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Performance prediction of DAB modulation and transmission using Rayleigh Fading channel

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Abstract

A Simulink-Matlab simulation model design and simulate the Digital audio broadcasting to overcome the analogue frequency modulation (FM) broadcasting system. Digital Audio Broadcasting (DAB) system developed within the Eureka 147 Project is a new digital radio technology for broadcasting radio stations that provides high-quality audio and data services to both fixed and mobile receivers. In wireless communication multipath fading and ISI is the main problem. In this model this problem can be overcome by using the combination of DAB with OFDM system. By plotting the graph between BER and SNR it can be prove that this model is efficient. This model presents the performance analysis of Eureka-147 DAB system. DAB transmission mode-II is implemented first and then extended successfully to other modes. A frame-based processing is used in this study. Performance studies for Rayleigh Fading channels have been conducted. For all studies BER has been used as performance criteria.

Keyword:- DAB, Matlab, Modulation, Simulation.

1. INTERODUCTION

Digital audio broadcasting (DAB) was developed in the early 1990's by the European consortium Eureka 147, mainly to replace the widely used analogue frequency modulation (FM) broadcasting system. The VHF band is a scarce resource in many parts of the world, so there was a need for a spectrally more efficient modulation method than FM. Digital Audio Broadcasting (DAB) is a new digital radio system that delivers radio services from the studio to the receiver. DAB is intended to deliver very high quality digital audio programmes and data services to fixed, mobile and portable receivers which can use simple whip antennas. It was developed in the 1990s by the Eureka 147 DAB project. DAB is very well suited for mobile reception and provides very high robustness against multipath reception. It allows use of single frequency networks (SFNs) for high frequency efficiency. DAB uses COFDM technology that makes it resistant to Multipath fading and inters symbol interference (ISI). FM reception can be badly affected by shadowing and by passive echoes (the arrival at the receiver of delayed "multipath" signals which have been reflected from tall buildings and hills).

A.DAB transmission system

The overall DAB transmission system can be broken down into a number of sub-blocks (Fig. 1). The audio signal is MPEG layer-2 encoded and then scrambled. Forward error correction is applied to the scrambled bit-stream by employing punctured convolutional codes with code-rates.

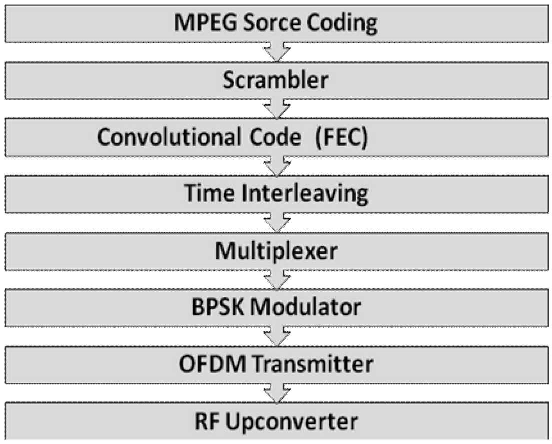

Fig1.DAB functional diagram of transmitter

The bit-stream is sent through a timeinterleaver before it is multiplexed with the other programmes to form an ensemble. The ensemble bit-stream is fragmented into individual OFDM symbols, which are obtained by differential BPSK modulation of the subcarriers and basically an inverse Fourier transform (IFFT) operation within the OFDM transmitter. In the receiver the corresponding inverse operations have to be carried out. The information bit-stream is divided into a number of lower rate bit-streams in OFDM, which are individually modulated onto orthogonal sub-carriers. To achieve orthogonality sub-carriers are spaced in frequency by the inverse of the symbol duration, theoretically resulting in zero inter-carrier interference. Although the sinc(f) responses mutually overlap, they go through zero at center frequencies of all other sub-carriers, giving a spectrum efficiency for BPSK modulation of each sub-carrier. Orthogonal sub-carriers can be realized with the IFFT algorithm, which can be readily integrated into hardware. Each sub-carrier is modulated with BPSK, which maps the incoming bits to complex symbols for each sub-carrier k.

B.DAB transmission modes

Technically, the DAB transmission system can be used in all VHF and UHF broadcasting frequency bands between 30 and 3000 MHz and four specific modes for typical applications have been defined (Table I). The total symbol duration consists of the principal symbol period and a guard interval, which prevents the echo of the previous symbol from interfering with the current symbol. By doing so, inter-symbol interference (ISI) is reduced to almost zero as long as the echoes from the various transmitters and propagation paths do not substantially exceed the guard interval.

