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REVIEW AND OPERATION SENSING-BASED CHANNEL ESTIMATION WITH VIRTUAL OVERSAMPLING FOR DIGITAL TERRESTRIAL TELEVISION BROADCASTING

Rajeshree[1], Vishal Jethva[2]
[1]PG Scholar, [2]Assistant Professor, E.C Department, SVBIT-Unava, Gandhinagar, Gujarat, India

Abstract: Time-domain synchronous orthogonal frequency division multiplexing (TDS-OFDM) has advantages in spectral efficiency and synchronization. However, its iterative interference cancellation algorithm will suffer from performance loss especially under severely fading channels with long delays and has difficulty supporting high-order modulations like 256 QAM, which may not accommodate the emerging ultra-high definition television service. To solve this problem, a channel estimation method for OFDM under the framework of compressive sensing (CS) is proposed in this paper. Firstly, by exploiting the signal structure of recently proposed time-frequency training OFDM scheme, the auxiliary channel information is obtained. Secondly, we propose the auxiliary information based subspace pursuit (A-SP) algorithm to utilize a very small amount of frequency domain pilots embedded in the OFDM block for the exact channel estimation. Moreover, the obtained auxiliary channel information is adopted to reduce the complexity of the classical SP algorithm. Simulation results demonstrate that the CS-based OFDM outperforms the conventional dual pseudo noise padded OFDM and CS-based TDS-OFDM schemes in both static and mobile environments, especially when the channel length is close to or even larger than the guard interval length, where the conventional schemes fail to work completely.

I. OVERVIEW

Orthogonal frequency division multiplexing (OFDM) is mainly categorized into three types of transmission schemes[1] : cyclic prefix OFDM (CP-OFDM), zero padding OFDM (ZP-OFDM), and time domain synchronous OFDM (TDS-OFDM). In traditional OFDM, a cyclic prefix (CP) is inserted as the guard interval between nearby OFDM symbols. CPOFDM and ZP-OFDM require many numbers of pilots, but this can be saved in TDS-OFDM. Thus, TDS-OFDM has higher spectral efficiency than CP-OFDM and ZP-OFDM. Also this TDS-OFDM has fast and reliable synchronization compared to the others. This can also use in digital television terrestrial broadcasting (DTTB) standard called the digital terrestrial multimedia broadcasting (DTMB). Digital terrestrial television broadcasting (DTTB) currently attracts a significant amount of attention in television services, as it provides for faster and more reliable transmission than conventional analog television services. Digital Television Terrestrial Multimedia Broadcasting (DTMB) is the TV standard for mobile and fixed terminals used in china. Integrated Services Digital Broadcasting-Terrestrial (ISDB-T) is a Japanese digital television system which is capable of offering different services such as television, mobile TV, emergency notification for earthquake, tsunami, etc. [3]. ISDB-T employs the Orthogonal Frequency Division Multiplexing (OFDM) which is a broadband modulation scheme transmitting a high rate stream using multiple subcarriers with low symbol rate [4]. In such transmission system, each subcarrier experiences a random flat fading while the whole signal spectrum experiences frequency selective fading. Thus, reliable estimation for channel frequency response (CFR) is necessary for accurate signal detection. Most wireless communications and wireless broadcasting implementations use CPOFDM, which can be considered as the “classic” version of OFDM with the lowest complexity. In recent years TDS-OFDM has been introduced, especially for TV broadcasting. DTMB can implement in both single and multicarrier modulation with a distinct structure called time domain synchronous OFDM. This standard is based on time-domain synchronous OFDM (TDSOFDM), where the level of the M-QAM modulation can either be 4, 16, 32, or 64.DTMB claim this standard that it has faster and more accurate channel tracking than the DVB-T standard does due to its use of TDSOFDM.

Compressive sensing (CS) is based on the sparsity level of the channel in which priori information is exceedingly important which is directly related to the estimation accuracy. The major aim is to reconstruct the signal. In this paper we find out the sparsity level of the channel which is not always satisfied with CS models [3]. To combine the theoretical CS model and the complex practical channel, we obtain the sparsity level of the channel into account and propose the performance analysis of sparsity level of channel based CS methods [2]. Firstly, a sparsity detection method is proposed to detect the real sparsity level of the channel. Then, we check whether the sparsity level meets the theoretical model, if it meets the CS method we propose the priori aided subspace pursuit (PA-SP) algorithm to reconstruct the sparse channel. Besides, by using the PA-SP algorithm for channel estimation it could acquire lower complexity and higher accuracy than other methods significant taps in the reconstructed channel.

