

# Coded OFDM Based Convolutional Coding Approach for Dab Application for Effective Ber Analysis

Sana Fatima<sup>1</sup> Rajendra Kulkarni<sup>2</sup>

<sup>1</sup>Assistant Professor

<sup>1,2</sup>Guru Nanak Dev Engineering College, Bidar, Karnataka, 585403, INDIA.

**Abstract**— In this paper we exhibit an investigation of Bit Error Rate (BER), for Digital Audio Broadcasting (DAB) framework, utilizing Coded OFDM with various channel coding plans. Examination is done for convolutional coded and turbo coded information in an Additive White Gaussian Channel (AWGN) in light of various imperative lengths and code generator polynomials utilized for coding. A relative study on the computational multifaceted nature is likewise done by applying a sound flag and measuring the information preparing time per outline, on PCs with various processor speeds. It is demonstrated that a coding increase of roughly 6 dB is accomplished utilizing turbo coding when contrasted with convolution coding, at an expense of higher computational multifaceted nature.

**Key words:** DAB, OFDM, Convolutional Codes, Turbo Codes

## I. INTRODUCTION

The prerequisite of versatility while associated with system is energizing the development of remote correspondence. The routine simple transmission systems don't perform well in versatile environment, since appropriate procedures to moderate the impacts of multipath spread instigated blurring have not been produced for these frameworks. Orthogonal Frequency Division Multiplexing (OFDM) is one such strategy to battle the impact of multipath blurring, recurrence specific blurring and Intersymbol Obstruction (ISI) [1]. OFDM Diminishes the measure of equipment execution since multiplexing and sifting operations can be performed by utilizing the Fast Fourier Transform (FFT). This wipes out the need numerous oscillators at the transmitter and synchronizing circles at the beneficiary. Because of the cyclic augmentation of sign period into a gatekeeper interim, OFDM framework is reasonable for Single Frequency Networks (SFN) [5].

In this paper an OFDM application standard called Computerized Audio Broadcasting (DAB) framework model is executed in Matlab/Simulink environment. The execution of this framework over a channel irritated by AWGN clamor is considered. Coded Orthogonal Frequency Division Multiplexing (COFDM) procedure is considered in which convolutional codes and turbo codes are utilized what's more, figured the subsequent piece mistake rates (BER). The variety in BER is dissected taking into account diverse coding parameters. A sound sign is transmitted and information preparing time per edge is measured and thought about for diverse channel coding plans.

## II. SYSTEM MODEL OF DAB USING CODED OFDM

### A. A Simplified DAB Block Diagram:

A general block diagram of the Digital Audio Broadcasting transmission system is shown in Fig. 1. The simple sign is encoded and connected to channel encoder. After channel coding the bit streams are QPSK mapped. The information is then gone to OFDM generator. The high information rate bit stream is separated into "N" parallel information surges of low information rate and separately regulated on to orthogonal subcarriers which is acknowledged utilizing IFFT calculation. Orthogonality of the subcarriers accomplishes zero Inter Image Interference, hypothetically [1]. At long last, the OFDM image is given cyclic prefix and the finished Touch outline structure is transmitted through an AWGN channel.

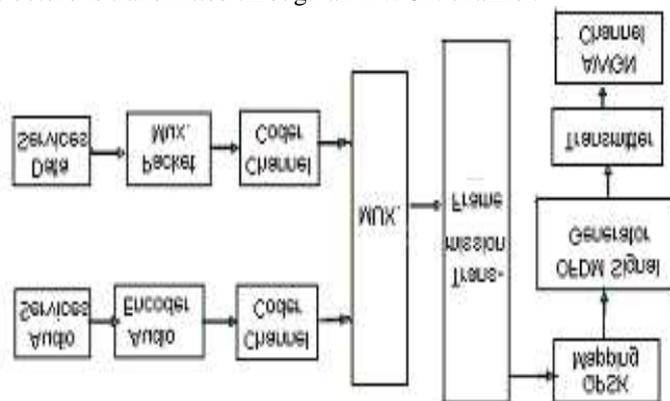


Fig. 1: DAB transmitter – Block Diagram.

