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Review on Optical Mimo System

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Abstract- In this paper present review study on optical communication with OFDM system by MIMO technique. At reviewing background knowledge that includes fundamentals of modulation and communication, signal propagation and channel modeling. In this paper ideas behind formulas, rather than mathematical derivations, are emphasized and several examples are provided to allow easy comprehension of the concepts. in-depth treatment of two essential signal processing tasks synchronization and channel estimation–is discussed. Then, MIMO (multiple-input multiple output) techniques with their application to optical OFDM systems are also delineated. This part also aims to present the readers with modern signal-processing algorithms in optical OFDM baseband receivers talks about hardware design, from design methodology to design of essential blocks with a couple of examples that cover the latest OFDM receiver and its developments.

Index Terms- OFDM (orthogonal frequency division multiplexing), MIMO (multiple input multiple output) DSB (digital broadcasting Systems), DAB (digital audio br0oadcasting), QPSK (quadrature phase shift keying) and QAM (quadrature amplitude modulation).

I. Introduction

This Pursuance for better ways of living has been instrumental in advancing human civilization. Communication services available at any time and place free people from the limitation of being attached to fixed devices. Nowadays, thanks to the remarkable progress in wireless technology, affordable wireless communication service has become a reality. Mobile phones hook people up whenever and wherever they want. Digital audio and video broadcasting offers consumers high-resolution, better-quality and even interactive programmes. The devices are now thin, light, small and inexpensive. Furthermore, smart mobile phones capable of multimedia and broadband internet access are showing up on the shelves [2,3].

Several projects studying wireless networks with different extents of coverage are under way. They will enable wireless access to internet backbone everywhere, either indoors or outdoors and in rural or metropolitan areas. In the following, their evolution and future developments will be introduced. The essential role that the orthogonal frequency-division multiplexing (OFDM) technique plays in wireless communication systems will also become very clear.

Digital Broadcasting Systems

In the modern world, most people fill the need for information and entertainment through audio and video broadcasting. The inauguration of AM radio can be traced back to the early twentieth century, whilst analog TV programmes were first broadcast before the Second World War. Around the middle of twentieth century, FM radio programmes became available. These technologies, based on analog communication, brought news, music, drama, movies and much more into our daily lives. To provide more and better programmes, digital broadcasting techniques, such as digital audio broadcasting (DAB) and digital video broadcasting (DVB), began to replace the analog broadcasting technologies in the past several years [4,5].

Digital Audio Broadcasting (DAB)

DAB is among the first standards that use the OFDM technique. The DAB project started in mid-1980 [1]. Based on OFDM, DAB has one distinct benefit: a single-frequency network (SFN). In a single frequency broadcasting network, one carrier frequency can be used for all transmitters to broadcast the same radio programme in the entire country without suffering from co-channel interference. On the other hand, in the FM system, only one out of approximately 15 possible frequencies can be used, resulting in a very inefficient frequency re-use factor of 15[6,7]. A single-frequency network and a multi-frequency network are illustrated in Fig.

In the DAB system, it is not necessary to search for radio stations as is necessary with AM/FM radios. The programmes of all radio stations are integrated in so-called multiplexes. Multiplexes save on the maintenance cost of individual radio stations. In addition, variable bandwidths can be assigned to each programme, fulfilling their respective demands for sound quality. Music radio multiplexes can transmit at a rate up to the highest-quality 192 Kbps, while mono talk and news programmes may use only 80 Kbps. Futhermore, the DAB system features better mobile reception quality thanks to the OFDM technique[11,12].