Finally, the proposed channel estimation scheme has improved accuracy and robustness compared with traditional CS based methods. Recently, researches, developments and standardization of UHDTV broadcasting are being performed in the world. In Japan, various actions toward the 4K/8K broadcasting are also progressing. The commercial 4K UHDTV broadcasting service by the CS satellite has already started in 2016 and the experimental 4K/8K UHDTV broadcasting by the BS satellite started in 2016. Currently, efforts to start the commercial 4K/8K satellite broadcasting service in 2018 are being increased. In addition to satellite broadcasting, various infrastructures for UHDTV broadcasting such as CATV, IPTV and so on are being facilitated. However, the standardization of terrestrial UHDTV broadcasting has not completed yet in Japan. As is well known, several standards for terrestrial UHDTV broadcasting such DVB-T2[1] and ATSC3.0[2] have already been formulated and some commercial services are going to be initiated currently. In Japan, extensive researches and developments toward the realization of the terrestrial 4K/8K UHDTV broadcasting in 2020 are currently being performed. As one of the candidates of the next generation terrestrial UHDTV broadcasting scheme, the preliminary specification that extends the current HDTV broadcasting standard, ISDB-T (Integrated Service Television Broadcasting - Terrestrial) and developments and field experiments are being performed[6]. This preliminary specification adopts the band segmented OFDM transmission scheme based on the current ISDB-T standard [3] and various extensions such as LDPC (Low Density Parity Check) code, non-uniform constellation QAM, dual polarized MIMO transmission, etc. are applied for efficient UHDTV transmission.

In the current ISDB-T standard, the band segmented OFDM transmission are based on the FDM (Frequency Division Multiplexing) scheme that the transmission band is divided into several unit segments and maximum 3 streams are simultaneously transmitted by combining several segments. By using band segmented transmission, flexible frequency utilization according to the requirements is made possible. In the current ISDB-T standard, 13 segments in the 6MHz transmission band are used for transmission and one of the typical configuration is that the central one segment is used for the transmission of the stream for mobile reception (so called ‘One Segment Service’) and the HDTV stream for stationary reception is transmitted using the remaining 12 segments (so called ‘Full Segment Service’).

By the use of the one segment service, reception of terrestrial broadcasting by the simple mobile receiver such as cellar phones is made possible and the service is widespread in Japan. In addition, the one segment service is currently very popular in the South American countries that adopted ISDB-T standard and internationalized mobile receiver for ISDB-T one segment service is available. In the next generation digital terrestrial UHDTV broadcasting, the scheme that inherits and extents the band segmented OFDM in ISDB-T is expected one of the good candidates that realize advanced and flexible broadcasting service for mobile and stationary receptions. However, it is not always possible to achieve the optimal band utilization using the band segmented OFDM scheme based on the FDM scheme using the fixed size segments. As in the case of current ISDB-T one segment service, around the fringe of the service area of full segment service for HDTV reception, the required carrier to noise ratio (CN ratio) has sufficiently larger margin as compared to that of the full segment service. As the result, the area that the one segment service can be received is usually very wider than that of the full segment service. Although the margins for mobile reception, indoor reception and so on are added against one segment service design, excessive signal power is sometimes assigned to the one segment service. Therefore, channel allocation based on the unit segment can’t always achieve optimal frequency band utilization due to the fixed allocation size of the unit segment. In the preliminary specification of the next generation terrestrial UHDTV broadcasting, the narrower segment as compare to ISDB-T is used by increasing the number of segments and more efficient and flexible frequency utilization is realized. However, limitation due to the fixed size segment still exists.

II. ORTHOGONAL FREQUENCY DIVISON MULTIPLEX

MULTICARRIER MODULATION

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique. Multicarrier transmission is a method devised to deal with frequency selective channels. In frequency selective channels different frequencies experience disparate degrees of fading. The problem of variation in fading levels among different frequency components is especially aggravated for high data rate systems due to the fact that in a typical single carrier transmission the occupied bandwidth is inversely proportional to the symbol period. The basic principle of multicarrier transmission is to translate high rate serial data stream into several slower parallel streams such that the channel on each of slow parallel streams can be considered flat. Parallel streams are modulated on subcarriers. In addition to that, by making symbol period longer on parallel streams the effect of the delay spread of the multipath channel, namely inter-symbol interference (ISI), is greatly reduced. In multipath channels multiple copies of the transmitted signal with different delays, which depend on characteristics of the material from which the transmitted signal has been reflected, are received at the receiver. The delay spread of a channel is a measure of degree of multipath effect - it is equal to the difference between arrival times of the first and the last multipath components. Due to the fact the length of the symbol period of each parallel stream scales proportionally to the number of subcarriers used the percentage of overlap between two adjacent symbols due to delay spread and resulting from it inter-symbol interference (ISI) also decreases proportionally to the number of subcarriers.