**B. DAB Transmission Modes:**

DAB system has four transmission modes, each with its own set of parameters, shown in Table-I [12]. In this paper Transmission Mode-I is selected for simulation.

Transmission Mode	No. of Sub-carriers	Sub carrier spacing	FFT Length	Maximum Radio Frequency
TM I	1536	1 KHz	2048	≈ 375 MHz
TM II	384	4 KHz	512	≈ 1.5 GHz
TM III	192	8 KHz	256	≈ 3 GHz
TM IV	768	2 KHz	1024	≈ 750 MHz

Table 1: Dab Transmission Modes

**III. CHANNEL CODING**

**A. Convolutional Encoding & Viterbi Decoding:**

A convolutional encoder comprises of a M-stage shift register with "k" inputs, endorsed associations with "n" modulo-2 adders and multiplexer that serializes the yields of the adders. Here the encoder chose has k=1, ie; the info succession touches base on a solitary information line. Subsequently the code rate is given by  $r = 1/n$ . In an encoder with a M stage shift enroll, the memory of the coder approaches M message bits and  $K = (M+1)$  movements are required before a message bit that has entered the movement register can at long last exit. This parameter K is alluded to as the imperative length of the encoder.

The channel coding utilized for standard DAB comprises of code rate  $1/2$ , memory 6, convolutional code with code generator polynomials 133 and 171 in octal organization [2]. For Spot lower code rates give better execution. Subsequently in this work, encoder with code rate  $\bar{w}$  is chosen. One such convolutional encoder is appeared in Fig. 2. The quantity of registers=6. Consequently the imperative length  $K=7$ . Generator Polynomials are 171, 133 and 115 in octal organization. Reproduction is done for different estimations of limitation length and generator polynomials, which are given in Table-III.

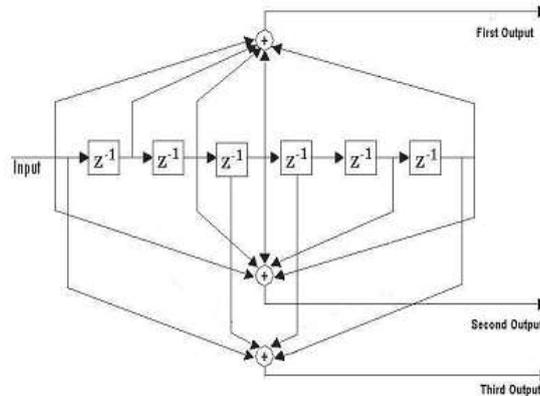


Fig. 2: A rate  $\bar{w}$  convolutional encoder with constraint length,  $K=7$ .

**B. Parallel Concatenated Convolutional Turbo Coding & Decoding:**

Parallel Concatenated Convolutional turbo code (PCC turbo code) comprises of two or more Recursive Systematic Convolutional (RSC) coders working in parallel [8]. The reason for interleaver is to offer each encoder an irregular variant of the data bringing about equality bits from each RSC that are free.

On the receiving side there are same number of decoders as on the encoder side, each working on the same information and an independent set of parity bits.

In this work, to give same code rate to turbo encoder as on account of convolutional encoder, a parallel connection of two indistinguishable RSC encoders are utilized which gives a code rate of  $\bar{w}$ . One such turbo encoder is appeared in Fig. 3, where the quantity of registers in each RSC encoder=2. Henceforth the limitation length  $K=3$ . Generator polynomials are 7 and 5 in octal arrangement. The number 7 indicates the input polynomial.  $\lambda$  is the arbitrary interleaver. Reenactment is completed for different estimations of requirement length, generator polynomials and input polynomials, which are given in Table-III.

