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Volume 06, Issue 07, Pages: 195 – 206.

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A NOVEL METHOD FOR BLIND INTERFERENCE ALIGNMENT OF ANTENNA SYSTEM WITH EXPERIMENTAL RESULTS

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ABSTRACT: In recent years, several experimental studies have come out to validatethe theoretical findings ofinterference alignment (IA), but only a handful of studies have focused on blind interference alignment. Unlike IA and other interference mitigation techniques, blind IA does not require channel state information at the transmitter (CSIT). The key insight is that the transmitter uses the knowledge of channel coherence intervals and receivers utilize reconfigurable antennas to create channel fluctuations exploited by the transmitter. In this work, we present a novel experimental evaluation of a reconfigurable antenna system for achieving blind IA. We In recent years, several experimental studies have come out to validate the theoretical findings of present a blind IA technique based on reconfigurable antennas for a 2-user multiple-input single-output (MISO) broadcast channel implemented on a software defined radio platform where each of the receivers is equipped with a reconfigurable antenna. We further compare this blind IA implementation with traditional TDMA scheme for benchmarking purposes. We show that the achievable rates for blind IA can be realized in practice using measured channels under practical channel conditions. Additionally, the average error vector magnitude and bit error rate(BER) performances are evaluated.

INTRODUCTION

1.1 Antenna Definition:

An antenna is any device that converts electronic signals to electromagnetic waves and vice versa effectively with minimum loss of signals.

1.2 Antenna History:

Antenna was founded in 1986 as independent foundation to support Non Governmental Organisations, Local Government and Educational Institutions with the introduction and facilitation of ICT. We have become the ICT partner for around 500 organisations in the field of labour, womens emancipation, environment, development, social change, education, human rights, peace and fair trade.From 1986 to 1991 we were the international helpdesk for Poptel Geonet, a mailbox and database service we helped to start in London, via which we facilitated 400 NGOs worldwide with mainly e-mail and databases. We were at that time the Technical Assistance Group for NGO networks like Interdoc, ISIS, IOCU, SATIS and HURIDOCS. During that same period Antenna assisted the launch of national and regional E-mail networks in west- and southern africa like Mango in Zimbabwe and Worknet in South Africa. But also networks in Asia (India, Cambodia, Philippines) and Latin America (Peru, Bolivia, Brazil, Colombia, Nicaragua and Uruguay). 150 of them attended the 1990 Antenna Interdoc Conference in the Netherlands after which APC - Association for Progressive Communications - was formed.From 1991 onwards we provide these services via our own server location in the Netherlands. In 1992 we hosted and built for the UNCED, for the Rio Earth Summitt, the on-line databases with all documents, agendas and related resources. Since then we worked also for UN agencies like WHO, ILO, UNEP, UNICEF, UNDP.In 1993 Antenna organised the dial-up track of the annual Internet Society workshop in Prague and co-founded the Internet Society chapter in the Netherlands in 1997.From 1993 to 1995 Antenna built the computer confercing system for the WWF International network, the Internet E-mail and Webserver for Greenpeace International and the E-mail system for MSF International.Since 1993 almost all development, emancipation and environment organisations in the Netherlands are supported by Antenna.Antenna is also reseller of ADSL, Leased Lines, and Internet access services of providers like Demon, Worldcom UUnet etc. Antenna has never received subsidies or grants for its activities and worked as 100% self reliant professional service since 1986. Although our slogan is "Networking for Progress, Not for Profit" Antenna in fact operates all these years on a healthy sound financial basis and positive result. Our contribution to the public sector via income tax and VAT (Moms) increases each year. What remains is reinvested in human and technical resources and innovation aimed to provide the best possible professional service. Antenna has assisted in the launch of various succesful ISP organisations aimed at NGOs in many countries. Most of them became and remained sustainable operations. Antenna has maintained self control over its resources, assets and technologies while sharing its expertise and experience with others.In 1986 but even now we still feel ISPs must provide independent, viable, affordable and sustainable services. No cross financing via other activities which can interrupt the services. Contracts must be respected, domains, E-mail and websites kept alive and accessible to avoid interruption of the daily work of all users.Some of the tarrifs of Antenna are higher compared to others, but include more service and quality components. We believe that services in order to remain a sustainable support for users must be both viable as affordable. When users feel they can not subscribe the offered service we have a range of budget models to accomodate users with lower income situations.