ORTHOGONAL FREQUENCY DIVISION

MULTIPLEXING (OFDM)

- The Orthogonal Frequency Division Multiplexing (OFDM) transmission scheme is the optimum version of the multicarrier transmission scheme. In the past, as well as in the present, the OFDM is referred in the literature Multi-carrier, Multi-tone and Fourier Transform.
- The concept of using parallel data transmission and frequency multiplexing was published in the mid 1960s. After more than thirty years of research and development, OFDM has been widely implemented in high speed digital communications. Due to recent advances of digital signal Processing (DSP) and
- Very Large Scale Integrated circuit (VLSI) technologies, the initial obstacles of OFDM implementation such as massive complex computation, and high speed memory do not exist anymore.
- The use of Fast Fourier Transform (FFT) algorithms eliminates arrays of sinusoidal generators and coherent demodulation required in parallel data systems and makes the implementation of the technology cost effective (Weinstein and Ebert, 1971).
- The OFDM concept is based on spreading the data to be transmitted over a large number of carriers, each being modulated at a low rate. The carriers are made orthogonal to each other by appropriately choosing the frequency spacing between them.
- In contrast to conventional Frequency Division Multiplexing, the spectral overlapping among sub-carriers are allowed in OFDM since orthogonality will ensure the subcarrier separation at the receiver, providing better spectral efficiency and the use of steep band pass filter was eliminated.
- OFDM transmission system offers possibilities for alleviating many of the problems encountered with single carrier systems. It has the advantage of spreading out a frequency selective fade over many symbols. This effectively randomizes burst errors caused by fading or impulse interference so that instead of several adjacent symbols being completely destroyed; many symbols are only slightly distorted.
- This allows successful reconstruction of majority of them even without forward error correction. Because of dividing an entire signal bandwidth into many narrow sub bands, the frequency response over individual sub bands is relatively flat due to sub band are smaller than coherence bandwidth of the channel. Thus, equalization is potentially simpler than in a single carrier system and even equalization may be avoided altogether if differential encoding is implemented.
- The orthogonality of sub channels in OFDM can be maintained and individual sub channels can be completely separated by the FFT at the receiver when there are no intersymbol interference (ISI) and inter carrier interference (ICI) introduced by the transmission channel distortion. Since the spectra of an OFDM signal is not strictly band limited, linear distortions such as multipath propagation causes each sub channel to spread energy into the adjacent channels and consequently cause ISI.
- One way to prevent ISI is to create a cyclically extended guard interval, where each OFDM symbol is preceded by a periodic extension of the signal itself. When theguard interval is longer than the channel impulse response or multipath delay, the ISI can be eliminated.
- By using time and frequency diversity, OFDM provides a means to transmit data in a frequency selective channel. However, it does not suppress fading itself. Depending on their position in the frequency domain, individual sub channels could be affected by fading.
- This requires the use of channel coding to further protect transmitted data. Coded OFDM combined with frequency and time interleaving is considered the most effective means for a frequency selective fading channel (Shelswell, 1995).

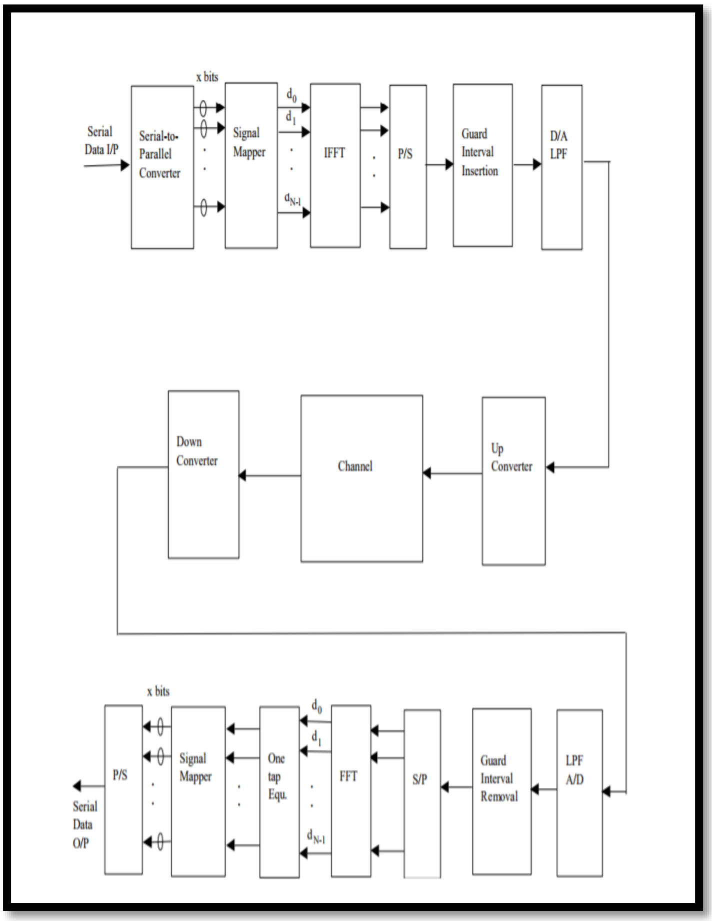

Figure 3.1 General OFDM System

- Figure 3.1 illustrates the process of a typical OFDM system. · The incoming serial data is first converted from serial to parallel and grouped into x bits each to form a complex number. The complex numbers are modulated in a baseband fashion by the IFFT and converted back to serial data for transmission.
- A guard interval is inserted between symbols to avoid intersymbol interference (ISI) caused by multipath distortion. The discrete symbols are converted to analog and lowpass filtered for RF up-conversion. · The receiver performs the inverse process of the transmitter. One tap equalizer is used to correct channel distortion. The tap coefficients of the filter are calculated based on channel information (Zou and Wu, 1995).

