CSCI 592
LAB ASSIGNMENT – 9

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OBJECTIVE

The main objective of the lab is to grasp the concept of Hamming code, which is a special technique for encoding and decoding information to enable error detection and correction.

TECHNOLOGY USED

- Simulator: EASy68K (Motorola 68000 Assembly)
- Programming Language: Assembly Language (Motorola 68K Syntax)
- Concepts: Hamming (7,4) Code, Parity Calculation, Bitwise Logic, Memory Access

PROCEDURE

- Store the 4-bit data input in memory location $002400 (encoder) and encoded bytes at $002500 (decoder).
- Use bitwise operations to extract individual bits a, b, c, and d.
- Calculate the parity bits r, s, and t using XOR logic.
- Construct the 7-bit encoded byte in the format a b c r d s t.
- For decoding, extract all bits from the encoded byte.
- Recalculate parity conditions and compare them to the original parity bits.
- Determine if a single-bit error occurred and store its position in register D0.

OPERATIONS

- Use MOVE.B to load input bytes and store encoded results.
- Use bit masking (AND.W) and shifting (LSR.W, LSL.W) to isolate and align bits.
- Compute parity using EOR.W (XOR) operations.
- Assemble encoded output in register D1 using sequential merging of bits.
- For decoding, repeat parity calculations and use conditional checks (CMP.B, BEQ, ADDI.B) to find error location.

ALGORITHM

Encoding Steps:

- Extract bits a, b, c, d from input nibble.
- Compute:
    - $r = a \oplus b \oplus c$
    - $s = a \oplus b \oplus d$
    - $t = a \oplus c \oplus d$
- Assemble encoded byte in 7-bit format: a b c r d s t

Decoding Steps:

- Extract bits a, b, c, r, d, s, t from input.
- Recompute:
    - $r' = a \oplus b \oplus c \oplus d$
    - $s' = a \oplus b \oplus d \oplus s$
    - $t' = a \oplus c \oplus d \oplus t$
- Combine r', s', t' as a binary value to indicate error position (0 = no error)

CODE LISTING

ENCODER

```
        ORG $1000
START:
        MOVE.L #0,D2
        MOVE.L #0,D3
        MOVE.L #0,D4
        MOVE.L #0,D5
        MOVE.L #0,D6
        MOVE.L #0,D7
        MOVE.B #11,$00002400
        LEA.L $00002400,A0
        MOVE.B (A0),D1
        MOVE.L #1,D2
        MOVE.L #2,D3
        MOVE.L #4,D4
        MOVE.L #8,D5
        AND.W D1,D2
        AND.W D1,D3
        AND.W D1,D4
        AND.W D1,D5
        LSR.W #1,D3
        LSR.W #2,D4
        LSR.W #3,D5
        MOVE.B D5,D0
        EOR.W D4,D5
        EOR.W D3,D5
        LSR.W #1,D1
        LSL.W #1,D1
        EOR.W D5,D1
        LSL.W #1,D1
        EOR.W D2,D1
        EOR.W D0,D4
        EOR.W D2,D4
        EOR.W D0,D3
        EOR.W D2,D3
        EOR.W D4,D1
        LSL.W #1,D1
        EOR.W D3,D1
        SIMHALT
        END START

DECODER
        ORG $1100
DECODER:
        MOVE.L #0,D0
        MOVE.L #0,D1
        MOVE.L #0,D2
        MOVE.L #0,D3
        MOVE.L #0,D4
        MOVE.L #0,D5
        MOVE.L #0,D6
        MOVE.L #0,D7
        MOVE.B #$55, $002500
        LEA.L $002500,A0
        MOVE.B (A0),D1
        MOVE.B D1,D2
        ANDI.B #$80,D2
        LSR.B  #7,D2
        MOVE.B D1,D3
        ANDI.B #$40,D3
        LSR.B  #6,D3

        MOVE.B D1,D4
```

```
        ANDI.B #$20,D4
        LSR.B  #5,D4
        MOVE.B D1,D5
        ANDI.B #$10,D5
        LSR.B  #4,D5
        MOVE.B D1,D6
        ANDI.B #$08,D6
        LSR.B  #3,D6
        MOVE.B D1,D7
        ANDI.B #$04,D7
        LSR.B  #2,D7
        MOVE.B D1,D0
        ANDI.B #$02,D0
        LSR.B  #1,D0
        MOVE.B D2,D1
        EOR.B  D3,D1
        EOR.B  D4,D1
        EOR.B  D6,D1
        CMP.B  D1,D5
        BEQ    R_OK
        MOVE.B #4,D5
R_OK:   TST.B  D5
        MOVE.B D2,D1
        EOR.B  D3,D1
        EOR.B  D6,D1
        CMP.B  D1,D7
        BEQ    S_OK
        ADDI.B #2,D5
S_OK:   TST.B  D5
        MOVE.B D2,D1
        EOR.B  D4,D1
        EOR.B  D6,D1
        CMP.B  D1,D0
        BEQ    T_OK
        ADDI.B #1,D5
T_OK:   MOVE.B D5,D0
        SIMHALT
        END DECODER
```

