

CS211 Digital Logic (H) Lab Assignment 2

Hamming Code Decoder

In this exercise, you're required to design a decoder for an (8,4) hamming error correction code.

A Brief Introduction

Computers suffer from errors all the time since messages transferred both internally and externally are easily interfered by the outside world. Fortunately, **error correction codes (ECC)** are designed to solve this problem. They are capable of detecting and correcting one or more errors at the price of some extra bits in every message.

Hamming Code

Hamming code is a widely used error correction code. It can detect up to two bit errors and correct single bit error, **known as single-error correction and double-error detection (SECDED)**. The (8,4) hamming code has 8 bits in total, four of which are data bits while the other four redundant bits are **parity bits**.

Objectives

Your task is to implement a (8,4) hamming code decoder. For a given 8-bit encoded message, your decoder should check whether error exists and output the correct message.

Here we denote the input 8-bit message as $b_0b_1b_2 \dots b_7$ (b_7 is the least significant bit). And we have the following equations.

$$A = b_7 \oplus b_6 \oplus b_5 \oplus b_4 \oplus b_3 \oplus b_2 \oplus b_1 \oplus b_0$$

$$B = b_7 \oplus b_5 \oplus b_3 \oplus b_1$$

$$C = b_7 \oplus b_6 \oplus b_3 \oplus b_2$$

$$D = b_7 \oplus b_6 \oplus b_5 \oplus b_4$$

The table below shows how $\{D, C, B, A\}$ can be interpreted.

DCBA	INFERENCE
0000	No error
xxx1	Single error in b_{xxx} For example, if $xxx=3$, it means b_3 has an error and you need to change b_3 from 0 to 1 or conversely.
xxx0 (other than 0000)	Multiple errors, unable to correct

After correction (if possible), we get another 8-bit string $c_0c_1c_2 \dots c_7$ (c_7 is the least significant bit), and then $c_3c_5c_6c_7$ (c_7 is the least significant bit) is the **actual output message we desire**.

Pin requirements:

- 8 switches denote the input 8-bit message
- One group of 7-seg tubes is used to display the corrected 4-bit output message in **hex** if possible (including the no error case) and display nothing otherwise.
- Another group of 7-seg tubes is used to indicate whether error(s) occurs or not. Show 0000 if there's no error and EEEE otherwise.
- Additionally, 1 LED to indicate whether error(s) occurs or not.

Notice: you need to display with the format as follows.



Submission requirements:

- Submit before the deadline on Sakai.
- A **PDF** file for each student in the format "2022summer_lab_ass2_SID_NAME".
- The whole project as a compressed package.

Content of the Submitted PDF document:

- Design files and test files (screenshots of the necessary part)
- Screenshot of the simulation waveform
- Pin constraint files (i.e. .xdc files)
- Photos of test on EGO1, **should include at least 3 different cases (no error, single error and multiple errors)**