

# Hamming Encoder-Decoder System for 4-bit Input

Ajay Singh

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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.