Antenna has proven as independent service organisation to be sustainable due to its self reliance since 1986. As foundation Antenna can not be bought, is aimed at servicing the public sector and will remain working in the public sphere and domain.Antenna has no growth scenario, we believe in the networked society, in the network economy, sharing and cooperating with other agencies, organisations and services. Antennas income comes for a substantial part by reselling its services via others, but also reselling the services of others via Antenna.Back in the good olden days, a large rooftop antenna was seen as a status symbol. Today, smart phones, tablets and GPS units have conditioned consumers to expect reliable wireless services in very small packages.These dramatic changes in technology and consumer preferences, along with the switch from analog to digital signals, have created a high demand for quality, over-the-air, digital HDTV antennas. The designs for those old, rooftop TV antennas are decades old and consist of a configuration in a horizontal "fish bone" style, with "arms" of varying lengths, allowing for the reception of a broader range of frequencies.Although antenna research and engineering have seen radical advancements over the years, manufactures of television equipment have mostly stuck with theses old designs for economic reasons. Since the transition to digital signals, most digital frquencies are broadcast in UHF (ultra-high frequency). These signals are smaller than VHF (very high frequency) signals, which were the more common transmission method for analog television. UHF signals are broadcast on channels 14 to 51, and VHF signals are broadcast on channels 2 to 13.The evolution of antenna technology is reviewed, from the days of Marconi to the present. Various periods over which antenna technology has been revitalized are reviewed, and the various antenna configurations developed during those periods are summarized along with some of their respective key characteristics. The history starts at the beginning of the 20^{th} century and the respective technologies developed in the decades that follow are identified. Individuals that played a key role, especially during the early stages of antenna technology, are identified. Future trends and needs are speculated. Key technologies that will contribute to future advancements are identified and will be presented at the conference.

1.3 Different Types Of Antennas :

Antennas can be classified in several ways. almost every antenna in the world can be understood as some combination or derivative of the antennas. The above antennas contain different types of antennas. Those are

1.3.1 Wire Antennas

Wire antennas need to be made a bit long and cut to resonance. They are affected by height above the ground andsurrounding objects. In order to get an idea of the right place to start, certain formulas are generally accepted. Different types of wire antennas are:

The short dipole antenna is the simplest of all antennas. It is simply an opencircuited wire, fed at its canter as shown in figure 1.1.The words "short" or "small" in antenna engineering always imply "relative to a wavelength". So the absolute size of the above dipole antenna does not matter, only

Dipole Antenna :

the size of the wire relative to the wavelength of the frequency of operation.Typically, a dipole is short if its length is less than a tenth of a wavelength:

$$L \langle \frac{\lambda}{10}$$

The dipole is the prototypical antenna on which a large class of antennas are based. A basic dipole antenna consists of two conductors (usually metal rods or wires) arranged symmetrically, with one side of the balanced feedline from the transmitter or receiver attached to each. The most common type, the half-wave dipole, consists of two resonant elements just under a quarter wavelengths long.

Spiral Antennas :

Spiral antennas belong to the class of "frequency independent"antennas; these antennas are characterized as having a very large bandwidth. The fractional Bandwidth can be as high as 30:1. This means that if the lower frequency is 1 GHz, the antenna would still be efficient at 30 GHz, and every frequency in between. Spiral antennas are usually circularly polarized. The spiral antenna's radiation pattern typically has a peak radiation direction perpendicular to the plane of the spiral (broadside radiation). The Half-Power Beam width (HPBW) is approximately 70-90 degree Spiral antennas are widely used in the defense industry for sensing applications, where very wideband antennas that do not take up much space are needed. Spiral antenna arrays are used in military aircraft in the 1-18 GHz range. Other applications of spiral antennas include GPS, where it is advantageous to have RHCP (right hand circularly polarized) antennas.

