**IEEE P802.15**

**Wireless Personal Area Networks**

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| Source | Trang Nguyen, Thanh Luan Vu, Yeong Min Jang (Kookmin University) |  |
| Re: | D4 comment resolution |
| Abstract | Provide additional text for Annex decoding guidance (Normative text) |
| Purpose | D4 comment and resolution |
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# Annex L.1 Generation of Hamming code

(Normative)

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| Trang’s note:* Black text: No update
* Red text and the second figure: are to add
* Subsection index is corrected
 |

**L.1.1 Generation matrix and Parity check matrix**

Hamming block coding (n, k) maps a block of k data bits input into n bits output.

For (n, k)=(8,4), the generator matrix G is defined as

$$G= \left(\begin{array}{c}0 0 0 1\\1 0 0 1\\0 1 0 1\\0 0 1 0\end{array}\right)\_{4,8}$$

The parity check matrix is defined as

$$H= \left(\begin{array}{c}1 0 1 0\\0 1 1 0\\1 1 1 0\\1 1 1 1\end{array}\right)\_{4,8}$$

For (n, k) = (15,11), the generator matrix G is defined as

$$G=\left(\begin{array}{c} 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0\\0 1 1 0 0 1 0 0 0 0 0 0 0 0 0\\0 0 1 1 0 0 1 0 0 0 0 0 0 0 0\\1 1 0 1 0 0 0 1 0 0 0 0 0 0 0\\ 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0\\0 1 0 1 0 0 0 0 0 1 0 0 0 0 0\\1 1 1 0 0 0 0 0 0 0 1 0 0 0 0\\0 1 1 1 0 0 0 0 0 0 0 1 0 0 0\\ 1 1 1 1 0 0 0 0 0 0 0 0 1 0 0\\1 0 1 1 0 0 0 0 0 0 0 0 0 1 0\\1 0 0 1 0 0 0 0 0 0 0 0 0 0 1\end{array}\right)$$

The parity check matrix is defined as

$$H=\left(\begin{array}{c}1 0 0 0 1 0 0 1 1 0 1 0 1 1 1\\0 1 0 0 1 1 0 1 0 1 1 1 1 0 0\\0 0 1 0 0 1 1 0 1 0 1 1 1 1 0\\0 0 0 1 0 0 1 1 0 1 0 1 1 1 1\end{array}\right)$$

**L.1.2 Encoding rule**

The block of output bits **x** is generated by multiplying the block of input bits **a** with the generation matrix G.

**x** = **aG**

For example, by applying Hamming (8,4), with **a** = 1011,

**x** = **aG** = (1 0 1 1)$ \left(\begin{array}{c}0 1 1 1\\1 0 1 1\\1 1 0 1\\1 1 1 0\end{array}\right)$ = (2 3 1 2 0 1 1 2) = (0 1 1 0 0 1 1 0)

1011 is encoded into 01100110 where blue digits are data; red digits are parity bits from the (7,4) Hamming code, and the green digit is the parity bit added by the (8,4) code. Finally, it can be shown that the minimum distance has increased from 3, in the (7,4) code, to 4 in the (8,4) code.

Table: 4-to-8 Hamming encoding

|  |  |
| --- | --- |
| **Input bits** | **Output bits** |
| 0 0 0 0 | 0 0 0 0 0 0 0 0 |
| 0 0 0 1 | 1 1 0 1 0 0 1 0 |
| 0 0 1 0 | 0 1 0 1 0 1 0 1 |
| 0 0 1 1 | 1 0 0 0 0 1 1 1 |
| 0 1 0 0 | 1 0 0 1 1 0 0 1 |
| 0 1 0 1 | 0 1 0 0 1 0 1 1 |
| 0 1 1 0 | 1 1 0 0 1 1 0 0 |
| 0 1 1 1 | 0 0 0 1 1 1 1 0 |
| 1 0 1 1 | 0 1 1 0 0 1 1 0 |
| 1 0 0 1 | 0 0 1 1 0 0 1 1 |
| 1 0 1 0 | 1 0 1 1 0 1 0 0 |
| 1 0 1 1 | 0 1 1 0 0 1 1 0 |
| 1 1 0 0 | 0 1 1 1 1 0 0 0 |
| 1 1 0 1 | 1 0 1 0 1 0 1 0 |
| 1 1 1 0 | 0 0 1 0 1 1 0 1 |
| 1 1 1 1 | 1 1 1 1 1 1 1 1 |

**L.1.3 Decoding guidline**

Error may occur at the receiver side,

**r = x+ e**

By using the parity check matrix H, the syndrome parity checking result is calculated by

**s = rHT**

If **s** = **0**, the r is an effective codeword. Otherwise, see if r is correctible by checking the error pattern.