DESCRIPTION

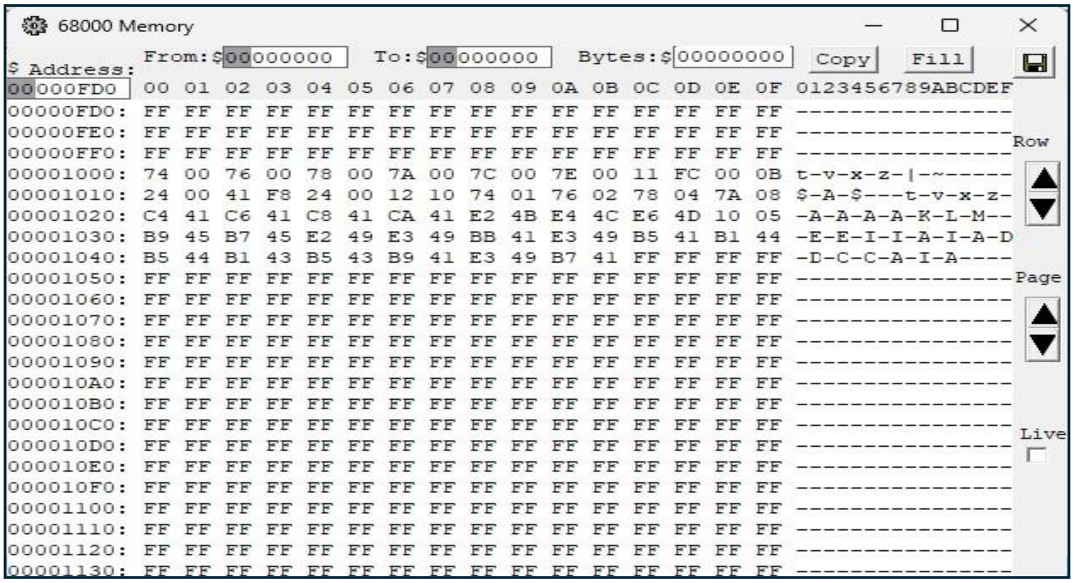
This lab involves the implementation of the Hamming algorithm using assembly language to detect and correct single-bit errors in a transmitted message. The encoded data consists of four information bits and three calculated parity bits. The decoder examines these bits to detect any single-bit errors and outputs the position of the error.

OBSERVATIONS

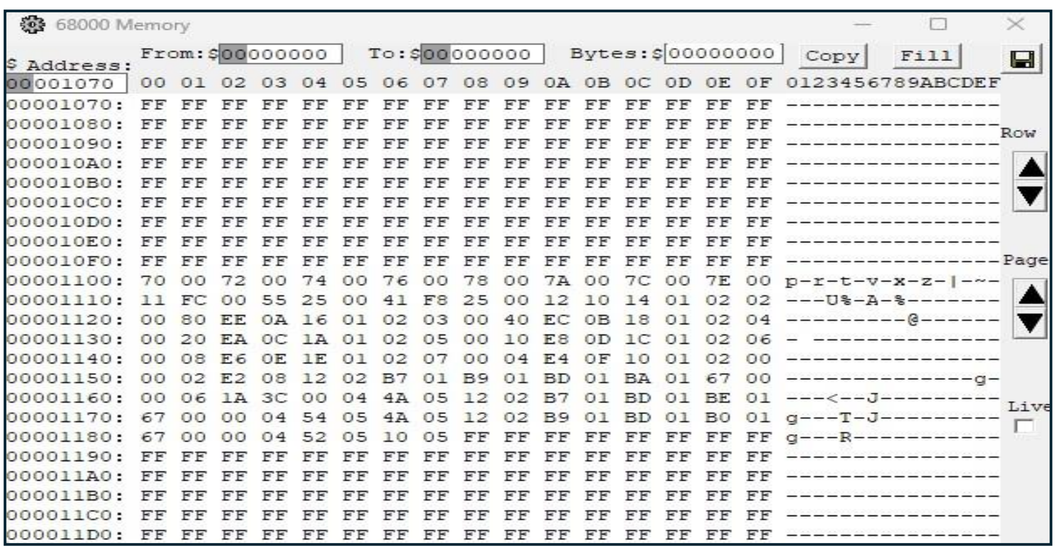
- The encoder correctly converted data like 00001011 into 01010101.
- The decoder was able to identify errors introduced manually (e.g., flipping bit 5 in the encoded message resulted in correct error position 101).
- The simulation worked as expected with both provided and custom test cases.

RESULTS

Encoding



Decoding



CONCLUSIONS

This lab successfully demonstrated the theoretical and practical application of Hamming (7,4) codes using assembly programming. Encoding logic ensures even-parity-based protection, and the decoding mechanism can reliably detect and localize single-bit errors. The implementation strengthens the understanding of error correction in digital communication systems.