Aperture Antennas:

Slot antenn Slot antennas are used typically at frequencies between 300 MHz and 24 GHz. The slot antenna is popular because they can be cut out of whatever surface they are to be mounted on, and have radiation patterns that are roughly omni directional (similar to a linear wire antenna, as we'll see). The polarization of the slot antenna is linear. The slot size, shape and what is behind it (the cavity) offer design variables that can be used to tune performanceConsider an infinite conducting sheet, with a rectangular slot cut out of dimensions *a* and *b*, as shown in Figure 1. If we can excite some reasonable fields in the slot (often called the aperture), we have a slot antenna.

Horn antennas:

Horn antennas are very popular at UHF (300 MHz-3 GHz) and higher frequencies (I've heard of horn antennas operating as high as 140 GHz) .Popular versions of the horn antenna include the E-plane horn, shown in Figure1.12. This horn antenna is flared in the E-plane, giving the name. The horizontal dimension is constant at **w**.Another example of a horn antenna is the H-plane horn, shown in Figure 1.13This horn is flared in

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the H-plane, with a constant height for the waveguide and horn of *h*.The most popular horn antenna is flared in both planes as shown in Figure 1.14. This is a pyramidal horn, and has a width *B* and height *A* at the end of the horn.As the above said, antennas all are single element antennas, which provide radiation pattern of all directions by proper excitation and feed. The single element antennas gain is very less and beam width is wide and band width is very less.But these are not applicable in wireless communication system. For that reason in the next chapter Array Antennas are designed for N=10,20, 40,60,80,100 element

OFDM (orthogonal frequency-division multiplexing):

OFDM (orthogonal frequency-division multiplexing) is a multicarrier modulation scheme that divides the incoming bit stream into parallel, lower rate sub streams and transmits them over orthogonal subcarriers. As a result, the bandwidth of each subcarrier is much smaller than channel coherence bandwidth and hence each subcarrier will experience relatively a flat fade. It is a bandwidth efficient modulation scheme and has the advantage of mitigating inter-symbol interference (ISI) in frequency selective fading channels. Today, OFDM is used in many wireless standards such as terrestrial digital video broadcasting (DVB-T), digital audio broadcasting (DAB-T), and has been implemented in wireless local area networks (WLANs) (IEEE 802.11a, ETSI Hiperlan2) an wireless metropolitan area networks (IEEE 802.16d).

The main drawback of OFDM is its high peak-to-average power ratio (PAPR) which causes serious degradation in performance when nonlinear power amplifier (PA) is used. This high PAPR forces the transmit PA to have a large input back off (IBO) in order to ensure linear amplification of the signal, which significantly reduces the efficiency of the amplifier.

4.1 Multiple Access Techniques:

Multiple access schemes are used to allow many simultaneous users to use the same fixed bandwidth radio spectrum. In any radio system, the bandwidth, which is allocated to it, is always limited. For mobile phone systems the total bandwidth is typically 50 MHz, which is split in half to provide the forward and reverse links of the system.

4.2 Wireless communication:

Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor. The most common wireless technologies use radio. With radio waves distances can be short, such as a few meters for television or as far as thousands or even millions of kilometers for deep-space radio communications Wireless operations permit services, such as a long-range communications, that are impossible or impractical to implement with the use of wires.