ADVANTAGES OF ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

In early multicarrier transmission systems subcarriers were non-overlapping to prevent inter-carrier interference which can greatly degrade performance of a system. Individual subcarriers were separated by guard bands which constituted wasted bandwidth.

The reason why Orthogonal Frequency Division Multiplexing (OFDM) has become the most popular technique of multicarrier transmission is that subcarriers overlap in frequency and therefore bandwidth utilization increases by up to 50%. Overlapping subcarriers is allowed because in OFDM modulation subcarriers are orthogonal to each other. Moreover, OFDM modulation/demodulation takes form of inverse DFT/DFT which can be efficiently implemented in hardware using Fast-Fourier Transform algorithm.

OFDM MODULATION

In OFDM transmitter N complex-value source symbols Xk k=0,1,...N-1, which can come from any constellation, such as QPSK or QAM, are modulated onto N orthogonal subcarriers - inverse Fourier-Transform complex exponentials evaluated at subcarrier frequencies fk :-

$$x(t) = \sum_{k=0}^{N-1} X_k * e^{j2\pi f_k t}$$

…… (3.1)

In a digital transmitter t=nTs where Ts is the sampling period. Subcarriers frequencies are uniformly distributed:-

$$f_k = k * f_s \quad k=0,1,\ldots N-1$$

……. (3.2)

Frequency spacing fs is equal to 1 NTs in order to preserve orthogonality between subcarriers. The final form of OFDM transmission takes a form of inverse-Fast-Fourier Transform:-

$$x_n = x(nT_s) = \sum_{k=0}^{N-1} X_k * e^{j\frac{2\pi nk}{N}} \quad n=0,1,\ldots N-1$$

….. (3.3)

N-sample long x sequence is called OFDM symbol and its duration is equal to N*Ts.

3.2.3 OFDM DEMODULATION

ADC at the receiver receives an analog signal which is a result of convolution of the transmitted OFDM symbol x(t) with the channel impulse response plus noise:-

$$r(t) = \int_{-\infty}^{\infty} r(t-\tau) * h(\tau, t) + n(t)$$

….. (3.4)

OFDM demodulation takes a form of Fast-Fourier Transform of the sampled received signal r(t) (after removal of Ng samples of the guard interval):-

$$R_k = \sum_{k=0}^{N-1} r_n * e^{-j\frac{2\pi nk}{N}} \quad k=0,1,\ldots N-1$$

…… (3.5)

Since inter-carrier interference (ICI) is avoided by maintaining orthogonality between subcarriers the channels (Hk's) at subcarriers' frequencies can be treated independently and the demodulated OFDM symbol in a frequency domain can be written as:-

$$R_k = H_k * X_k + N_k$$

…… (3.6)

After channel estimation which yields complex-valued channel attenuation factors Hk at each subcarrier's frequency the decoded k-th transmitted data symbol Xkcan be obtained through the following transformation:-

$$\hat{X}_k = \text{QAM/QPSK de-mapper } \left(\frac{R_k}{H_k}\right)$$

…….. (3.7)

III. DIGITAL TERRESTRIAL BROADCASTING

Digitalization of Broadcasting

The era of total digital broadcasting, from program production to digital receivers, will soon be upon us as a result of advances in image compression technology, higher integration and improved performance in LSI devices, and the rapid progress in digital technologies including the development of digital transmission systems. Figure 4.1 outlines the sequence by which broadcast signals are transmitted. This sequence begins with the relay of video signal by a camera on the scene or in studio and continues through program production, editing, storage, network operations, transmission, and reception. In recent years, broadcast studios have introduced advanced digital technologies and functionalities that will allow processing of broadcast signals in the studio and over relay networks. The digitalization of broadcast signals sent to households has also become a major concern in many countries. Some examples of the many advantages of digital broadcast signals are multichannel broadcasting capability, high image quality, sophisticated functions, convergence of broadcasting with other media, and efficient spectrum utilization The International Telecommunication Union Radio communication Sector (ITU-R), which debates the merits of broadcast systems from an international perspective, has been the scene of a longtime controversy on standardization, particularly among its membership from Japan, the United States, and Europe. An agreement, however, has finally been reached, and international standards are now being formulated for satellite, terrestrial, and cable systems for each of these regions. Intense competition has subsequently evolved with each of these groups trying to promote its own system throughout the world. In this regard, a number of countries including Singapore, Hong Kong, and Brazil have already begun comparison trials of the three systems for digital terrestrial television broadcasting, the broadcast signal of greatest importance.

