Efficient Transmitter Design Techniques in Digital Communication

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

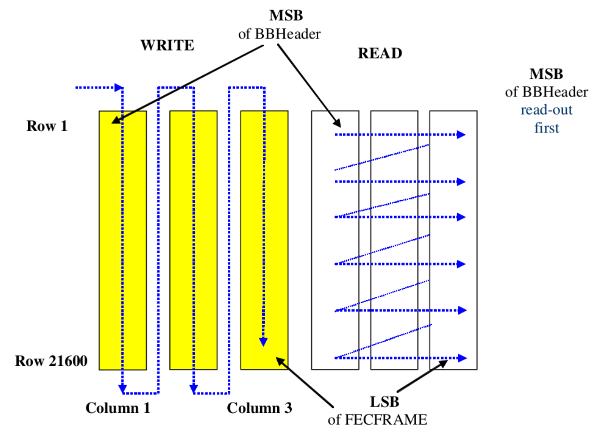

Fig. 1: Bit Interleaver Structure for 8PSK mapping scheme

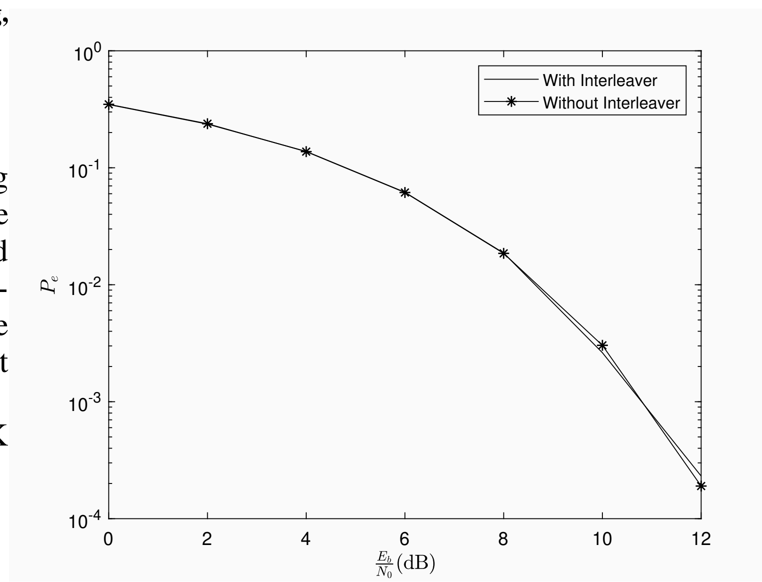

Fig. 2: Bit interleaver for 8PSK

2. Physical Layer Framing(PLFRAMING)

PLFRAMING is useful for specifying the modulation scheme, code rate and frame characteristics, useful for Frame synchronization at the receiver.

Fig. 3 shows the Typical Structure of PLFRAME according to [1]. More details are available in Tables I and II.

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

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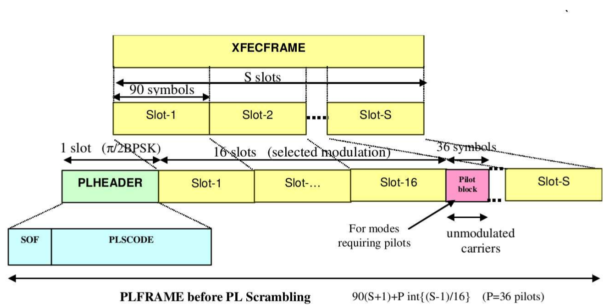

Fig. 3: Structure of PLFRAME.

	SHORT FRAME (16200 bits)								
PLFRAME	SOF	PLSC	Slot-i	#Slots	Pilot Symbols	Pilot Blocks	#Pilots	Without Pilots	With Pilots
QPSK	26	64	90	90	36	5	180	8190	8370
8PSK	26	64	90	60	36	3	108	5490	5598
16APSK	26	64	90	45	36	2	72	4140	4212
32APSK	26	64	90	36	36	2	72	3330	3402

TABLE I: Short frame details.

	NORMAL FRAME (64800 bits)								
PLFRAME	SOF	PLSC	Slot-i	#Slots	Pilot Symbols	Pilot Blocks	#Pilots	Without Pilots	With Pilots
QPSK	26	64	90	360	36	22	792	32490	33282
8PSK	26	64	90	240	36	14	504	21690	22194
16APSK	26	64	90	180	36	11	396	16290	16686
32APSK	26	64	90	144	36	8	288	13050	13338

TABLE II: Long frame details.

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

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.

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

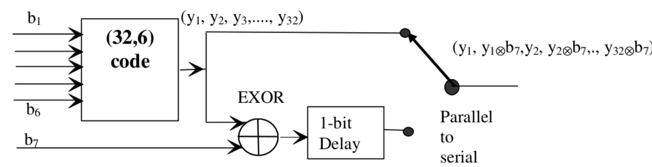

Fig. 5: Physical Layer Signalling generation

- 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].

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

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

PARAMETERS OF THE *normal* AND *short* PLFRAME

	normal frame: $\eta_{\mathrm{LDPC}} = 64800$ bits				short frame: $\eta_{\mathrm{LDPC}} = 16200$ 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

16 slots after the PLHEADER and next is inserted after the 32 slots and so on.

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

Where , $\alpha_{PIL} = \left\lfloor \frac{(S-1)}{16} \right\rfloor$.

Eq.(2.4) specifies the total length K of the PL-FRAME. Smiliarly, Fig. 6 Shows the Parameters of PLFRAME.

3. Pulse Shaping

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

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