Efficient Transmitter Design Techniques in Digital Communication

Theresh Babu Benguluri,Sandeep Kumar,Siddharth Maurya,Sai Manasa,Raktim Goswami,Abhishek Bairagi , G V V Sharma*

CONTENTS

***Abstract*—A brief description of Efficient Transmitter Design (ETD) techniques is provided. These include Interleaver/Deinterleaver for combating bursty errors, Physical Layer Framing for the efficient detection of Frame starting, and Pulse Shaping to combat InterSymbol Interference.**

1. Interleaver/Deinterleaver

For 8PSK, 16APSK, and 32APSK mapping schemes, a block interleaver [1] is used to mitigate the effects of bursty channel. For Concatenated Channel coding schemes bit interleaving is necessary. The mapped data is serially put as column wise and searially read out row wise. Fig. 1 shows bit interleaving scheme for 8PSK.

Fig. 2 generated by

shows the BER comparison of 8PSK mapping scheme with and without interleaver.

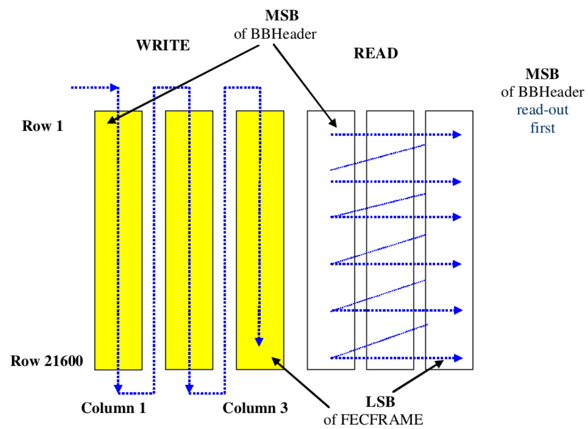

Fig. 1: Bit Interleaver Structure for 8PSK mapping scheme

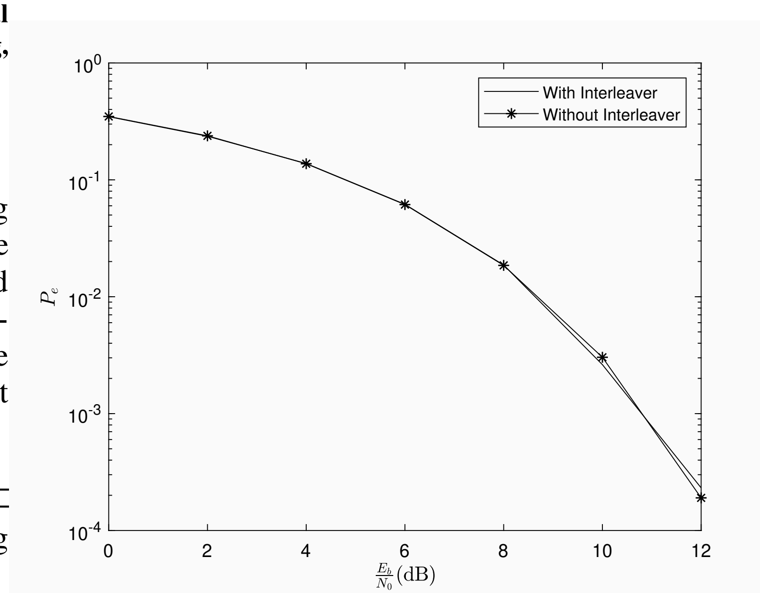

Fig. 2: Bit interleaver for 8PSK

2. Physical Layer Framing(PLFRAMING)

PLFRAMING useful for the specifying modulation scheme and code rate and frame characteristics.In receiver synchronization, Frame synchronization plays a key role.

Fig. 3 shows the Typical Structure of PLFRAME according to [1].

$$I_{2i-1} = Q_{2i-1} = \frac{1}{\sqrt{2}}(1 - 2y_{2i-1}) \quad i = 1, 2, \ldots, 45 \tag{2.1}$$

*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India e-mail: gadepall@iith.ac.in.

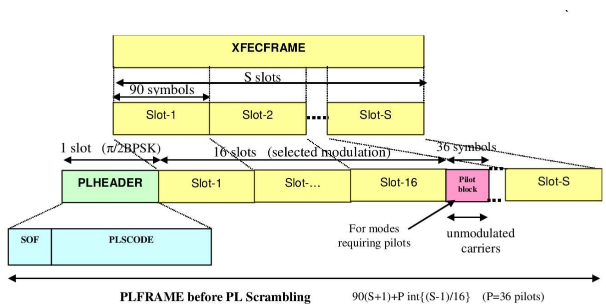

Fig. 3: Structure of PLFRAME.

$$I_{2i} = -Q_{2i} = -\frac{1}{\sqrt{2}}(1 - 2y_{2i-1}) \quad 1, 2 \ldots, 45 \quad (2.2)$$

The PLHEADER, represented by binary stream , $y_1, \ldots, y_{90}$ is modulated into 90 $\frac{\pi}{2}$-BPSK symbols. Eqs.(2.1) and (2.2) shows the generation of $\frac{\pi}{2}$-BPSK mapping.

- PLHEADER consists of two fields,
  1) Starting of Frame(SOF) 26 symbols
  2) Physical Layer Signalling Code (PLSC) , 64 symbols

A. Generation of SOF

SOF consistutes a fixed sequence $18D2E82_{HEX}$ in binary format which is from right to left.