Features of Digital Broadcasting

Compared with conventional analog systems, digital broadcasting is distinguished by the following features.

Robust versus noise

In analog broadcasting, a weakening of the received signal means degraded picture quality

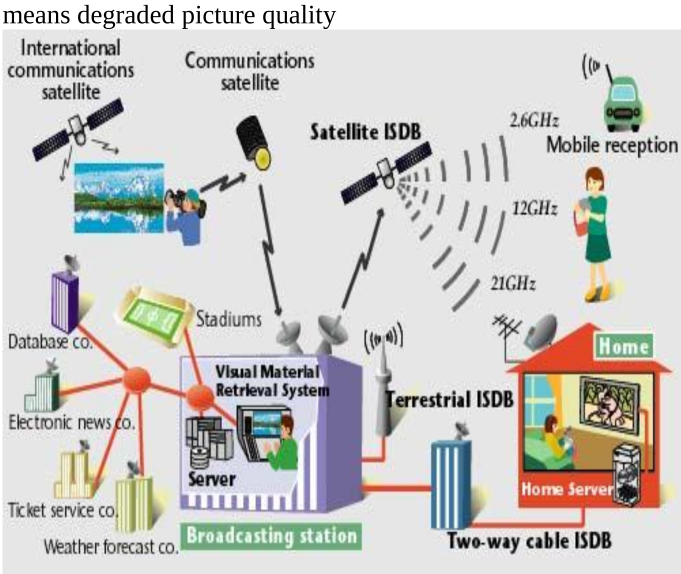

Fig. 4.1 Sequence of Broadcasting Signals

in the form of noise on the television screen. As shown in Fig. 4.2, a digital signal needs only to identify itself as a "1" or "0" making digital broadcasting more robust to noise compared with analog broadcasting.

(2) Large band compression of video and audio signals

ITU-R recommends the same compression technique for both video and audio signals, namely, MPEG-2. In the digital compression of video signals, however, the manner in which a disturbance appears depends on the characteristics of the picture. Recent MPEG-2 image-compression techniques have achieved compression ratios of 1/20 for standard TV and 1/60 for HDTV. Research on MPEG-2 continues with the aim of further improving compression ratios while maintaining an adequate level of picture quality.

(3) Error correction techniques not possible with analog signals

Basically speaking, noise cannot be removed in analog broadcasts. In digital broadcasts, however, it is possible to correct bit errors caused by disturbances on the transmission path by using error correction techniques. Here, only bit errors that are too large to be corrected will actually be labeled as "errors." While extra parity bits that must be transmitted for the

Fig. 4.2 Digital Signal and Noise

transmission power, the obtained correction effect essentially outweighs the advantage of not sending these bits. Error correction has become an indispensable technology for digital systems.

(4) Identical method of handling video, audio, data, and control signals

Digital signals consist of signals of "0" and "1" bits that are transmitted in groups called packets within which the type of digital signal is indicated. As result, all signal types can be handled in the same way. This characteristic makes it easier to add new services.

(5) High-performance data broadcasting

In data broadcasting provided by conventional analog channels, such as teletext broadcasting that uses the vertical blanking period of the TV signal, the transmission capacity is quite small, at about 11 kbps per scanning line (1H). Satellite and terrestrial digital broadcasting, on the other hand, are capable of delivering advanced data broadcasting services having transmission rates of several Mbps. Considering, moreover, that telephone lines or their like can be effectively used as uplinks, many digital data broadcasting applications can be envisioned, such as receiving immediate responses from viewers and providing easy access to the Internet.

(6) Easy to scramble signals

In contrast to the difficulty of scrambling an analog broadcasting signal, scrambling a digital signal can be scrambled so that only subscribers can receive the content of a broadcast by simply adding a specific "0" and "1" signal to the original digital signal.

(7) Low transmission power

Because digital signals are robust to noise as mentioned in item (1) above, transmitter power can be lowered. Although actual transmission power depends on bit rate and send/receive conditions, it can generally be said that digital terrestrial television broadcasting can reach a particular service area for a transmission power of about 1/10 that of an equivalent analog broadcast.