TABLE 1
THE DAB TRANSMISSION MODES

Mode	Total symbol duration	Main application
I.	1246 us	Terrestrial DAB,Large coverage area,VHF.
II.	312 us	Terrestrial DAB,small to medium coverage area,UHF.
III.	156 us	Satellite DAB,no long echoes,UHF.
IV.	623 us	For Canada, between mode 1 and 2.

All modes have an ensemble bandwidth of exactly 1.536 MHz, but since the symbol duration and therefore the carrier spacing (inverse of the useful symbol duration) vary, the number of carriers that can be accommodated within the ensemble bandwidth differs from one mode to another. If the receiver physically moves within the reception area, Doppler spread increases and temporal coherence of the channel is reduced. In addition the signal spectrum is Doppler shifted. If the received OFDM sub-carriers are shifted with respect to the reference frequency in the receiver, inter-carrier interference is increased. The closer the sub-carriers are spaced, the more severe becomes inter-carrier interference, consequently symbol duration is a compromise: i.e. if symbol duration is too short then delay spread of the channel causes intersymbol interference, while if symbol duration is too long then sub-carriers become closely spaced in frequency enabling already small Doppler shifts to produce high intercarrier interference. While if symbol duration is too long then sub-carriers become closely spaced in frequency enabling already small Doppler shifts to produce high intercarrier interference.

2. SIMULINK MODEL IN MATLAB

Information source

This is the first block in the transmitter section of the DAB system model for simulation. It generates random binary data bit sequence for FIC and MSC. Therefore the data for one transmission frame is given by:

$$DATA\ bits = FIC_{DATA} + MSC_{DATA}$$

MSC is a time interleaved data channel divided into a number of sub channel which are individually convolutionally coded.FIC is used to signal the multiplex configuration of the DAB transmission and service information.

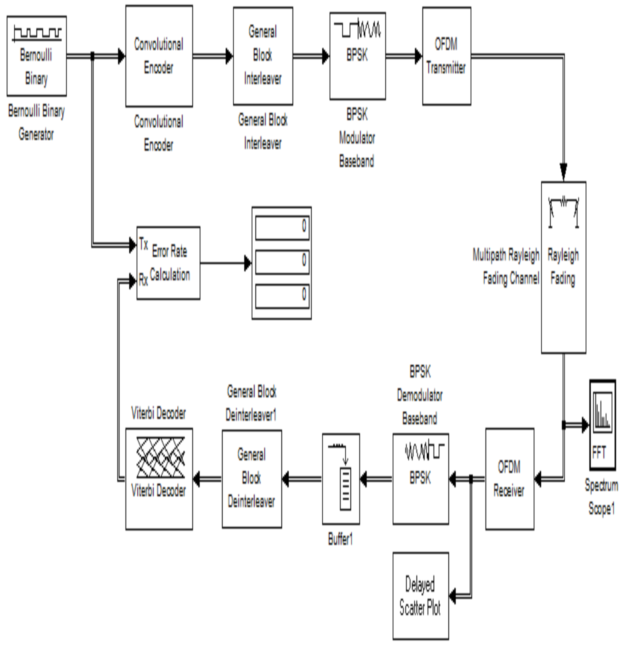

Fig 2. Simulink model of DAB transmitter and receiver.

Convolution Encoder

The Convolutional Encoder block encodes a sequence of binary input vectors to produce a sequence of binary output vectors. This block can process multiple symbols at a time. Here the output data stream Tx_bits from previous block is input to convolutional encoder. Channel coding is based on punctured convolutional forward-error-correction (FEC) which allows both Equal and Unequal Error Protection (UEP) described in section . DAB system has a convolutional encoder with constraint length 7 and octal forms of generator polynomials are 133,171, 145 and 133, respectively.

General block intetrleaver

The General Block Interleaver block rearranges the elements of its input vector without repeating or omitting any elements. If the input contains *N* elements, then the **Elements** parameter is a column vector of length *N*.

BPSK Modulator

In mobile communications the multipath effect can degrade the phase of the carriers. The solution to this problem is to send the information as the difference between the phases of two symbols. This is accomplished by this block BPSK modulation. In this modulation scheme there is no absolute phase reference, each symbol is referenced only against the previous symbol. This greatly simplifies the decoder.

