**Framing**

Bit Stuffing – 011111**0**00 -> é obrigatório colocar este 0 sempre que a combinação de 1 zero e 5 uns aparece e não for suposto ser flag

**Controlo de erros**

Hamming

**Paridade impar = nº impar de 1’s coloca-se 1 e par 0**

**Paridade par = nº par de 1’s coloca-se 2 e ímpar 0**

Coloca-se bits em todas as posições que são potências de 2 (2^0=1,2^1=2,2^2=4,2^3=8…)

1 0 1 0 0 1 1 0 0

2^0 2^1 1 2^2 0 1 0 2^3 0 1 1 0 0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2^x | 2^0  0 | 2^1  0 | 1 | 2^2  1 | 0 | 1 | 0 | 2^3  0 | 0 | 1 | 1 | 0 | 0 |  |
| 2^0=1 | 1 | - | 1 | - | 1 | - | 1 | - | 1 | - | 1 | - | 1 | 2-1 |
| 2^1=2 |  | 1 | 1 | - | - | 1 | 1 | - | - | 1 | 1 | - | - | 4-1 |
| 2^2=4 |  |  |  | 1 | 1 | 1 | 1 | - | - | - | - | 1 | 1 | 1-1 |
| 2^3=8 |  |  |  |  |  |  |  | 1 | 1 | 1 | 1 | 1 | 1 | 2-1 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Para saber onde é o erro, pegamos nos valores em que dá o nº de 1’s diferente e somamos (ex: 2^0+2^1+2^3=11, 11 é onde houve o suposto erro)

1

a)

A: 01000111 -> 2^6+2^2+2^1+1=71

B: 11100011 -> 227

ESC: 11100000 -> 224

FLAG: 01111110 -> 126

**2** 7 1 **3** 2 2 7 **3** 2 2 4 **3** 1 2 6

b)

0100 11100000 0111 11100011 11100000 01111110

c) 0 1 0 0 0 1 1 1 1 1 **0** 1 0 0 0 1 1 1 1 1 **0** 0 0 0 0 0 0 0 1 1 1 1 1 1 0

2-

A B **ESC** ESCC **ESC** ESC **ESC** FLAG **ESC** FLAG D

3-

0 1 1 1 1 0 1 1 1 1 1 **0** 0 1 1 1 1 1 **0** 1 0

4- dividing: 1001

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 |  |  |  |  |  |  |  |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |  |  |  |
|  |  |  |  | 1 | 0 | 0 | 1 |  |  |  |
|  |  |  |  | 0 | 1 | 0 | 0 | 0 |  |  |
|  |  |  |  |  | 1 | 0 | 0 | 1 |  |  |
|  |  |  |  |  |  |  |  | 1 | 0 | 0 |

Trocando o terceiro bit a contar da esquerda

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 |  |  |  |  |  |  |  |
| 0 | 0 | 1 | 0 | 1 | 1 |  |  |  |  |  |
|  |  | 1 | 0 | 0 | 1 |  |  |  |  |  |
|  |  | 0 | 0 | 1 | 0 |  |  |  |  |  |
|  |  |  |  | 1 | 0 | 0 | 1 |  |  |  |
|  |  |  |  | 1 | 0 | 0 | 1 |  |  |  |
|  |  |  |  | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

Resto diferente de zero logo houve um erro no envio

5-dividing: 1001

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 |  |  |  |  |  |  |  |
| 0 | 0 | 1 | 1 | 0 | 0 |  |  |  |  |  |
|  |  | 1 | 0 | 0 | 1 |  |  |  |  |  |
|  |  | 0 | 1 | 0 | 1 | 0 |  |  |  |  |
|  |  |  | 1 | 0 | 0 | 1 |  |  |  |  |
|  |  |  | 0 | 0 | 1 | 1 | 1 | 0 |  |  |
|  |  |  |  |  | 1 | 0 | 0 | 1 |  |  |
|  |  |  |  |  |  | 1 | 1 | 1 | 0 |  |
|  |  |  |  |  |  | 1 | 0 | 0 | 1 |  |
|  |  |  |  |  |  |  | 1 | 1 | 1 | 0 |
|  |  |  |  |  |  |  | 1 | 0 | 0 | 1 |
|  |  |  |  |  |  |  | 0 | 1 | 1 | 1 |

6-

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2^0  **1** | 2^1  **0** | 1 | 2^2  **0** | 0 | 1 | 0 | 2^3  **0** | 1 | 1 | 1 | 1 | Nº 1’s |
| 2^0 | 1 | - | 1 | - | 1 | - | 1 | - | 1 | - | 1 | - | 3 |
| 2^1 |  | 1 | 1 | - | - | 1 | 1 | - | - | 1 | 1 | - | 4 |
| 2^2 |  |  |  | 1 | 1 | 1 | 1 | - | - | - | - | 1 | 2 |
| 2^3 |  |  |  |  |  |  |  | 1 | 1 | 1 | 1 | 1 | 4 |

After encoding: **1 0 1 0 0 1 0 0 1 1 1 1**

7-

0xE4F-> 1 1 1 0 0 1 0 0 1 1 1 1

2^0-> 1; 2^1->1; 2^2->0 ;2^3->0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2^0 | 2^1 | 1-**0** | 2^2 | 0 | 1 | 0 | 2^3 | 1 | 1 | 1 | 1 | 1’s |
| 2^0 | 1 | - | 1 | - | 1 | - | 1 | - | 1 | - | 1 | - | 3 |
| 2^1 |  | 1 | 1 | - | - | 1 | 1 | - | - | 1 | 1 | - | 4 |
| 2^2 |  |  |  | 1 | 1 | 1 | 1 | - | - | - | - | 1 | 2 |
| 2^3 |  |  |  |  |  |  |  | 1 | 1 | 1 | 1 | 1 | 4 |

Erro no bit 2^1=2;

8-

R= 4\*10^3 bps

Tp= 20\*10^-3 s

L=?

U=50%=0,5

0.5=1/(1+2a)⬄a+0.5=1 ⬄ a=0.5

a=Tp/Tf ⬄ 0.5=20\*10^-3 / Tf ⬄ Tf = 40\*10^-3

Tf=L/R ⬄ L=Tf\*R ⬄ L=160 bits

9-

Tp= 3000\*6=18000 us = 0,18s

R= 1,544 Mbps= 1,544\*10^6 bps

L= 64 byte = 512 bits

Tf= 512/(1,544\*10^6) = 0,00033 s

a= 0,18/0,00033 = 545,5

1=W/(1+2\*545,5) ⬄ W= 1092

1092 = 2^k ⬄ log2(1092)=k ⬄ 10,09=k

10-

Frame size= 1000 bits

Speed transmission = 1Mbs = 1 000 000 bps

Tp= 270 msec = 270\*10^-3 s

Tf = 1000/1 000 000= 0,001

a= (270\*10^3)/0,001 =27

1. U= 1/(1+2\*27) = 0,018 = 1,8 %
2. U= (2^3)/(1+2\*27) = 0,145 = 15%
3. U= (2^2)/(1+2\*27) = 0,072 = 7%

11-

Data rate = 1Mbps=1\*10^6 bps

Dist = 100m

Frame size = 1500 bytes = 12 000 bits

Speed = 2\*10^8 m/s

Tf = 12000/(1\*10^6) = 0.012

Tp = 100/(2\*10^8) =5\*10^-7

a= 0,00004166

1. U= 1/(1+2\*0,00004166)=0,99=100%
2. U= 1, porque W >= 1+2a
3. ?????