Lecture 8

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Example problem 2

Let us assume the even parity hamming code from the above example (111001101) is transmitted and the received code is (110001101). Now from the received code, let us detect and correct the error.

To detect the error, let us construct the bit location table.

Bit Location	9	8	7	6	5	4	3	2	1
Bit designation	D_5	$\mathbf{P_4}$	D_4	D_3	D_2	$\mathbf{P_3}$	D_1	$\mathbf{P_2}$	$\mathbf{P_1}$
Binary representation	1001	1000	0111	0110	0101	0100	0011	0010	0001
Received code	1	1	0	0	0	1	1	0	1

- *<u>Checking the parity bits</u>*

- For P1 : Check the locations 1, 3, 5, 7, 9. There is three 1s in this group, which is wrong for even parity. Hence the bit value for P1 is 1.
- For P2 : Check the locations 2, 3, 6, 7. There is one 1 in this group, which is wrong for even parity. Hence the bit value for P2 is 1.
- For P3 : Check the locations 3, 5, 6, 7. There is one 1 in this group, which is wrong for even parity. Hence the bit value for P3 is 1.
- For P4 : Check the locations 8, 9. There are two 1s in this group, which is correct for even parity. Hence the bit value for P4 is 0.
- The resultant binary word is 0111. It corresponds to the bit location 7 in the above table. The error is detected in the data bit D4. The error is 0 and it should be changed to 1.
- **Thus the corrected code is 111001101**.

Practice Question

Implement the even bit Hamming codeword for 1011.
Determine p1, p2 and p3.

d7	d6	d5	p4	d3	p2	p1
1	0	1		1		

Explanation

- P1 = p1 d3 p5 d7
- = 1 => 1 1 1
- P2 = p2 d3 d6 d7
- = 0 = >1 0 1
- P4 = p4 d5 d6 d7
- = 0 = >1 0 1
- So receiver will send 1010101 in channel to the transmitter.

d7	d6	d5	p4	d3	p2	p1
1	0	1	0	1	0	1

Practice Question

- **If the 7 bit haming code word received is 1011011 assuming the even parity state whether the received code word is correct or wrong. If worng locate the bit having error.**

d7	d6	d5	p4	d3	p2	p1
1	0	1	1	0	1	1

Explanation

- P4 = p4 d5 d6 d7
- = 1 => 1 0 1 p4 is 1
- P2 = p2 d3 d6 d7
- = 0 = >0 0 1 p2 = 0
- P1 = p1 d3 p5 d7
- = 1=> 011 = 1
- P4 p2 p1 = 101 = 5..
- Error at 5th bit.
- Corrected answer after changing the 5th bit will be : 1001011

Binary Multiplication

- **Binary multiplication** is one of the four binary arithmetic. The other three fundamental operations are addition, subtraction and division. In the case of a binary operation, we deal with only two digits, i.e. 0 and 1. The operation performed while finding the binary product is similar to the conventional multiplication method. The four major steps in binary digit multiplication are:

Binary Multiplication Table

- $0 \times 0 = 0$
- $0 \times 1 = 0$
- $1 \times 0 = 0$
- $1 \times 1 = 1$

Example 1:

- Solve 1010 × 101
- Solution
- 1010

 (×) 101
- ——————
- 1010
- 0000X
- ———————
-   01010 ……. First Intermediate Sum
- 1010XX
- ————————
- 110010

Example 2:

Solve 110 by 100

```
   110
 X 100
   ———
   000
  000X
 110XX
   ————
 11000
```

Example 3:

- 1011.01 × 110.1

```
      1 0 1 1.0 1
          1 1 0.1
    ---------------
      1 0 1 1 0 1
    0 0 0 0 0 0
    ---------------
     0 1 0 1 1 0 1   ......... First Intermediate sum
   1 0 1 1 0 1
   ---------------
   1 1 1 0 0 0 0 1   ......... Second Intermediate Sum
 1 0 1 1 0 1
 ---------------
1 0 0 1 0 0 1.0 0 1  ........ Final Sum
```

Binary Division

- The division is probably one of the most challenging operations of the basic arithmetic operations. There are different ways to solve division problems using binary operations. Long division is one of them and the easiest and the most efficient way.