QPSK mapping

The QPSK digital symbol mapping block is responsible for mapping (in parallel) serial bit stream in each data block into a digital constellation according to QPSK modulation scheme given in DAB standard , defined as:Each data block of 768 bits is mapped onto the 384 complex coefficients for one OFDM symbol of duration TS. The first 384 bits will be mapped to the real parts of the 384 QPSK symbols, the last 384 bits will be mapped to the imaginary parts. QPSK encodes two bits per symbol. Therefore output of this block is complex consisting of 75 blocks of 384 bits.

Frequency de-interleaving

Frequency interleaving was performed at the transmitter to nullify transmission disturbances such as selective fade. This sub-block performs the reverse of the frequency interleaving by re-arrangement of the bits to get QPSK symbol block identical with the output of QPSK mapping.

QPSK de-mapping

This sub-block converts the received complex QPSK symbols from the frequency de-interleaver output into bits. When the sign of the real part of the complex QPSK symbol is negative, the decoded bit is „1□ and when it is positive the decoded bit is „0□. The same rule is applicable to imaginary part of the complex QPSK symbol . The decoded bits should be arranged in the similar manner in which bit was used for QPSK mapping. The decoded I phase component bit will be assigned to index 1 to 384 and Q phase component bits to index 385 to 768.

Viterbi Decoder

The Viterbi Decoder block decodes input symbols to produce binary output symbols. This block can process several symbols at a time for faster performance. The input to the Viterbi decoder will be hard-decided bits that are „0 or „1.

3.RESULT

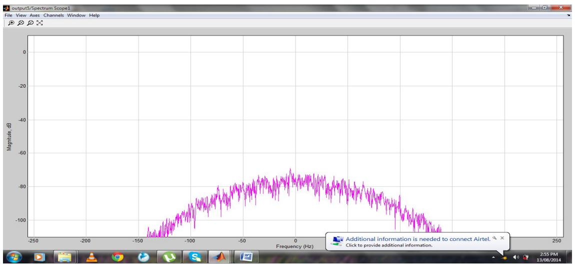

Fig 3. Output of spectrum scope

Fig. 4 shows output of spectrum scope. It is combination of signal from OFDM transmitter and Rayleigh Fading.

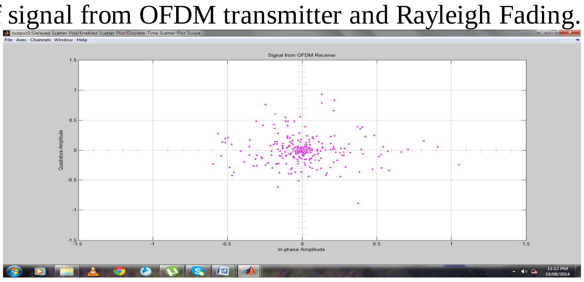

Fig 4. Constellation when Doppler shift is 5

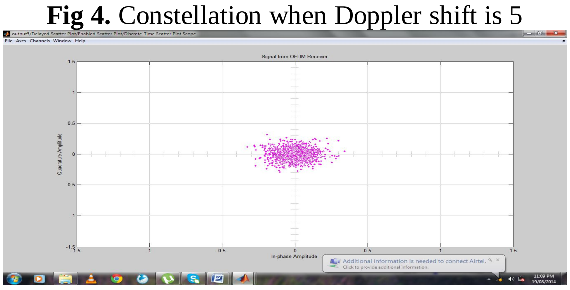

Fig 5. Constellation when Doppler Shift is 50

The above figures i.e. figure 4 and 5 shows the constellation diagram of the signal transmitted using OFDM system for a modulation scheme of BPSK. For fig 4 Doppler shift is 5Hz, while for fig 5 Doppler shift is 50Hz . It can be seen very clearly that the scatter plot converges to a circle as the Doppler shif is increased. The system gives good BER when Doppler shift is Zero. From this we concluded that Doppler shift effect is directly proportional to BER.

4. CONCLUSION

The performance of DAB modulation schemes can be predicted under specific artificial test conditions in Matlab/Simulink. The graphical user interface enables the user to adjust parameters rapidly and to obtain a quantitative feel as to how transmission quality is affected if these parameters are adjusted. Finding the relation between bit error ratio and subjective audio quality at an early stage leads to efficient performance estimation since extensive listening tests are avoided. Simulation in the complex baseband domain is well suited to predict the performance of modulation schemes including different kinds of channels. Frame-based processing should be used to model multi-rate systems such as DAB. In future DAB system has various scope as the listener welcome a new technology which offers more choice and higher technical quality, as well as a very robust signal when listening in a vehicle or on a portable set. A new frequency allotment plan at VHF has been agreed for Europe. It provides sufficient frequencies for the start of terrestrial DAB services.

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