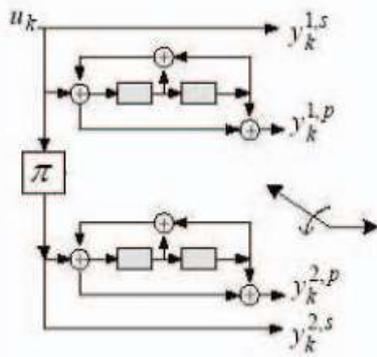


Fig. 3: A rate  $\bar{w}$  turbo encoder with 2 parallel recursive systematic convolutional encoders, each with constraint length,  $K=3$ . The inputs are data bits and called  $u_k$ . The yields are code bits. Of these, the yield of first encoder,  $y_{k1, s}$  is known as the precise piece, and it is the same as the information bit. The second yield bit,  $y_{k1, p}$  is the principal equality bit which is recursive deliberate piece. An interleaver, indicated by  $\Lambda$ , is put in the middle of the two encoders to guarantee that the information got by the second encoder is measurably autonomous. The third yield bit,  $y_{k2, p}$  is the second equality bit which is additionally a recursive deliberate piece. The fourth yield  $y_{k2, s}$  is deterministically reshuffling adaptation of  $y_{k1, s}$ , which is not transmitted.

For decoding, the Viterbi Algorithm is not suited to generate the A-Posteriori-Probability (APP) or soft decision output for each decoded bit. Here Maximum-A-Posteriori (MAP) algorithm is used for computing the metrics. Block diagram of turbo decoder is shown in Fig. 4.

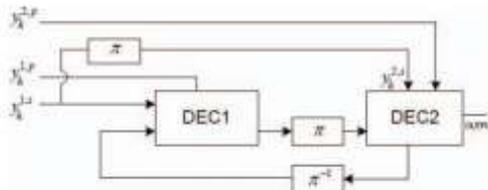


Fig. 4: Turbo decoder – Block Diagram.

In Fig. 4, DEC1 and DEC2 are 2 APP decoders.  $\Lambda$  and  $\Lambda^{-1}$  are random interleaver and deinterleaver respectively [14]. The symbol vector sent for each time are described by  $y_k=(y_{k1, s}, y_{k1, p}, y_{k2, p})$ . The goal is to take these and make a guess about the transmitted vector and hence code bits which in turn decode  $u_k$ , the information bit.

#### IV. SIMULATION MODEL

##### A. Simulation Parameters:

The simulation parameters are shown in Table-II [1]. The different channel coding schemes and its parameters used for the analysis are given in Table-III. Even though, a complete DAB system consists of a multiplex of many information service channels, here, for the purpose of analysis, only a single audio signal is selected for transmission.

Transmission Mode	Mode I
No. of sub-carriers	1536
Transmission frame duration ( $F_t$ )	96 ms.
OFDM Symbols per Transmission Frame	76
Sample Time ( $T_s$ )	0.48828 $\mu$ s
Frame length	196608 (or $F_t/T_s$ )
FFT length	2048
Guard interval (Cyclic Prefix)	504
OFDM length	2552
Channel Coding schemes Used	Convolutional coding (rate $1/3$ ), Turbo coding (rate $1/3$ )
Modulation	QPSK
Channel	AWGN

Table 2: Simulation Parameters

Channel Coding types	Constraint length	Code generator polynomials (Octal format)	Feedback Polynomial
Convolutional Coding	3	7, 6, 5	—
	4	15, 13, 11	—
	5	34, 27, 23	—
	6	71, 57, 47	—
	7	171, 133, 115	—
Turbo Coding	3	7, 5	7
	4	15, 13	15
	5	34, 27	34
	6	71, 57	71
	7	171, 133	171

Table 3: Channel Coding Parameters

B. Simulation Block Diagram:

Fig. 5 and Fig. 6 show the simulation models for DAB using convolutional coding and turbo coding respectively. Simulations are carried out using Matlab/Simulink.

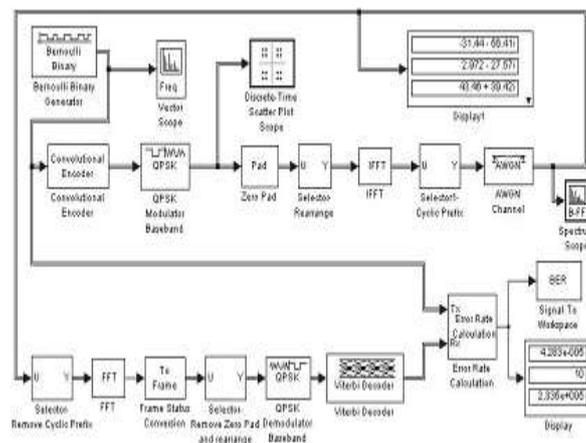


Fig. 5: Simulation model for DAB transceiver using convolutional coding & viterbi decoding.