Binary Division Rules

- The main rules of the binary division include:
- $1 \div 1 = 1$
- $1 \div 0 =$ Meaningless
- $0 \div 1 = 0$
- $0 \div 0 =$ Meaningless

Example 4:

- Solve 01111100 ÷ 0010
- **Solution:**
- Given
- 01111100 ÷ 0010
- Here the dividend is 01111100, and the divisor is 0010
- Remove the zero’s in the **Most Significant Bit** in both the dividend and divisor, that doesn’t change the value of the number.
- So the dividend becomes 1111100, and the divisor becomes 10.

- **Step 1:** First, look at the first two numbers in the dividend and compare with the divisor. Add the number 1 in the quotient place. Then subtract the value, you get 1 as remainder.
- **Step 2:** Then bring down the next number from the dividend portion and do the step 1 process again
- **Step 3:** Repeat the process until the remainder becomes zero by comparing the dividend and the divisor value.
- **Step 4:** Now, in this case, after you get the remainder value as 0, you have zero left in the dividend portion, so bring that zero to the quotient portion.

10) 1111100 (111110

(-) 10

11

(-) 10

11

(-) 10

11

(-) 10

10

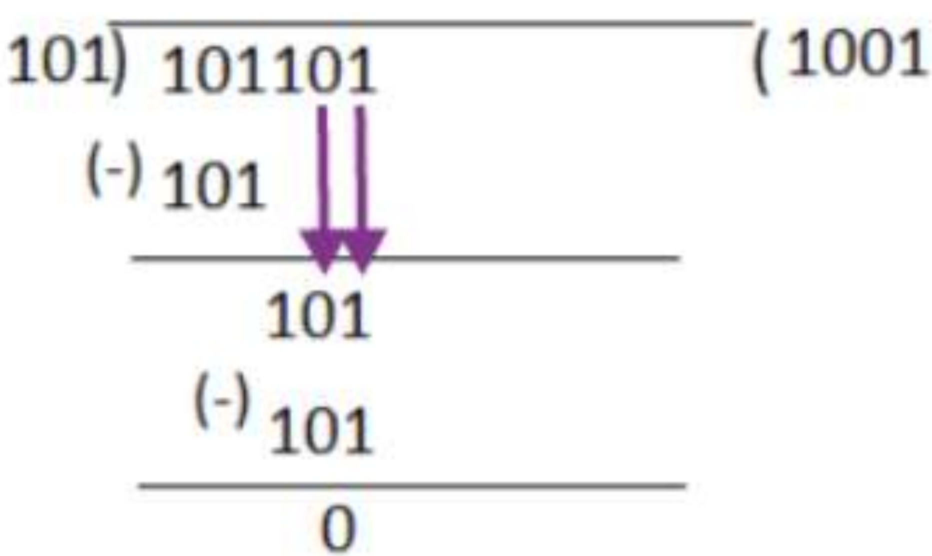
(-) 10

00

00

Example 5:

- Solve using the long division method: 101101 ÷ 101



So, when you bring down the fourth bit of the dividend, it does not match with the divisor. In order to bring down the 5^{th} and 6^{th} bit of the dividend, add two zeros in the quotient value.

Quick Quiz (Poll 1)

Solve $100101 \times 0110 =$

- **A.**1011001111
- **B.** 0100110011
- **C. 0**11011110
- **D.**0110100101

Solution

```
        1 0 0 1 0 1
x           0 1 1 0
      _____________
        0 0 0 0 0 0
      1 0 0 1 0 1 0
    1 0 0 1 0 1 0 0
0 0 0 0 0 0 0 0 0
___________________
0 1 1 0 1 1 1 1 0
___________________
```

Therefore, 100101 x 0110 = 011011110.