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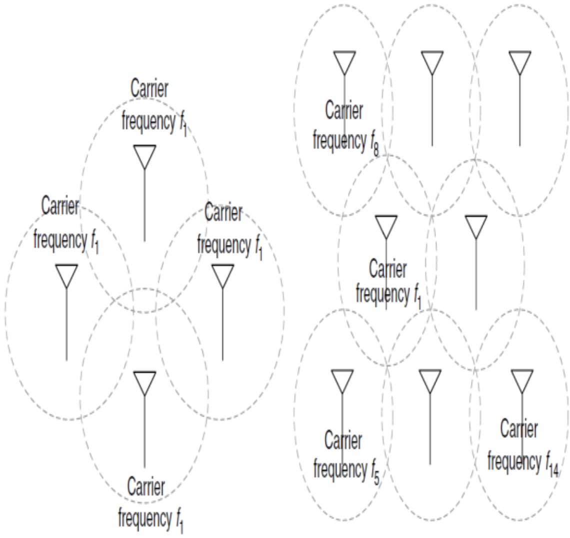

(a) Single-frequency network and (b) multi-frequency network

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Digital Video Broadcasting (DVB) DVB is the European standard for digital television broadcasting [2]. The DVB standards include DVB-S for satellites, DVB-C for cables, DVB-T for terrestrial transmission and DVB-H for low-power handheld terminals. Among them, DVB-T and DVB-H utilize OFDM as the modulation scheme. DVB-T receivers started shipping in late-1990 and now digital DVB-T programmes are available in many countries. As the DAB system, DVB-T/H technology also supports countrywide single-frequency networks. In addition, DVB-T/H standards offer several modes of operation that are tailored for large-scale SFN and high mobility reception. On the other hand, researchers in wireless optical communications (WOC) are trying to find a way to gain the interest of communication companies by providing new and attractive alternatives to radio communications, as we must not lose sight of the fact that most wireless communications are established inside rooms. Thus, WOC systems offer some advantages over their radio-frequency (RF) counterparts [15]: they are, theoretically, unregulated and have unlimited1 bandwidth. There is also an inherent security capability, as light (communication) is confined to the room, and there is immunity to multipath fading.

However, they are not exempt from drawbacks: strict power limitations due to eye-safety constraints, severe path losses and multipath dispersion and, last but not least, limited maximum achievable signal-to-noise ratio (SNR) due to unavoidable natural and artificial noise sources are the main problems. Over the last few years, OFDM has begun to be proposed for both fibre and wireless optical communications [4] as an effective solution to mitigating inter-symbol interference (ISI) caused by dispersive channels. Furthermore, the frequency-domain channel equalization provided by an OFDM system does not undergo severe complexity penalty when data rates and dispersion increase as opposed to serial time-domain equalizers, and MIMO techniques can be applied to these systems with relative ease. Finally, the complexity of transmitters and receivers is transferred from an analogue to a digital domain by employing Fast Fourier Transform (FFT) and Inverse FFT (IFFT) blocks as demodulators and modulators, respectively. Therefore, all these aspects favour the implementation of OFDM systems in the current digital era [13,14].

II. OPTICAL COMMUNICATION

Today's telecommunication services intensely rely on optical-fiber systems. Such optical communication systems are requested to handle high speed, multi-channels, long-haul signal transmission [1]. Recently, optical coherent 100 Gb/s communication links became a critical technology for communication networks. Moreover, digital signal processing is under consideration as a promising technique for optical signal modulation, fiber transmission, signal detection and dispersion compensation. There are different reasons why the utilization of coherent detection associated digital signal processing can be very benficial. Firstly, coherent detection is a promising technology to increase optical receiver sensitivity, permitting a greater span loss to be tolerated. Secondly, coherent detection enables supporting of more spectrally efficient modulation formats such as quadrature phase shift keying (QPSK) and quadrature amplitude modulation (QAM). And instead of implementing costly physical impairments compensation links, coherent detection allows digital signal processing for compensation of transmission impairments such as chromatic dispersion (CD), polarization mode dispersion (PMD), signal carrier offset, spectrum narrowing, etc. Furthermore, next generation optical transmission systems require adaptive for time varying transmission impairments such as channel spectrum narrowing and random phase noise. Digital signal processing is a powerful solution for future adaptive optical transmission links [10,11].

