**Model answer chapter 5 "Internal Memory":**

**1. For the Hamming code shown in Figure 5.10, show what happens when a check bit (of bit position 8) rather than a data bit is in error?**

**Answer:**

The stored word is 001101001111, as shown in Figure 5.10. Now suppose that the only error is in C8, so that the fetched word is 001111001111. Then the received block results in the following table:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Poistion** | **12** | **11** | **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** |
| **Bits** | **D8** | **D7** | **D6** | **D5** | **C8** | **D4** | **D3** | **D2** | **C4** | **D1** | **C2** | **C1** |
| **Block** | **0** | **0** | **1** | **1** | **1** | **1** | **0** | **0** | **1** | **1** | **1** | **1** |
| **Codes** |  |  | **1010** | **1001** |  | **0111** |  |  |  | **0011** |  |  |

The check bit calculation after reception:

|  |  |
| --- | --- |
| Position | Code |
| Hamming | 1111 |
| 10 | 1010 |
| 9 | 1001 |
| 7 | 0111 |
| 3 | 0011 |
| XOR = syndrome | 1000 |

The nonzero result detects and error and indicates that the error is in bit position 8,

which is check bit C8.

**2. Suppose an 8-bit data word stored in memory is 11000010. Using the Hamming algorithm, determine what check bits would be stored in memory with the data word. Show how you got your answer.**

**Answer:**

Data bits with value 1 are in bit positions 12, 11, 5, 4, 2, and 1:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Poistion** | **12** | **11** | **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** |
| **Bits** | **D8** | **D7** | **D6** | **D5** | **C8** | **D4** | **D3** | **D2** | **C4** | **D1** | **C2** | **C1** |
| **Block** | **1** | **1** | **0** | **0** |  | **0** | **0** | **1** |  | **0** |  |  |
| **Codes** | **1100** | **1011** |  |  |  |  |  | **0101** |  |  |  |  |

The check bits are in bit numbers 8, 4, 2, and 1.

Check bit 8 calculated by values in bit numbers: 12, 11, 10 and 9

Check bit 4 calculated by values in bit numbers: 12, 7, 6, and 5

Check bit 2 calculated by values in bit numbers: 11, 10, 7, 6 and 3

Check bit 1 calculated by values in bit numbers: 11, 9, 7, 5 and 3

Thus, the check bits are: 0 0 1 0

**3. For the 8-bit word 00111001, the check bits stored with it would be 0111. Suppose when the word is read from memory, the check bits are calculated to be 1101.What is the data word that was read from memory?**

**Answer:**

The Hamming Word initially calculated was:

bit number:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **12** | **11** | **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** |
| **0** | **0** | **1** | **1** | **0** | **1** | **0** | **0** | **1** | **1** | **1** | **1** |

Doing an exclusive-OR of 0111 and 1101 yields 1010 indicating an error in bit 10 of

the Hamming Word. Thus, the data word read from memory was 00011001.

**4. How many check bits are needed if the Hamming error correction code is used to detect single bit errors in a 1024-bit data word?**

**Answer:**

Need K check bits such that 2K – 1 >= 1024 + K.

The minimum value of K that satisfies this condition is 11**.**