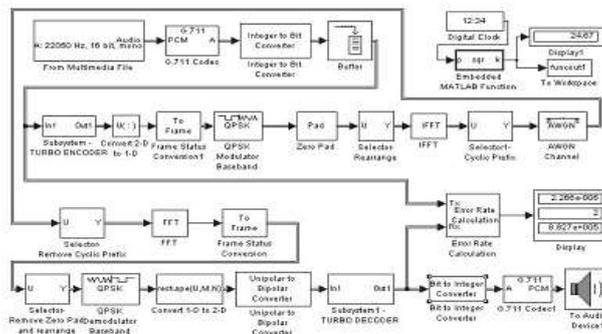


Fig. 6: Simulation model for DAB transceiver using turbo coder and decoder. An audio signal is inputted and analyzed.

## V. RESULTS

Coding Scheme	Frame Processing time on low speed computer (milli seconds)	Frame Processing time on high speed computer (milli seconds)
Conv_CnstrLn3	3.93	2.59
Conv_CnstrLn4	4.18	2.81
Conv_CnstrLn5	4.60	3.13
Conv_CnstrLn6	5.51	3.86
Conv_CnstrLn7	7.07	5.18
Turbo_CnstrLn3	28.36	16.79
Turbo_CnstrLn4	44.43	27.66
Turbo_CnstrLn5	77.89	50.20
Turbo_CnstrLn6	142.50	92.57
Turbo_CnstrLn7	270.90	180.30