Fiber optics is a major building block in the telecommunication infrastructure. Its high bandwidth capabilities and low attenuation characteristics make it ideal for gigabit transmission and beyond. In this module, you will be introduced to the building blocks that make up a fiber optic communication system. You will learn about the different types of fiber and their applications, light sources and detectors, couplers, splitters, wavelength-division multiplexers, and state-of-the-art devices used in the latest high-bandwidth communication systems. Attention will also be given to system performance criteria such as power and rise-time budgets. Companies such as AT&T, MCI, and U.S. Sprint use optical fiber cable to carry plain old telephone service (POTS) across their nationwide networks. Local telephone service providers use fiber to carry this same service between central office switches at more local levels, and sometimes as far as the neighborhood or individual home. Optical fiber is also used extensively for transmission of data signals. Large corporations, banks, universities, Wall Street firms, and others own private networks. These firms need secure, reliable systems to transfer computer and monetary information between buildings, to the desktop terminal or computer, and around the world. The security inherent in optical fiber systems is a major benefit. Cable television or community antenna television (CATV) companies also find fiber useful for video services. The high information-carrying capacity, or bandwidth, of fiber makes it the perfect choice for transmitting signals to subscribers [12].

The growth of the fiber optics industry over the past five years has been explosive. Analysts expect that this industry will continue to grow at a tremendous rate well into the next decade and beyond. Anyone with a vested interest in telecommunication would be all the wiser to learn more about the tremendous advantages of fiber optic communication. With this in mind, we hope this module will provide the student with a rudimentary understanding of fiber optic communication systems, technology, and applications in today's information world.

In wireless optical communications, the optical link is typically established by means of optical modulation (IM), in which the desired waveform is modulated onto the instantaneous power of the carrier, in conjunction with direct detection (DD) as a down-conversion technique at the receiver end. Therefore, the transmitted waveform x(t) is the instantaneous optical power of the emitter, and the received waveform y(t) is the instantaneous current in the receiving photo detector. In this way, the optical channel with IM/DD can be modelled as a baseband linear system with impulse response h(t) or, alternatively, this can be described in terms of the frequency response:

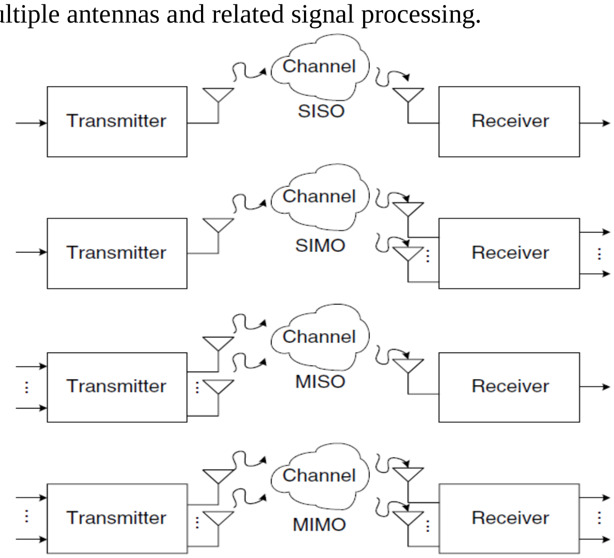
$$H(f) = \int_{-\infty}^{\infty} h(t) e^{-j2\pi f t} dt$$

which is the Fourier transform of $h(t)$ [13,14]. This channel model $h(t)$ is practically stationary because it only varies when emitter, receiver or objects in the room are moved by tens of centimetres. In many applications, optical links are operated in the presence of intense infrared and visible background light. The received background light adds shot noise, which is usually the limiting noise source in a well-designed receiver. Due to its high intensity, this shot noise can be modelled as white, Gaussian, and independent of $x(t)$. When little or no ambient light is present, the dominant noise source is receiver preamplifier noise, which is also signal-independent and Gaussian (though often nonwhite) [15]. Thus, the noise $n(t)$ is usually modelled as Gaussian and signal-independent, and the instantaneous output current at the receiver can be represented as:

$$y(t) = Rx(t) \otimes h(t) + n(t)$$

III. MIMO TECHNIQUE

Multiple antennas can be used at the transmitter and at the receiver of a communication system. Such systems are called multiple input and multiple output (MIMO) systems. MIMO systems may be implemented in several different ways and can be categorized into three types. The first type of MIMO system provides spatial diversity and enhances power efficiency. It includes space–time/frequency block code (STBC/SFBC), space–time trellis code (STTC) and delay diversity systems. The second type of MIMO system implements spatial multiplexing to increase its transmission rate. Independent data streams are transmitted over a group of antennas. At the receiver, signals from several antennas are detected and the transmitted information recovered. In the third type of MIMO system, some capacity gain can be achieved over non-MIMO systems by pre-processing the signals to be transmitted according to the channel characteristics and then decoding the received signals accordingly to the number of transmit (TX) antennas and the number of receive (RX) antennas, wireless systems can be classified as single-input single-output (SISO), single input multiple-output (SIMO), multiple-input single-output (MISO) and multiple-input multiple-output (MIMO) systems, in which the input and output are with respect to the channel between the transmitter and the receiver The advantages of employing multiple antennas and related signal processing.



- Array gain As multiple copies of the signals are received at a receiver with more than one antenna, the signals can be combined coherently to achieve gain in effective SNR. Such gain is usually called array gain. Combining methods such as equal-gain combining (EGC) and maximal ratio combining (MRC) are very popular [3]. In an SIMO system, the average SNR increase is proportional to the number of receive antennas. In the case of multiple transmit antennas, however, array gain can also be obtained, provided that spatial pre-coding based on the channel information is implemented. With this pre-coding, the multiple copies of transmitted signals supposedly will arrive at the single receiving antenna coherently.

- Diversity gain In a SISO system without signal redundancy, deeply faded signals are beyond detection. On the other hand, in wireless systems with multiple TX antennas and/or multiple RX antennas, signals can be transmitted/received with diversity so as to combat channel fading. Receive diversity in MIMO systems refers to the combination of independently faded signals from different receive antennas so that the processed signal suffers less fading than that of the receiver with only one antenna. Similarly, using coding that transmits redundant information from multiple TX antennas, transmit diversity can be achieved. Well known spatial coding techniques include space–time trellis codes (STTC) [4], space–time block codes (STBC) [5,6], space–frequency block codes (SFBC), and space–time–frequency block codes (STFBC) [7].
- Capacity gain MIMO technology brings one very important enhancement to wireless communications: gain in transmission rate. By multiplexing the transmitted data streams among different antennas, namely spatial multiplexing, an increase in data rate can be attained. This rate increase is proportional to the minimum of the number of TX antennas and the number of RX antennas. If either the transmitter or the receiver has a single antenna, then there exists no obvious capacity gain. Hence, spatial multiplexing is mainly applied to MIMO systems. Note that several data streams are simultaneously transmitted over the air and received at the RX antennas. At the receiver, these signals need to be processed to recover the information contained in the individual data streams.
- Beam forming When combining the received signals from multiple antennas, it is possible to create strong differentiation in gains for signals that arrive from different angles. The beam-forming technique [8] has traditionally been applied in the transmitter or the receiver to control the directionality of the transmit/receive antenna pattern. With proper knowledge of the channel and accordingly setting the combining coefficients, a beam forming receiver can increase the antenna gain along the direction of the intended transmitter while at the same time suppressing the interferences from other directions. Lured by these advantages, researchers have intensively studied the use of multiple antennas and, thus, this field has grown rapidly, both in theory and in implementation during the past few years [9]. The enhancement in spectral efficiency has resulted in the adoption of MIMO technology in several wireless standards. In this chapter, a brief introduction of channel capacity under different transmit/receive antenna configurations will be given first. Then, diversity gain attained by special signal arrangements in the spatial domain will be illustrated. Incorporation of the MIMO techniques into wireless OFDM systems will then be discussed. Moreover, this chapter will also cover how SISO OFDM transceivers should be extended to enjoy MIMO advantages, especially in terms of synchronization and channel estimation. Finally, several MIMO encoding and detection schemes will be presented.

OFDM has the advantage of converting a wideband frequency-selective fading channel into numerous narrow-band flat-fading sub-channels. Hence, channel fading can be mitigated by a simple one-tap equalizer. On the other hand, MIMO techniques bring about a significant performance boost for wireless communications under flat-fading channels. As a result, by combining MIMO and OFDM, new high-speed wireless communication systems enjoy the benefits from both technologies[16,17].