(8) Simplified channel planning
Because low power transmission is possible, there is little effect on adjacent channels or on identical channels in different areas. Channel planning is therefore easier and more channels overall can be used.
(9) Modulation systems robust against ghosts and fading
Ghosts, which is a form of interference caused by buildings, are a major problem in digital terrestrial broadcasting. Assuming that the maximum bit rate is desired for a limited frequency bandwidth, it is impossible to deal with ghosts by using the conventional single carrier modulation system. Instead, multi-carrier orthogonal frequency division multiplexing (OFDM) can be used to eliminate ghosts. OFDM can also be applied to the mobile reception environment in general.
(10) Applicable to LSI technology
LSI devices are achieving higher levels of integration and higher speeds each year. Since most tasks performed by digital broadcast receivers consist of digital signal processing, smaller and cheaper receivers can be expected.
(11) Sudden drop in service quality just beyond service area
In analog broadcasting, moving away from the transmitting antenna means more noise on the television screen and gradual deterioration of the picture as receive power weakens. In digital broadcasting, on the other hand, the use of error correction techniques results in a steep curve for the relationship between receive power and bit error rate on the receiver side. As a consequence, exceeding the receive-power limit results in complete loss of reception as opposed to a gradual deterioration in picture quality.
(12) New frequencies needed for digital broadcasting
At present, a large range of frequencies are being used for analog broadcasts in Japan's terrestrial broadcasting system and few frequencies are available for digital broadcasts. For digital terrestrial broadcasting, it will therefore be necessary to appropriate some of the frequencies currently being used for analog broadcasting or to allocate new frequencies for digital broadcasting. It has been decided to reserve low frequencies in the UHF band for digital broadcasting in Japan.
(13) Users must purchase new receivers
Since conventional analog receivers cannot, of course, be used for receiving digital broadcasts, users will have to purchase receivers especially designed for digital broadcasts.
(14) Facility investment required by broadcast stations
Broadcasters will have to invest in various types of equipment including video/audio encoding devices, program-production equipment for data broadcasting, operating equipment, and transmission equipment.
Although items (11) to (14) above represent disadvantages regarding the digitalization of broadcast signals, there is a huge movement throughout the world to realize high-quality, multichannel, high-performance broadcast systems that will eventually overcome these shortcomings.
System Comparison of DVB-T and DTMB systems
In DVB-T, only the central 83% subcarriers are actually available for data transmission. The remaining FFT points at side parts are deliberately shut down to limit the signal spectrum within 8 MHz analog bandwidth. In order to aid channel estimation and synchronization, continual and scattered pilots are inserted in OFDM symbols, occupying more than 10% subcarriers. There are about 1% subcarriers allocated to the transmission parameter signaling (TPS) which relates to the transmission parameters, e.g. channel coding and modulation. All these factors degrade the spectrum utilization in DVB-T and further introduce a useful data rate loss. On the other hand, in DTMB, the synchronization and channel estimation are performed by using PN sequences. So there is much less spectrum efficiency loss due to pilots. The only spectrum efficiency degradation comes from the 36 symbols of system information in each 3780-long OFDM block. These symbols take about 1% subcarriers, which is equivalent to the cost of TPS in DVB-T. Eventually, the spectrum utilization of DTMB is about 10% higher than that of DVB-T.
GI is also an expense of transmission power and useful data rate. In DVB-T, CP is a duplicate of data part with the same power. However, in DTMB, two types of PN sequence frame header are boosted to obtain better channel estimation and synchronization performance. The boosted PN sequence spends more power than the non-boosted CP given

		Single carrier mode	**Multicarrier mode**
Origin		Former ADTB-T	Former DMB-T
Number of subcarriers		C = 1	C = 3780
PN sequence Frame Header	Length	595 (1/6)	420 (1/4), 945 (1/9)
	Power	Non boost	Boosted by 2
	Phase	Same in a superframe	Different or same
Mapping		4QAM-NR, 4QAM, 16QAM, 32QAM	4QAM, 16QAM, 64QAM
Interleaver		Time domain	Time & Frequency domain
Coding	Outer	BCH(762, 752)	
	Inner	LDPC(7493, 3048), (7493, 4572), (7493, 6096)	
	Code rate	0.4(7488, 3008), 0.6(7488, 4512), 0.8(7488, 6016)	

Table 1. Parameters of DTMB

The same GI length. In order to evaluate the transmission costs in the two systems, all factors mentioned above should be taken into account. An evaluation of power efficiency can be obtained by calculating the ratio of the power allocated to the data subcarriers over all power spent in the transmission. Specifically, in DVB-T, this power efficiency factor can be computed by

$$\gamma_{DVB-T} = \frac{N_{data}}{N_{data} + N_{TPS} + N_{pilot} \times boost} \times \frac{1}{1+GI} \quad \text{.......(1)}$$

Where Ndata, NTPS, Npilot represent the number of data, TPS and pilot subcarrier, respectively. The boost is the boost factor for pilot subcarriers. The GI stands for the fraction of GI over data part. In DTMB, a similar expression can be written as

$$\gamma_{DTMB} = \frac{N_{data}}{N_{data} + N_{info}} \times \frac{1}{1+GI \times boost}. \quad \text{..(2)}$$

