MPI Design Project

P23 – AUTOMATIC WASHING MACHINE

SUBMITTED BY

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SUBMITTED IN

COMPLETE FULFILLMENT OF THE REQUIREMENTS OF THE COURSE

MICROPROCESSORS PROGRAMMING AND INTERFACING

PROBLEM STATEMENT

SYSTEM TO BE DESIGNED – AUTOMATIC WASHING MACHINE

Description: An Automatic washing machine with Dryer.

The Washing Machine can handle three different types of load: Light, Medium and Heavy.

The Washing Machine has three different cycles: Rinse, Wash and Dry.

Depending on the load the number of times a cycle is done and the duration of the cycle varies.

Light Load: Rinse- 2 mins, Wash- 3 mins, Rinse – 2 mins, Dry Cycle –2 mins

Medium Load: Rinse- 3 mins, Wash- 5 mins and Rinse – 3 mins Dry Cycle –4 mins

Heavy load: Rinse - 3 mins, Wash- 5 mins and Rinse – 3 mins, Wash- 5 mins and Rinse – 3 mins, Dry Cycle – 4 mins

- The Washing Machine is a single tub machine.
- The Washing machine is made of a Revolving Tub and an Agitator. The Agitator is activated during the Rinse and Wash cycle; revolving tub is active only during the Dry cycle. The door of the washtub should remain closed as long as the agitator is active.
- Before each cycle the water, level is sensed. At the beginning of the cycle the water level should be at the maximum possible level, the water should be completely drained during dry cycle. The cycle should begin only when the water level is correct.
- At the end of each cycle a buzzer is activated. The user should drain the water at the end of the rinse/wash cycle and refill the water for the next cycle; once this has been completed the user can press the resume button.
- At the beginning of the wash cycle the user should add the detergent.
- At the end of the complete wash process the Buzzer is sounded.
- User can turn off system by pressing STOP Button
- Different sounds are used for different events.
- Display the load selected using a seven-segment display.

User Interface: The User Interface is shown in fig below

The number of times the load button is pressed determines load: 1press- light; 2 presses medium and 3 presses –heavy.

To begin washing process START is pressed.

Pressing STOP can stop the process.
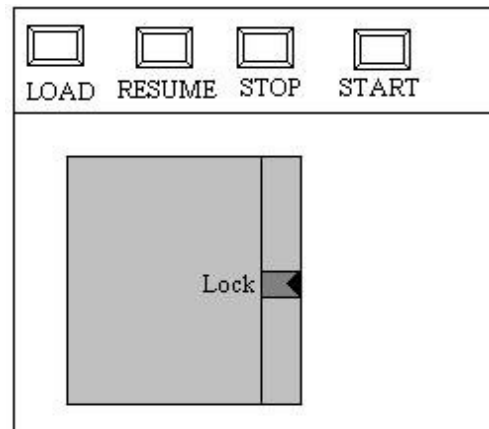
COMPONENTS USED:

- 74LS138
- 74LS245
- 74LS273
- 2732
- 6116
- 74LS447
- 7404(Not gate)
- 7432(2 input OR gate)
- 4072(4 input OR gate)
- 4078 (8 input NOR gate)
- 8255
- Led
- Buzzer
- Button
- Resistor
- Agitator, Revolving Tub(Motor)
- Sw-spst
- 8086
- Sw-spdt-mom
- Relay

MEMORY MAPPING:

ROM chip used: 2732

RAM chip used: 6116

ROM:8KB = 4KB(even)+4KB(odd)

- ROM (Even Bank):00000H,00002H, ...,01FFCH,01FFEH
- ROM (Odd Bank):00001H,00003H, ...,01FFDH,01FFFH

RAM:4KB = 2KB(even)+2KB(odd)

- RAM (Even Bank):02000H,02002H, ...,02FFCH,02FFEH
- RAM (Odd Bank):00001H,00003H, ...,02FFDH,02FFFH

	A19-A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
ROM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
RAM	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1

I/O MAPPING:

8255(Programmable peripheral interface)- 00H to 06H

PORT	ADDRESS	INPUT/OUTPUT
PORT A	00H	Input Port
PORT B	02H	Output Port
PORT C	04H	Output port (both upper and lower ports)
CONTROL REGISTER	06H	