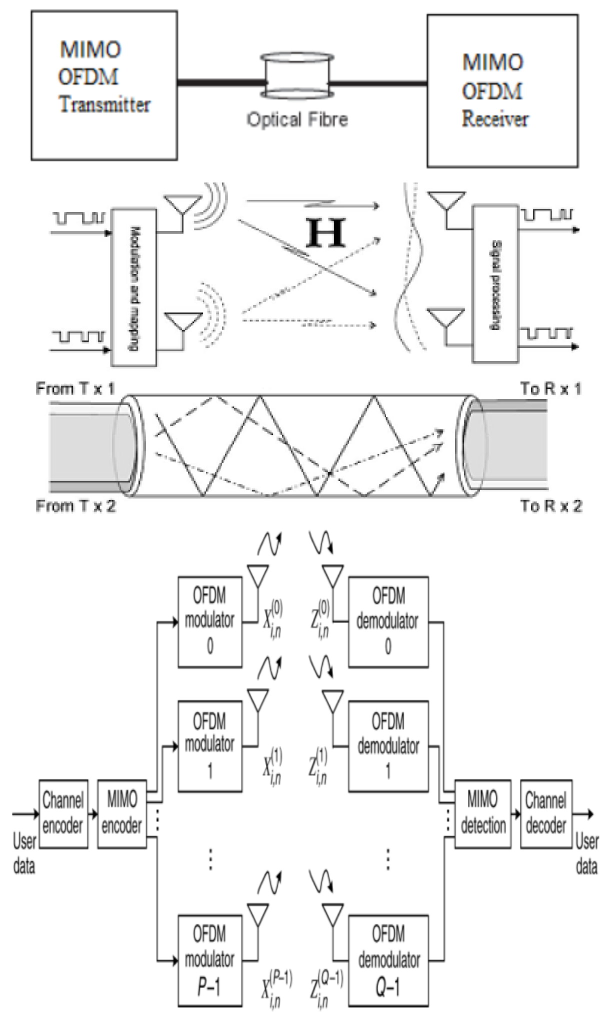


Fig. depicts a typical MIMO–OFDM system architecture with P transmit antennas and Q receive antennas. User data are first encoded by a channel encoder block, which may consist of one or more channel encoders. Afterwards, the MIMO encoder parses the data from the channel encoder block into several spatial streams. Recall that the signals transmitted by the OFDM transmitters can be represented on a symbol–subcarrier grid in the time–frequency plane. Now, in the MIMO–OFDM systems, a third spatial dimension is introduced, and, thus, the MIMO encoder output signals can be formatted in either space– time blocks, space–frequency blocks or space–time–frequency blocks. Signals at different symbols and subcarriers but with the same space coordinate are fed into a single OFDM modulator, connected to its own transmit antenna.

IV. Conclusion

The maximum achievable diversity advantage of OFDM-MIMO system. In contrast to the conventional OFDM, the factor comes from the band hopping approach, which is regardless of the temporal correlation of the channel. In this paper the impact of a of OFDM and MIMO were assessed in the presence of future work. It was found that the systems are less robust to phase noise compared to their linear systems. it has been observed that strategies to find the truly significant receiving branches, during the data retrieving for a specific user, can be applied to reduce the complexity of the demodulation problem while maintaining and, even improving, the system performance. The results have also shown that aggregate high data rates can be obtained for indoor wireless optical communications at practical signal-to-noise ratios. These demonstrations show the suitability of optical OFDM in high-speed transmission systems with high spectral efficiency. Multi input Multi output is a very attractive technique for multicarrier transmission and become one of the standard choices for high speed data transmission over a communication channel. It has various advantages, but also has one major drawback i.e. Effect of noise within frequency selective fading channel In this paper we present Analysis for future work optical MIMO OFDM System using Different Modulation Schemes. In this paper we present a comparative study with inphase component to show the better noise reduction parameters.

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