EE2016-B- Fall 2022

數位系統導論

Fundamentals of Logic Design-

Final Project: Hamming-code Error-correction using Verilog

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Hamming Code (漢明碼)

- 所謂的Hamming code 主要是一種偵測法，它利用資料流中插入一些驗證碼的方式來做一個檢查和驗算。
- 先取 K bits 的檢查碼：M ≦ 2^n ，K = n + 1。如 8 bits 資料，則 8 ≦ 2^3，K = 3 + 1 = 4，檢查位元為 4 bits。則漢明碼編碼為 M + K = 8 + 4 = 12 bits。
- 漢明碼編碼的用途是用在資料的除錯，當發生 1 位元的錯誤時，漢明碼編碼規則可以找出錯誤位置。

Hamming Code (漢明碼)

- Ex1: Assume that sender sends the dataword 10101101 please find
- the hamming code (H3 H2 H1 H0)
- the codeword

- Step1. 建立表格

1	2	3	4	5	6	7	8	9	10	11	12

為什麼有12呢? 明明codeword才8bit而已，那是因為，你還得加上hamming code(h3 h2 h1 h0) 所以我們一開始建立的表格要是12格。

Hamming Code (漢明碼)

- Ex1: Assume that sender sends the dataword 10101101 please find
- the hamming code (H3 H2 H1 H0)
- the codeword
- Step2. Hamming code 插入的地方通常是2的次方，所以在表格上，2的次方的地方要留下來給Hamming code填

1	2	3	4	5	6	7	8	9	10	11	12
H0	H1		H2				H3				

Hamming Code (漢明碼)

- Ex1: Assume that sender sends the dataword 10101101 please find
- the hamming code (H3 H2 H1 H0)
- the codeword
- Step3. 接下來，我們把題目的8bit填進去

1	2	3	4	5	6	7	8	9	10	11	12
		1		0	1	0		1	1	0	1
H0	H1		H2				H3				

Hamming Code (漢明碼)

- Ex1: Assume that sender sends the dataword 10101101 please find
- the hamming code (H3 H2 H1 H0)
- the codeword
- Step4. 接下來，我們將bit數為1的地方，轉成二進制。

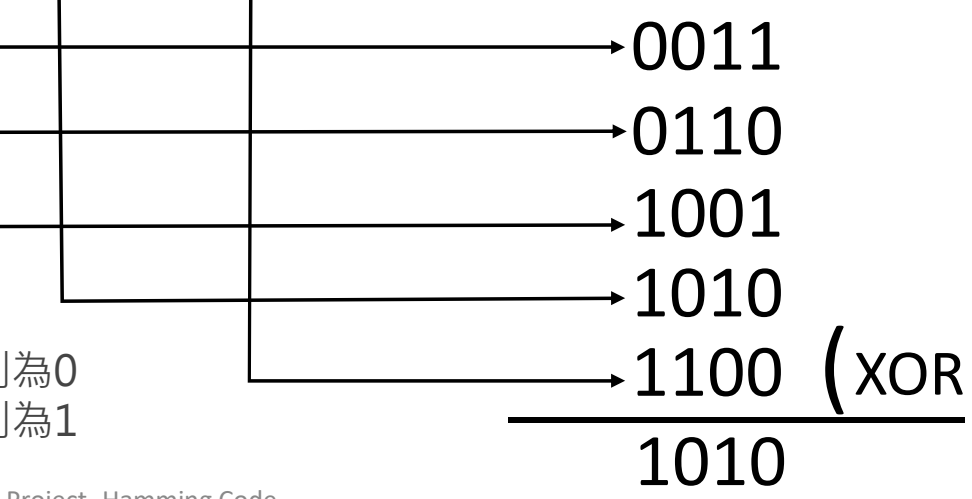
1	2	3	4	5	6	7	8	9	10	11	12
		1		0	1	0		1	1	0	1
H0	H1	0011	H2		0110		H3	1001	1010		1100

Hamming Code (漢明碼)