B. Generation of PLSC

- Generation of PLSC involes definining 7 symbols and multiplying first 6 symbols with the defined G matrix in [1]. First 5 symbols called as MODCOD filed and next 2 symbols as TYPE field.
- First 5 symbols represents MODCOD which specifies Frame's mapping scheme and code rate.
- Next 2 symbols represents TYPE filed which specifies Frame length and presence and absesnce of pilot fileds. (0 = normal: 64 800 bits; 1 = short: 16 200 bits) ; (0 = no pilots, 1 = pilots)

Fig. 4 shows the MODCOD coding for various mapping schemes. Similarly, Fig. 5 shows the generation of 64 bits.

After the generation of PLS code, we will again scramble the PLS Code with the fixed SCR sequence which is defined in the [1].

$$PLSC = PLSC \oplus SCR \quad (2.3)$$

Mode	MOD COD	Mode	MOD COD	Mode	MOD COD	Mode	MOD COD
QPSK 1/4	1_D	QPSK 5/6	9_D	8PSK 9/10	17_D	32APSK 4/5	25_D
QPSK 1/3	2_D	QPSK 8/9	10_D	16APSK 2/3	18_D	32APSK 5/6	26_D
QPSK 2/5	3_D	QPSK 9/10	11_D	16APSK 3/4	19_D	32APSK 8/9	27_D
QPSK 1/2	4_D	8PSK 3/5	12_D	16APSK 4/5	20_D	32APSK 9/10	28_D
QPSK 3/5	5_D	8PSK 2/3	13_D	16APSK 5/6	21_D	Reserved	29_D
QPSK 2/3	6_D	8PSK 3/4	14_D	16APSK 8/9	22_D	Reserved	30_D
QPSK 3/4	7_D	8PSK 5/6	15_D	16APSK 9/10	23_D	Reserved	31_D
QPSK 4/5	8_D	8PSK 8/9	16_D	32APSK 3/4	24_D	DUMMY PLFRAME	0_D

Fig. 4: MODCOD coding for various mapping schemes

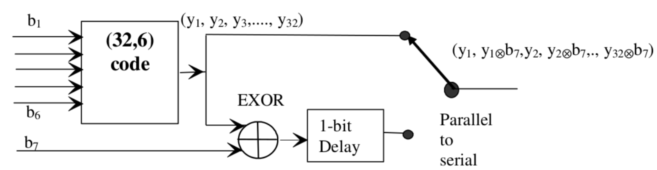

Fig. 5: Physical Layer Signalling generation

C. Generation of Pilots

Pilot block consists of $P = 36$ symbols. Each pilot is composed of un-modulated complex symbol.Where, $I = Q = \frac{1}{\sqrt{2}}$ The first pilot block inserted 16 slots after the PLHEADER and next is inserted after the 32 slots and so on.

$$K = \begin{cases} 90 \times (S + 1) & \textit{with out pilots} \\ 90 \times (S + 1) + 36 \times \alpha_{PIL} & \textit{with pilots} \end{cases} \quad (2.4)$$

Where , $\alpha_{PIL} = \left\lfloor \frac{(S-1)}{16} \right\rfloor$.
Eq.(2.4) specifies the total length K of the PLFRAME. Smiliarly, Fig. 6 Shows the Parameters of PLFRAME.

3. Pulse Shaping

$$Y_k(m) = H_k(m) * X_k + V_k(m) \quad m = 1, \ldots, M; k = 1, \ldots, N \quad (3.1)$$

PARAMETERS OF THE *normal* AND *short* PLFRAME

	normal frame: $\eta_{LDPC} = 64800$ bits				short frame: $\eta_{LDPC} = 16200$ bits			
η_{MOD}	S	α_{PIL}	K	η (%)	S	α_{PIL}	K	η (%)
QPSK: 2	360	22	33282	97.35	90	5	8370	96.77
8PSK: 3	240	14	22194	97.32	60	3	5598	96.46
16APSK: 4	180	11	16686	97.09	45	2	4212	96.15
32APSK: 5	144	8	13338	97.17	36	2	3402	95.24

Fig. 6: paramters of plframe

Where, H_k represents the pulse shape, $V_k(m) \sim \mathcal{N}\left(0, \sigma^2\right)$.

At the Receiver we will,

$$Y_k(m) * H_k^*(M - m) = H_k^*(M - m) * H_k(m) * X_k + V_k(m) \tag{3.2}$$

$H(f)$ will be choosen from the [1] which is converted to time domain form to get $H_k(m)$

$$H(f) = \begin{cases} 1 & |f| < f_N(1-\alpha) \\ \left\{\frac{1}{2} + \frac{1}{2}\sin\frac{\pi}{2}\left[\frac{f_N - |f|}{\alpha}\right]\right\}^{\frac{1}{2}} & |f| = f_N(1-\alpha) \\ 0 & |f| > f_N(1-\alpha) \end{cases} \tag{3.3}$$

References

[1] A. Morello and V. Mignone, “DVB-S2X: The New Extensions to the Second Generation DVB Satellite Standard DVB-S2,” *Int. J. Satell. Commun. Netw.*, vol. 34, no. 3, pp. 323–325, May 2016. [Online]. Available: https://doi.org/10.1002/sat.1167