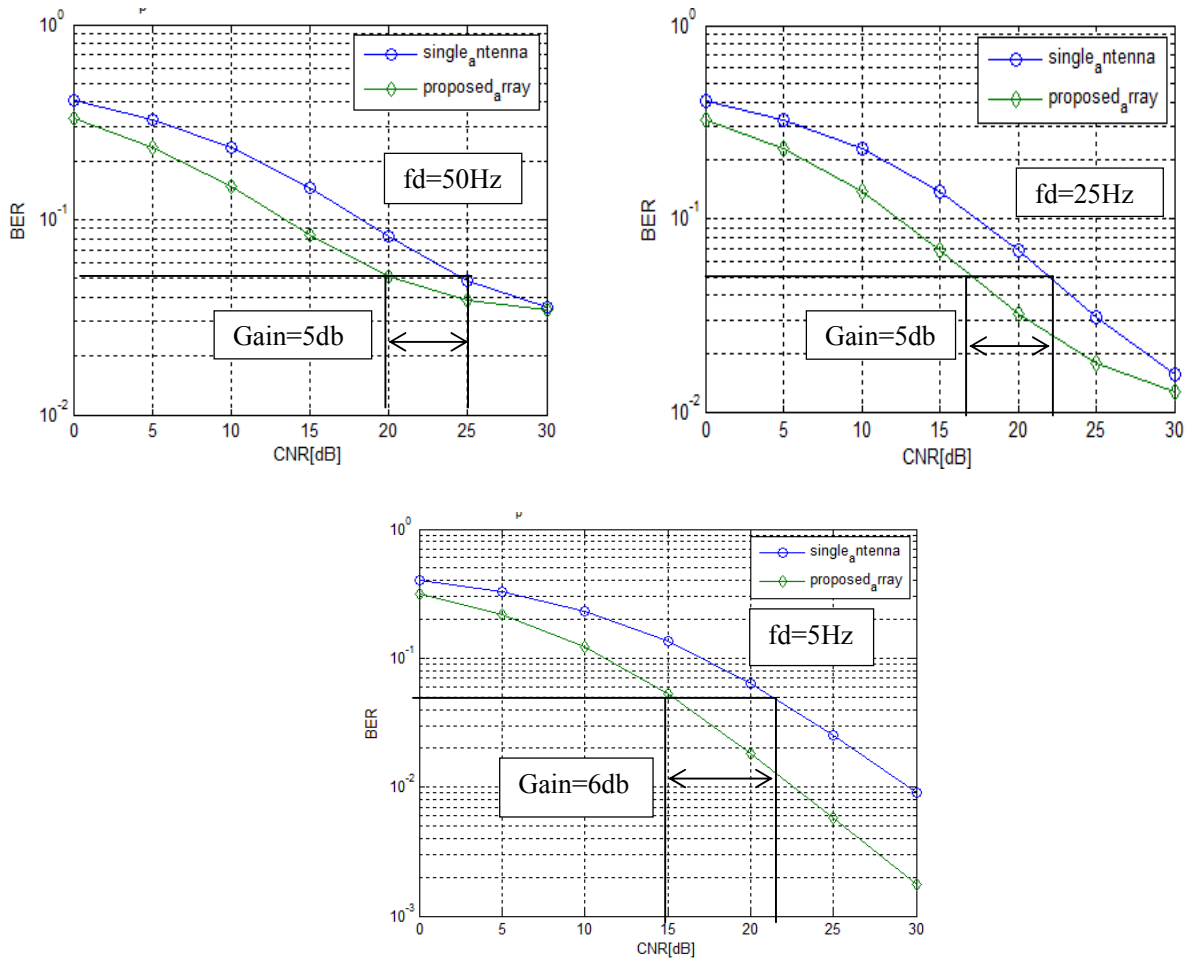


Figure:4 Simulated results at different Doppler frequencies

#### 4. Conclusion

BER of the proposed diversity antenna receiver has been demonstrated. The obtained diversity gain for this scheme is 5db-6db, when compare with the single antenna output, at different Doppler frequencies. Our next step is to analyse this diversity receiving scheme using the shared aperture antenna.

#### References

1. Sklar B., Rayleigh fading channels in mobile digital communication systems Part 2: Mitigation, IEEE Communication magazine, July 1997, pp. 102-109.
2. R. Fuji, K. Ura, C. Shimizu, H. Takahashi, Y. Kuwahara, Evaluation of the Analogue Phase Diversity antenna for ISDB Using Fading Emulator, IEEE APS 2009.
3. Press W. H., Flannery B. P., Teuskolsky S. A., and Vetterling W. T., Numerical Recipes in C, Cambridge University Press, 1998.
4. Noorsaliza A and Y. Kuwahara, Adaptive Beamforming for the ESPAR Antenna by Means of the Downhill Simplex Method, IEICE Tech. Report, vol. 109, no. 218, AP2009-103, pp.37-42, Oct. 2009.
5. COST207, Digital land mobile radio communications(final report),” Commission of the European Communities, Directorate General communications, Information Industries and Innovation, 1989.