Supporting technologies include:

Wi-Fi is a wireless local area network that enables portable computing devices to connect easily to the Internet.[18] Standardized as IEEE 802.11 a,b,g,n, Wi-Fi approaches speeds of

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some types of wired Ethernet. Wi-Fi has become the de facto standard for access in private homes, within offices, and at public hotspots.[19] Some businesses charge customers a monthly fee for service, whileothers have begun offering it for free in an effort to increase the sales of their goods.[20]Cellular data service offers coverage within a range of 10-15 miles from the nearest cell site.[13] Speeds have increased as technologies have evolved, from earlier technologies Mobile Satellite Communications may be used where other wireless connections are unavailable, such as in largely rural areas[23] or remote locations.[13] Satellite communications are especially important for transportation, aviation, maritime and mi litary use.[24] Wireless Sensor Networks are responsible for sensing noise, interference, and activity in data collection networks. This allows us to detect relevant quantities, monitor and collect data, formulate meaningful user displays, and to perform decision-making functions

4.3 MIMO (multiple-input and multiple-output):

multiple-input and multiple-output is a method for multiplying the capacity of a radio link using multiple transmit and receive antennas to exploit multipath propagation, At one time in wireless the term "MIMO" referred to the mainly theoretical use of multiple antennas at both the transmitter and the receiver. In modern usage, "MIMO" specifically refers to a practical technique for sending and receiving more than one data signal on the same radio channel at the same time via multipath propagation. MIMO is fundamentally different from smart antenna techniques developed to enhance the performance of a single data signal, such as beamforming and diversity

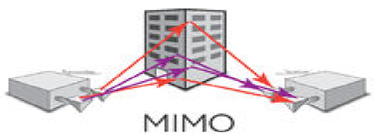

Fig:4.3 MIMO

MIMO can be sub-divided into three main categories, precoding, spatialmultiplexing or SM, and diversity coding. Precoding is multi-stream beam forming, in the narrowest definition. In more general terms, it is considered to be all spatial processing that occurs at the transmitter. In (single-stream) beam forming, the same signal is emitted from each of the transmit antennas with appropriate phase and gain weighting such that the signal power is maximized at the receiver input. The benefits of beam forming are to increase the received signal gain - by making signals emitted from different antennas add up constructively - and to reduce the multipath fading effect. In line-of-sight propagation, beam forming results in a well-defined directional pattern. However, conventional beams are not a good analogy in cellular networks, which are mainly characterized by multipath propagation. When the receiver has multiple antennas, the transmit beam forming cannot simultaneously maximize the signal level at all of the receive antennas, and precoding with multiple streams is often beneficial. Note that precoding requires knowledge of channel state information (CSI) at the

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transmitter and the receiver.Sharing of the spectrum is required in order increase the user capacity of any wireless network. FDMA, TDMA and CDMA are the three major methods of sharing the available bandwidth to multiple users in wireless system. There are many extensions, and hybrid techniques for these methods, such as OFDM, and hybrid TDMA and FDMA systems. However, an understanding of the three major methods is required for understanding of any extensions to these methods.

4.4 Frequency Division Multiple Accesses (FDMA):

In Frequency Division Multiple Access (FDMA), the available bandwidth is subdivided into a number of narrower band channels. Each user is allocated a unique frequency band in which to transmit and receive on. During a call, no other user can use the same frequency band. Each user is allocated a forward link channel (from the base station to the mobile phone) and a reverse channel (back to the base station), each being a single way link. The transmitted signal on each of the channels is continuous allowing analog transmissions. The bandwidths of FDMA channels are generally low (30 kHz) as each channel only supports one user. FDMA is used as the primary breakup of large allocated frequency bands and is used as part of most multi-channel systems.

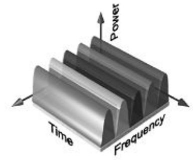

Fig.1.2 FDMA showing that the each narrow band channel is allocated to a single user.

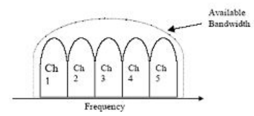

Fig.1.3 FDMA spectrum, where the available band width is sub-divided into narrow band channels.

Fig. 4.4.1 & Fig. 4.4.2 show the allocation of the available bandwidth into several channels.

4.5 Time Division Multiple Access:

Time Division Multiple Access (TDMA) divides the available spectrum into multiple time slots, by giving each user a time slot in which they can transmit or receive. **Fig.4.5** shows how the time slots are provided to users in a round robin fashion, with each user being allotted one time slot per frame. TDMA systems transmit data in a buffer and burst method, thus the transmission of each channel is non-continuous.

