

# Hamming Encoder-Decoder System for 4-bit Input

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## 1 Introduction

In this project, we designed an encoder-decoder system to implement Hamming code generation for 4-bit input data. The system can encode the input data to produce a 7-bit Hamming code with embedded parity bits. Additionally, it includes the capability to decode the Hamming code and detect/correct errors.

## 2 Design and Implementation

The Hamming encoder generates a 7-bit Hamming code using a 4-bit input. The parity bits are calculated based on specific bit positions, providing error detection and correction capabilities.

### 2.1 Encoder Logic

```
1 module hamming_encoder (  
2     input wire [3:0] data_in,  
3     output wire [6:0] code_out  
4 );  
5  
6 reg [6:0] code;  
7  
8 always @(*) begin  
9     code[0] = data_in[0] ^ data_in[1] ^ data_in[3];  
10    code[1] = data_in[0] ^ data_in[2] ^ data_in[3];
```

```

11     code[2] = data_in[0];
12     code[3] = data_in[1] ^ data_in[2] ^ data_in[3];
13     code[4] = data_in[1];
14     code[5] = data_in[2];
15     code[6] = data_in[3];
16 end
17
18 assign code_out = code;
19
20 endmodule

```

Listing 1: Hamming Encoder Logic

## 2.2 Decoder Logic

```

1 module hamming_decoder (
2     input wire [6:0] code_in,
3     output wire [3:0] data_out
4 );
5
6 reg [3:0] corrected_data;
7
8 // Parity check equations
9 wire p1 = code_in[0] ^ code_in[2] ^ code_in[4] ^ code_in[6];
10 wire p2 = code_in[1] ^ code_in[2] ^ code_in[5] ^ code_in[6];
11 wire p3 = code_in[3] ^ code_in[4] ^ code_in[5] ^ code_in[6];
12
13 // Syndrome calculation
14 wire [2:0] syndrome;
15 assign syndrome = {p3, p2, p1};
16
17 always @(*) begin
18     case (syndrome)
19         3'b000: corrected_data = code_in[0:3];
20         3'b001: corrected_data = code_in[1:4];
21         3'b010: corrected_data = code_in[2:5];
22         3'b011: corrected_data = code_in[3:6];
23         3'b100: corrected_data = code_in[4:7];
24         3'b101: corrected_data = code_in[5:8];
25         3'b110: corrected_data = code_in[6:9];
26         3'b111: corrected_data = code_in[7:10];
27         default: corrected_data = 4'b0000; // Handle error or
                uncorrectable
28     endcase

```

```
29 end
30
31 assign data_out = corrected_data;
32
33 endmodule
```

Listing 2: Hamming Decoder Logic

### 3 Usage

To use the encoder-decoder system, instantiate the `hamming_encoder` or `hamming_decoder` module and provide the appropriate input. The encoded/decoded data will be available at the respective outputs.

### 4 Conclusion

The Hamming encoder-decoder system provides a robust method for error detection and correction in digital communication systems. The provided encoder logic generates a 7-bit Hamming code from a 4-bit input, while the decoder logic can be implemented to detect and correct errors.