Table 4: Frame Processing Time Comparison

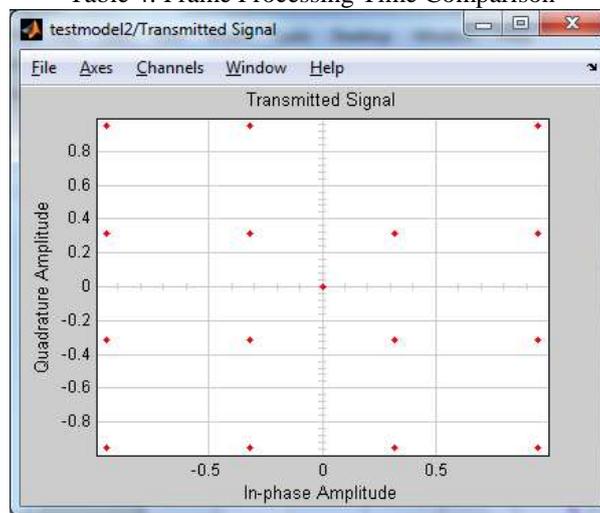


Fig. 7: Transmitted Signal

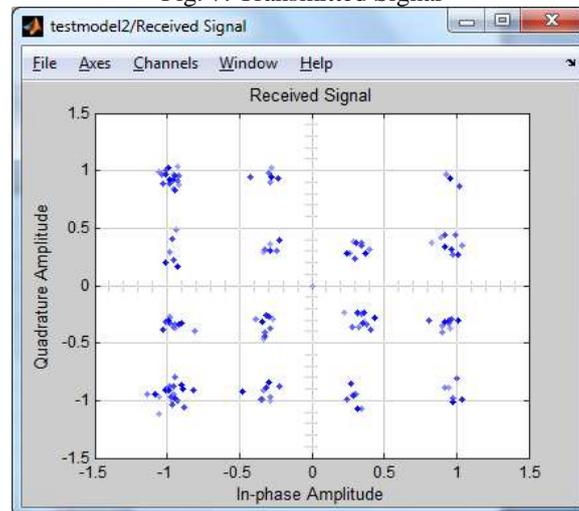


Fig. 8: Received Signal

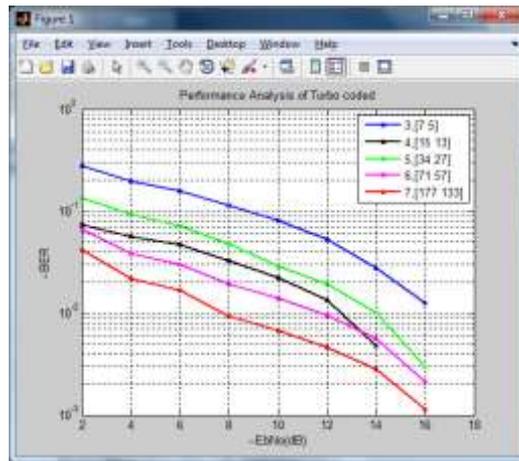


Fig. 9: Performance Analysis Of Turbo Codes

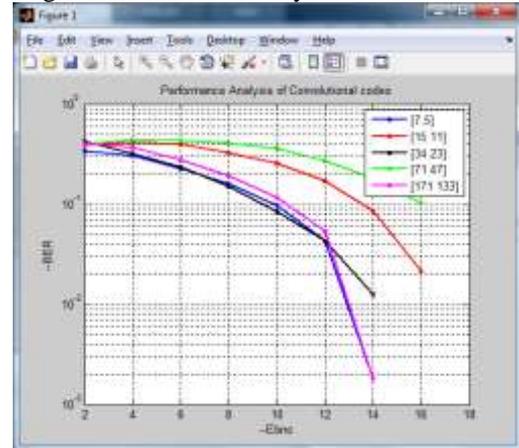


Fig. 10: Performance Analysis Of Convolutional Codes

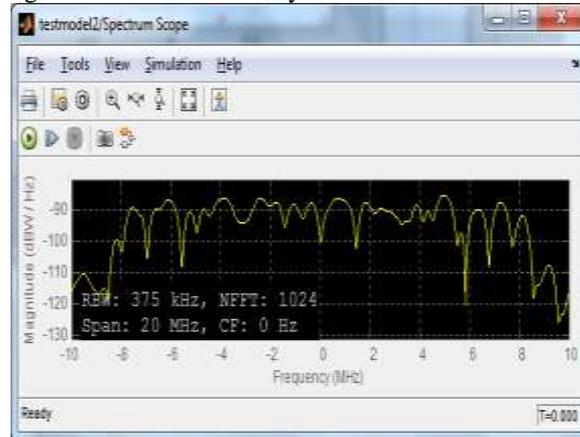


Fig. 11: Frequency spectrum

## VI. CONCLUSION

Computerized Audio Broadcasting framework utilizing Coded OFDM is executed and contemplated over an AWGN channel. Bit-Error-Rate (BER) is measured and looked at by utilizing mistake adjusting codes like, Convolutional Code and Parallel Concatenated Convolutional Turbo Code. A decent BER for sound is thought to be 10<sup>-4</sup>. Utilizing turbo coding, it is almost accomplished with an Eb/No of 3 dB. A coding increase of about 6 dB is accomplished utilizing turbo coding, when contrasted with convolutional coding, at an expense of high computational many-sided quality. Likewise, reenactment is done on low speed and rapid PCs and edge preparing time is measured as a section of study on Quality of Service (QoS). It is demonstrated that, slightest complex turbo code obliges 3 to 4 times the preparing time taken by most astounding complex convolutional code. In this way coding increase is accomplished utilizing turbo code by trading off on computational time required.

The burdens of the customary codes like convolutional codes is that, with an end goal to approach the hypothetical point of confinement for Shannon's channel limit, we require to expand the imperative length of a convolutional code, which, thus, causes the computational intricacy of a most extreme probability decoder to increments exponentially. At last we achieve a point where unpredictability of the decoder is high to the point that it gets to be hard to figure it out physically furthermore

there is no impressive diminishment in BER. Further coding addition is conceivable with turbo codes with sensible coding and deciphering multifaceted nature. In this paper, it is intended to legitimize these conclusions with reenactments.

The channel chose just presents Gaussian clamor. In any case, issues confronted by blurring and multipath can be examined by picking other channel models. Rather than QPSK adjustment conspire, the same framework can be examined utilizing other tweak procedures like DQPSK also, QAM. Rather than parallel linked convolutional turbo codes, serial connected convolutional turbo code additionally can be executed and examined.

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