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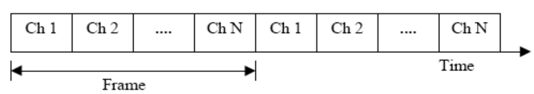

Fig: 4.5.1

TDMA scheme, where each user isallocated a small time slotThe input data to be transmitted is buffered over the previous frame and burst transmitted at a higher rate during the time slot for the channel. TDMA can not send analog signals directly due to the buffering required, thus are only used for transmitting digital data. TDMA can suffer from multipath effects, as the transmission rate is generally very high. This leads the multipath signals causing inter-symbol interference. TDMA is normally used in conjunction with FDMA to subdivide the total available bandwidth into several

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channels. This is done to reduce the number of users per channel allowing a lower data rate to be used. This helps reduce the effect of delay spread on the transmission. **Fig. 4.5.2** shows the use of TDMA with FDMA. Each channel based on FDMA, is further subdivided using TDMA, so that several users can transmit of the one channel. This type of transmission technique is used by most digital second generation mobile phone systems. For GSM, the total allocated bandwidth of 25MHz is divided into 125, 200 kHz channels using FDMA. These channels are then subdivided further by using TDMA so that each 200 kHz channel allows 8-16 users.Time-division multiplexing (TDM) is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern.

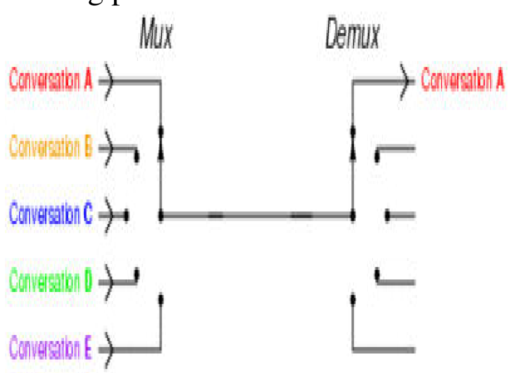

Fig: 4.5.2 TDMA

4.6 TDMA USES:

- The GSM telephone system
- The Tactical Data Links Link 16 and Link 22

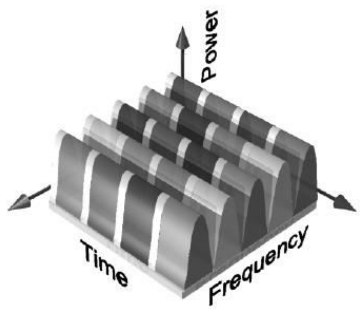

Fig.4.6 TDMA/FDMA hybrid, showing that the bandwidth is split into frequency channels and time slots.

4.7 TDMA DRAW BACKS:

Disadvantage using TDMA technology is that the users has a predefined time slot. When moving from one cell site to other, if all the time slots in this cell are full the user might be disconnected.Another problem in TDMA is that it is subjected to multipath distortion. To overcome this distortion, a time limit can be used on the system. Once the time limit is expired the signal is ignored.Attenuation is the “drop in the signal power when transmitting from one point to another. It can be caused by the transmission path length, obstructions in the signal path, and multipath effects”. **Fig.5.2.1** shows some of the radio propagation effects that cause attenuation. Any objects, which obstruct the line of sight signal from the transmitter to the receiver, can cause attenuation.