(2) Uses the same notation as (1) except that Ninfo represents the number of system information symbols. It should be noticed that this power efficiency factor presents the power allocation in data subcarriers independent of mapping and coding scheme. Or, in other words, it is a measurement of the transmission overhead in terms of power, showing the efficiency of the system data structure. Parameters and the resulting power efficiency factors are presented in Table III. In GI = 1/4 case, although DTMB has higher spectrum utilization ratio of 10%, DTMB and DVB-T have the same power efficiency factor. This is mainly due to the fact that the PN sequence which takes a large portion of transmitted signal, are boosted, decreasing the overall power efficiency. However, this problem is less Significant in the GI = 1/9 mode of DTMB. The power efficiency factor in this case is 0.81, which is not only significantly higher than the equivalent GI = 1/8 mode in DVB-T, but is even slightly higher than it in the case of the minimum GI of 1/32.

Besides increasing the spectrum utilization, PN sequence makes it possible to achieve a faster channel acquisition in DTMB. In the DVB-T system, complete channel estimation can be performed by using pilots from four consecutive OFDM blocks, while, in DTMB, it can be made for every block relying on its own PN sequence. This feature is expected to make DTMB more robust in high mobility scenario.

	DVB-T		DTMB
	2K mode	*8K mode*	*C = 3780*
FFT size	2 048	8 192	3 780
Nb. of subcarriers	1 705	6 817	3 780
Nb. of data subcarriers	1 512	6 048	3 744
Subcarrier spacing	4 464 Hz	1 116 Hz	2 000 Hz
Signal bandwith	7.61 MHz	7.61 MHz	7.56 MHz
OFDM symbol duration	224 µs	896 µs	500 µs
Power efficiency factor	0.66 (GI=1/4), 0.73 (GI=1/8), 0.77 (GI=1/16), 0.79 (GI=1/32)		0.66 (GI=1/4), 0.81 (GI=1/9)

Table 2. Parameter Comparison between DVB-T & DTMB

IV. MODELLING AND SIMULATION

Core Working Model

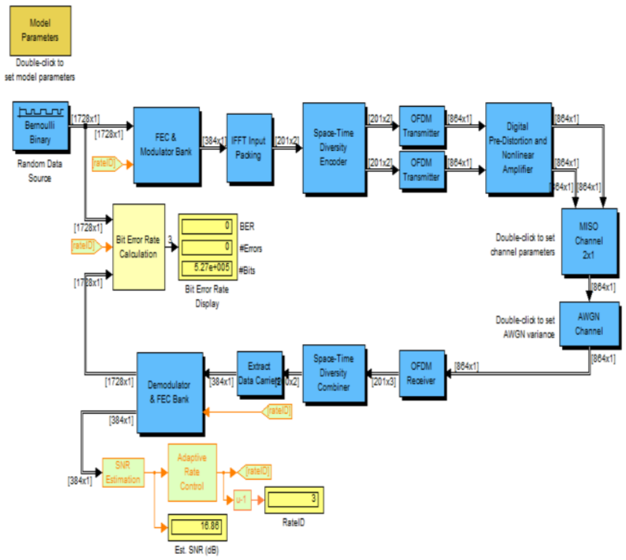

Fig.5.1 OFDM transmission network model

The above shown figure explains us the core system for transmission i.e., How we will use OFDM transmission for DTTB. Above MATLAB simulation is for multiple input single output (MISO) channel. We modulate the binary data & then after fourier transform & encoding for secure & less SNR transmission we use Digital pre-distortion technique. Afterwards, the data is send through gauss noise channel & received with OFDM receiver where data is extracted & demodulated to check SNR & receive original data.

Performance of the Model

We have simulated the model from fig. 5.1 in MATLAB. The Performance Parameters of each stage are as shown in below figures.