- Ex1: Assume that sender sends the dataword 10101101 please find
- the hamming code (H3 H2 H1 H0)
- the codeword

- Step5. 將這些轉成二進制的地方(紅色字)，拿出來做XOR運算。

1	2	3	4	5	6	7	8	9	10	11	12
		1		0	1	0		1	1	0	1
H0	H1	0011	H2		0110		H3	1001	1010		1100



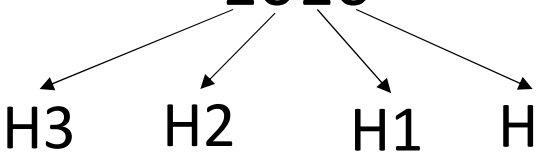
※XOR運算，直式相加，
如果結果是偶數 (比如說第一行 10100 加起來 = 2)則為0
如果結果是奇數 (比如說第二行 11010 加起來 = 3)則為1

Hamming Code (漢明碼)

- Ex1: Assume that sender sends the dataword 10101101 please find
- the hamming code (H3 H2 H1 H0)
- the codeword
- Step5. 將這些轉成二進制的地方(紅色字)，拿出來做XOR運算。

0011
0110
1001
1010
1100 (XOR
1010

1	2	3	4	5	6	7	8	9	10	11	12
0	1	1	0	0	1	0	1	1	1	0	1
H0	H1	0011	H2		0110		H3	1001	1010		1100



= Hamming Codes

The codeword:011001011101

Hamming Code (漢明碼) for Error-correction

- Ex2. Assume that the receiver receives the codeword 1101110101 hamming code , please find A) which bit is incorrect B)the correct codeword

Step1.一樣，我們先把表格建立出來

1	2	3	4	5	6	7	8	9	10
1	1	0	1	1	1	0	1	0	1
0001	0010		0100	0101	0110		1000		1010

為什麼是10格? 因為1101110101是已經加入hamming code的碼，所以我們有10bit。

Hamming Code (漢明碼) for Error-correction

- Ex2. Assume that the receiver receives the codeword 1101110101 hamming code , please find A) which bit is incorrect B)the correct codeword

Step2.將1101110101填入表格，並且將有1的地方都轉成2進制

1	2	3	4	5	6	7	8	9	10
1	1	0	1	1	1	0	1	0	1
0001	0010		0100	0101	0110		1000		1010

Step3.接下來，我們將這些做XOR運算

0001
0010
0100
0101
0110
1000
1010 (XOR

0110

※XOR運算，直式相加，
如果結果是偶數 則為0
如果結果是奇數 則為1

結果出來的是0110 ，這代表有錯誤，因為如果用hamming code解回去，其結果要為0000。

Hamming Code (漢明碼) for Error-correction

- Ex2. Assume that the receiver receives the codeword 1101110101 hamming code , please find A) which bit is incorrect B)the correct codeword

Step4.所以我們將0110轉10進制，得出6，6的意思就是代表第六bit有錯誤，於是我們回到表格

1	2	3	4	5	6	7	8	9	10
1	1	0	1	1	1->0	0	1	0	1
0001	0010		0100	0101			1000		1010

0001
0010
0100
0101

1000
1010 (XOR

0000

Correct!!!!

Final Project

- Implement an error-detection hardware using Hamming Code by Verilog.
- TA will repeatedly provide you a bit stream with an error bit with the bit-stream length smaller than 32 bits, and your Verilog code should output (1) the Hamming code and (2) the error-bit position.
- The TA will repeatedly provide you 3 cases, and your code should output all the correct results.
- Demo deadline: Starting from pm 7:00, 13th, Jan., 2023.
- Location: 原本上課教室地點。
- Demo Platform: EDA playground. Others are rejected.
- Codes: Your demo codes, including the Verilog design and testbench codes, need to be printed on 3 pdf files (each project for each separated pdf file) and uploaded to the new-ee-class. (You can upload the code files before demo.)
- Copy is NOT allowed. The scores will be zero.