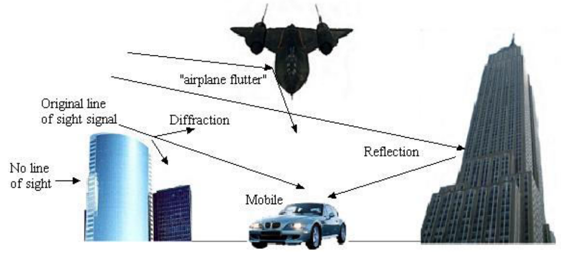

Fig. 5.2.1 Some channel characteristics

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Shadowing of the signal can occur whenever there is an obstruction between the transmitter and receiver. It is generally caused by buildings and hills, and is the most important environmental attenuation factor. Shadowing is most severe in heavily built up areas, due to the shadowing from buildings. However, hills can cause a large problem due to the large shadow they produce. Radio signals diffract off the boundaries of obstructions, thus preventing total shadowing of the signals behind hills and buildings. However, the amount of diffraction is dependent on the radio frequency used, with low frequencies diffracting more then high frequency signals. Thus high frequency signals, especially, Ultra High Frequencies (UHF), and microwave signals require line of sight for adequate signal strength. To over come the problem of shadowing, transmitters are usually elevated as high as possible to minimize the number of obstructions. Typical amounts of variation in attenuation due to shadowing are shown in **Table 5.2**

Description	Typical Attenuation due to Shadowing
Heavily built-up urban center	20dB variation from street to street
Sub-urban area (fewer large buildings)	10dB greater signal power then built-up urban center
Open rural area	20dB greater signal power then sub-urban areas
Terrain irregularities and tree foliage	3-12dB signal power variation

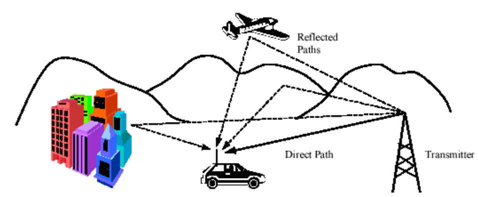
Table 5.2 Typical attenuation in a radio channel.

Shadowed areas tend to be large, resulting in the rate of change of the signal power being slow. For this reason, it is termed slow-fading, or lognormal shadowing.

5.3 Multipath Effects:

5.3.1 Rayleigh fading:

In a radio link, the RF signal from the transmitter may be reflected from objects such as hills, buildings, or vehicles. This gives rise to multiple transmission paths at the receiver. **Fig. 5.3.1** show some of the possible ways in which multipath signals can occur.**Fig: 5.3.1** Multipath SignalsBecause of the



multipath phase of the signal may by that constructive or destructive interference when it reaches to the Rx. This is experienced over very short distances (typically at half wavelength distances), thus is given the term fast fading. These variations can vary from 10-30dB over a short distance.

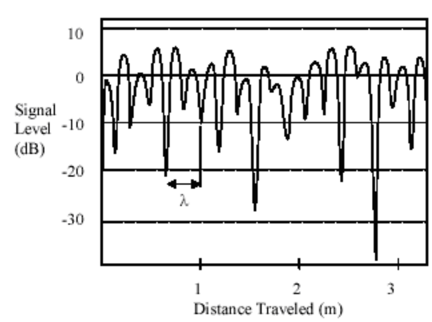


Fig: 5.3.2 Typical Rayleigh fading while the mobile unit is moving.

The Rayleigh distribution is commonly used to describe the statistical time varying nature of the received signal power. It describes the

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probability of the signal level. Being received due to fading. **Table 5.3** shows the probability of the signal level for the Rayleigh distribution.

Signal Level (dB about median)	% Probability of Signal Level being less then the value given
10	99
0	50
-10	5
-20	0.5
-30	0.05

Table 5.3 Cumulative distributions for Rayleigh distribution

5.4 Channels We Used:

The transmission signal models of the electromagnetic wave which travels form transmitter to receiver. Along the way the wave encounters a wide range of different environments. Channel models represent the attempt to model these different environments. Their aim is to introduce well defined disturbances to the transmission signal. In this lecture we discuss channel models which are typical for DAB transmission. We consider the effects of noise, movement, and signal reflection. The general strategy is to have a pictorial representation of the channel environment before we introduce the mathematical model.