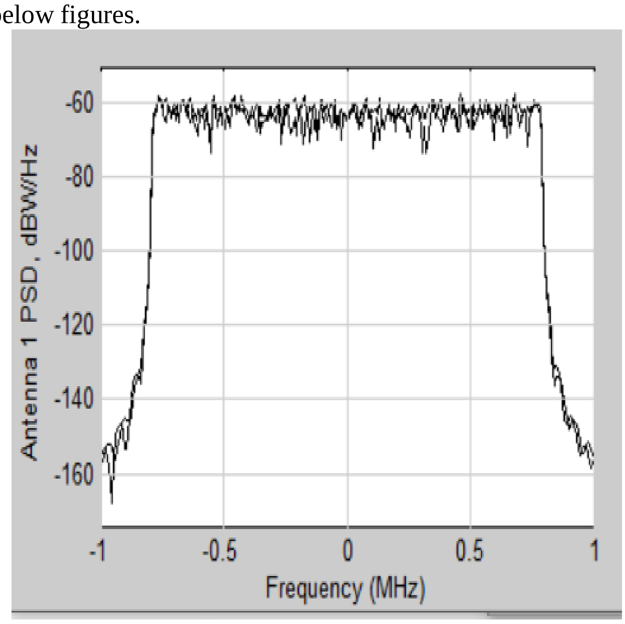

Fig. 5.2 Transmitter antenna

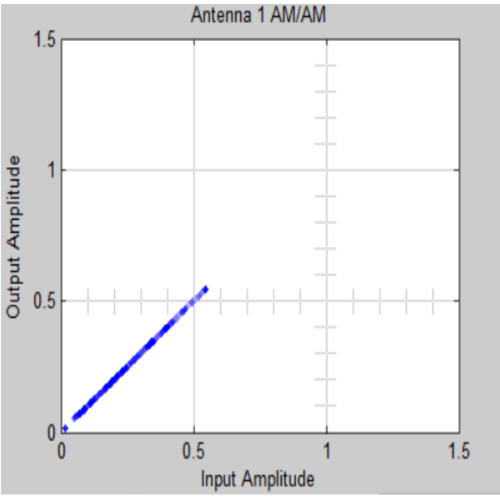

Fig. 5.3 Digital pre-distortion and Amplifier

Digital Pre-distortion helps not to let the data fluctuate too much, i.e. it gives a refined data for transmission to the amplifier. Because of this even when the noise is added through Gauss noise channel in our transmission, If we use adaptive rate control the data can be identified very easily and extraction becomes the same so.

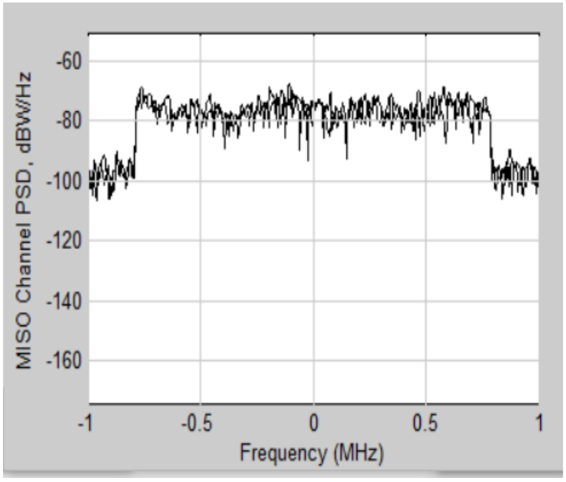

Fig. 5.4 AWGN channel spectrum

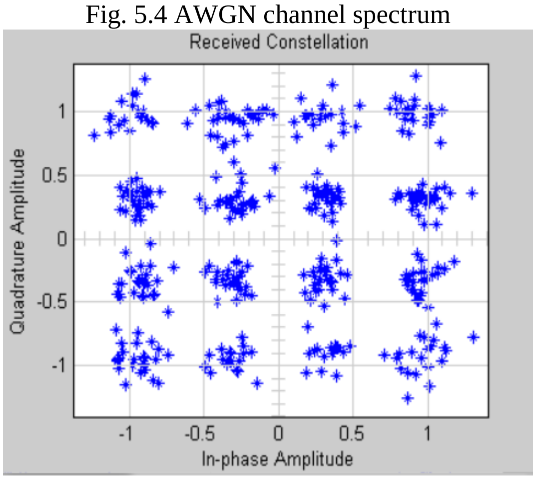

Fig. 5.5 Extracted Data

V. CONCLUSION

We have proposed CS-based accurate channel estimation employing MOMP for ISDB-T system. The proposed CS is a time domain based channel estimation. We discuss a fractional delay issue that exist in time domain based channel estimation. We introduced virtual oversampling at the receiver in order to guarantee successful reconstruction of the unknown CIR under the impact of fractional delay.

Furthermore, we also proposed MOMP, which is a modification of OMP to reduce the computational complexity caused by the virtual oversampling. Since the virtual oversampling carries out at the receiver side, the system can avoid the increase of bandwidth during transmission. OFDM requires synchronization in both the time and frequency. Time synchronization involves finding the best possible time instant for the start of received and down converted OFDM frame. Frequency synchronization deals with finding an estimate of the difference in the frequencies between the transmitter and receiver local oscillators. Subcarriers have the minimum frequency separation required to maintain orthogonally of their corresponding time domain waveforms, yet the signal spectra corresponding to the different subcarriers overlap in frequency. The MSE performance of this method outperforms the conventional schemes and is close to the CRLB by simultaneously exploiting the time-domain PN sequence and frequency-domain pilots. Simulation results show that the proposed scheme has a good BER performance in both static and mobile scenarios and can well support the 256 QAM, especially when the maximum channel delay spread is fairly close to or even larger than the GI length. Besides, by using the auxiliary channel information, the proposed A-SP algorithm has lower complexity than the conventional SP algorithm. Thus, this scheme is expected to extend TDS-OFDM in the emerging UHDTV applications under SFN with long channel delay spread.

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