SIMULATION RESULTS:

Sum rate performance of the blind IA and TDMA

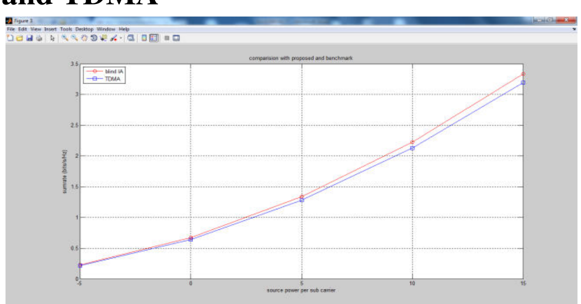

Figure:sumrate performance of blind ia and tdma

CDF performance of the blind IA and TDMA

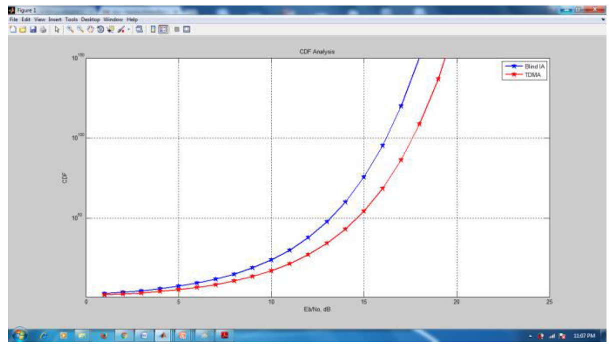

Figure: The performance analysis of BLIND IA and TDMA

BER performance of the blind IA and TDMA

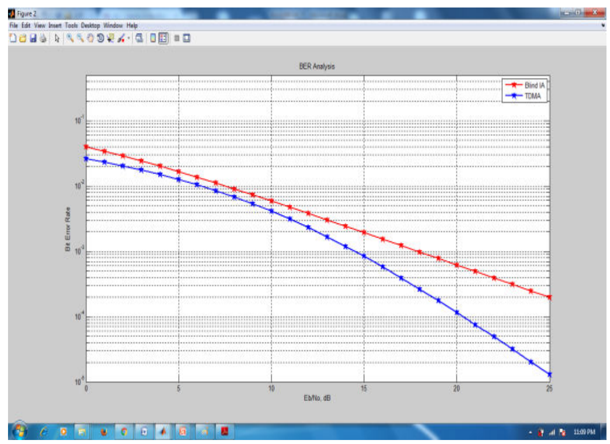

Figure: BER performance of BLIND IA and .1 TDMA

8.APPLICATIONS

1. Several wireless standards as well as number of mobile multimedia applications.
2. WiMAX
3. 4G wireless systems
4. DVB/DAB
5. Wireless network in downlink and SC-FDMA in the uplink.
6. High speed wireless multiple access communication systems.

8.2 ADVANTAGES

Another attractive solution is the "companding" technique which was originally designed for speech processing using the classical μ-law transformation and showed to be rather effective . It is the most attractive PAPR reduction technique for multicarrier transmission due to its good performance and low complexity. This technique 'soft' compresses, rather than 'hard' clips, the signal peak and causes far less OBI. However, companding techniques may introduce undesired effects because of the requisite expansion of the compressed signal at the receiver end, a process which amplifies receiver noise.

CONCLUSION :

In this paper, we presented an experimental study of a blind interference alignment scheme that employs a pattern reconfigurable antenna. Unlike other interference mitigation techniques such as beam forming or IA, our reconfigurable antenna-based blind IA implementation does not require CSIT. Using our MIMO-OFDM tested and the Reconfigurable Alford Loop Antenna, we validated the practicality of realizing blind IA with a reconfigurable antenna. Furthermore, we studied the performance of our implementation and how it compares to TDMA. Our measurement results show that the implementation with this antenna achieves significant gain in sum rates compared to TDMA. Due to the inherent interference of blind IA, our implementation incurs 5 dB degradation in terms of PP-SINR. However, for a given PP-SINR, both blind IA and TDMA have similar performance. Because the Reconfigurable Alford Loop antenna used in this work has several radiation patterns to choose from, a natural extension of our work is the study of optimal antenna pattern selection for blind IA.

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