PORT A

PA0- Start Button

PA1- Stop Button

PA2- Load Button

PA3- Resume Button

PA4- Door Lock Switch

PA5- Water Max Switch

PA6- Water Min Switch

PORT B

PB0- Agitator

PB1- Revolving tub

PB2- Buzzer - Dry

PB3- Buzzer - Wash

PB4-Buzzer - Rinse

PORT C

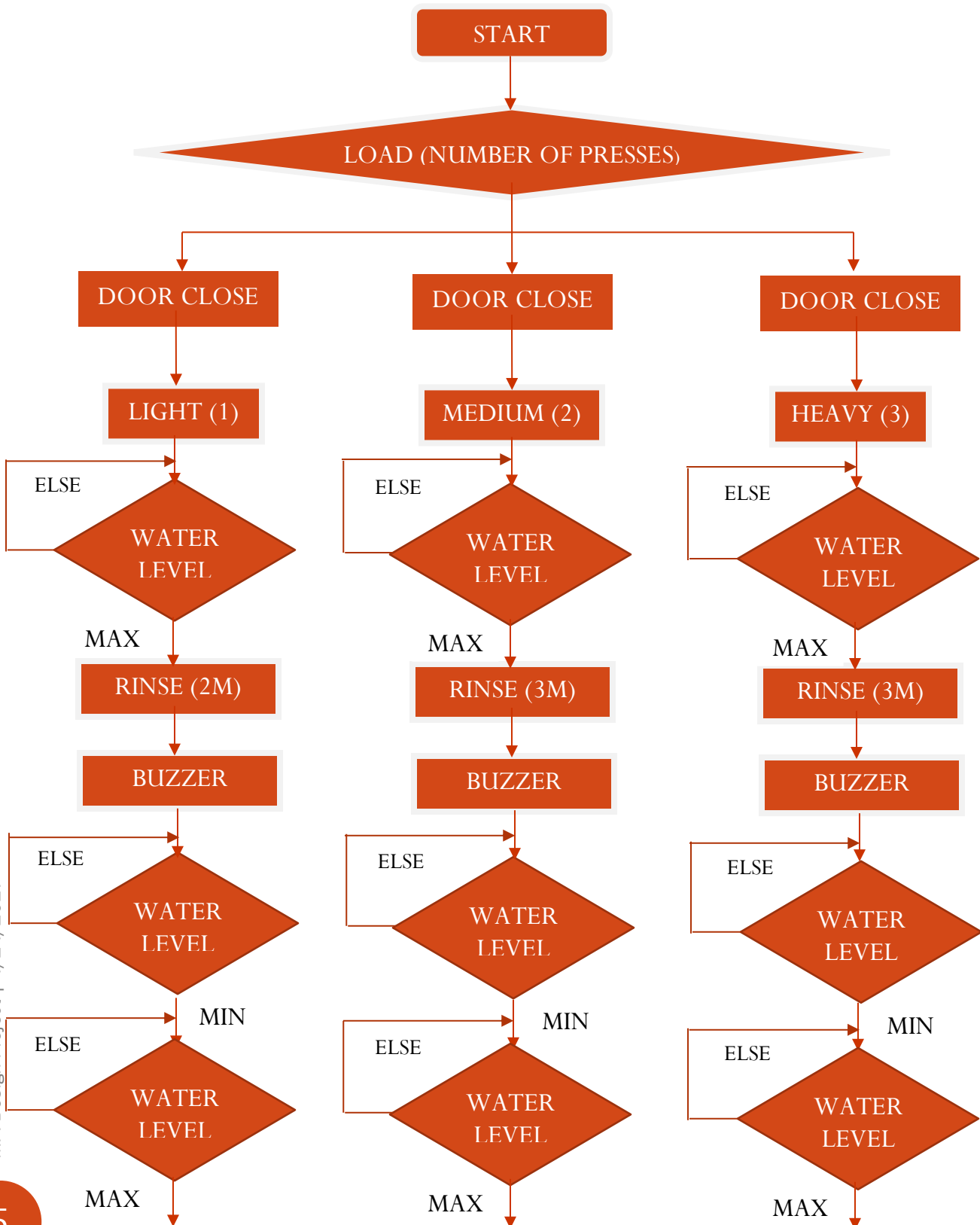PC0-PC3: input to BCD to 7 segment decoder.

ASSUMPTIONS:

- Water level max or min is modelled using switches (SW-SPST). In reality they will be pressure sensitive switches (as water reaches max level the switch will automatically be pressed). Here we will be manually pressing the water - max/water - min switch.
- Before every wash cycle, the user is given 1 minute to put detergent.
- Assume that the door is locked when the agitator is running. Before the agitator starts running, the program checks if door is locked or not.
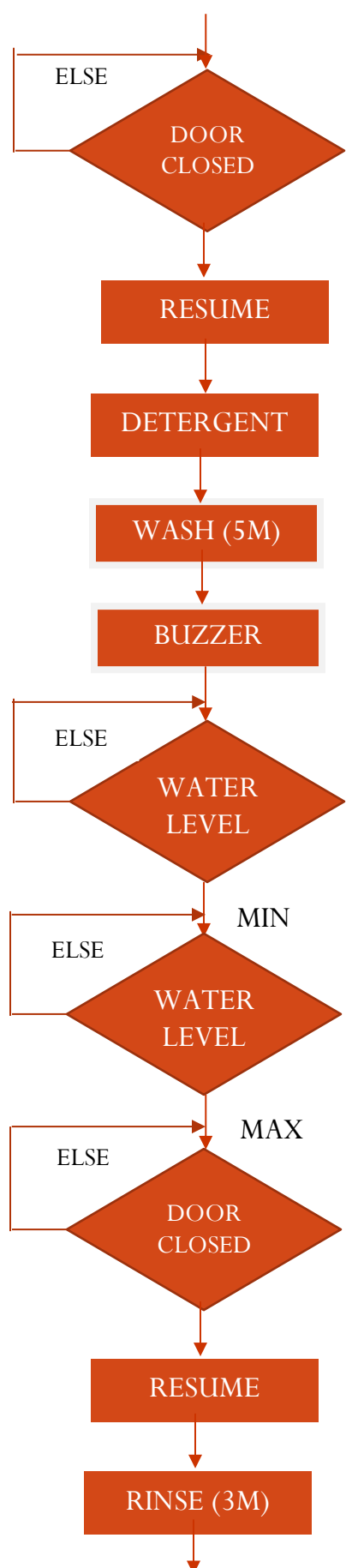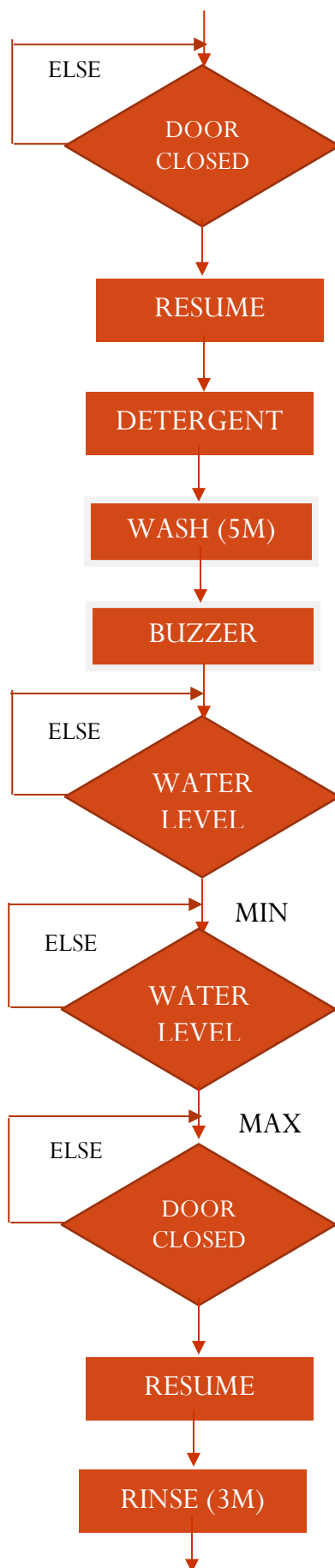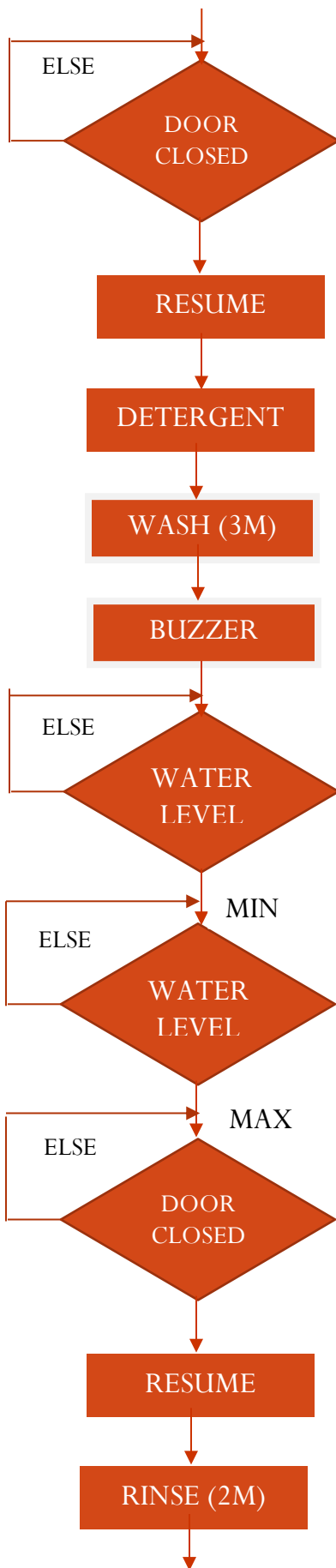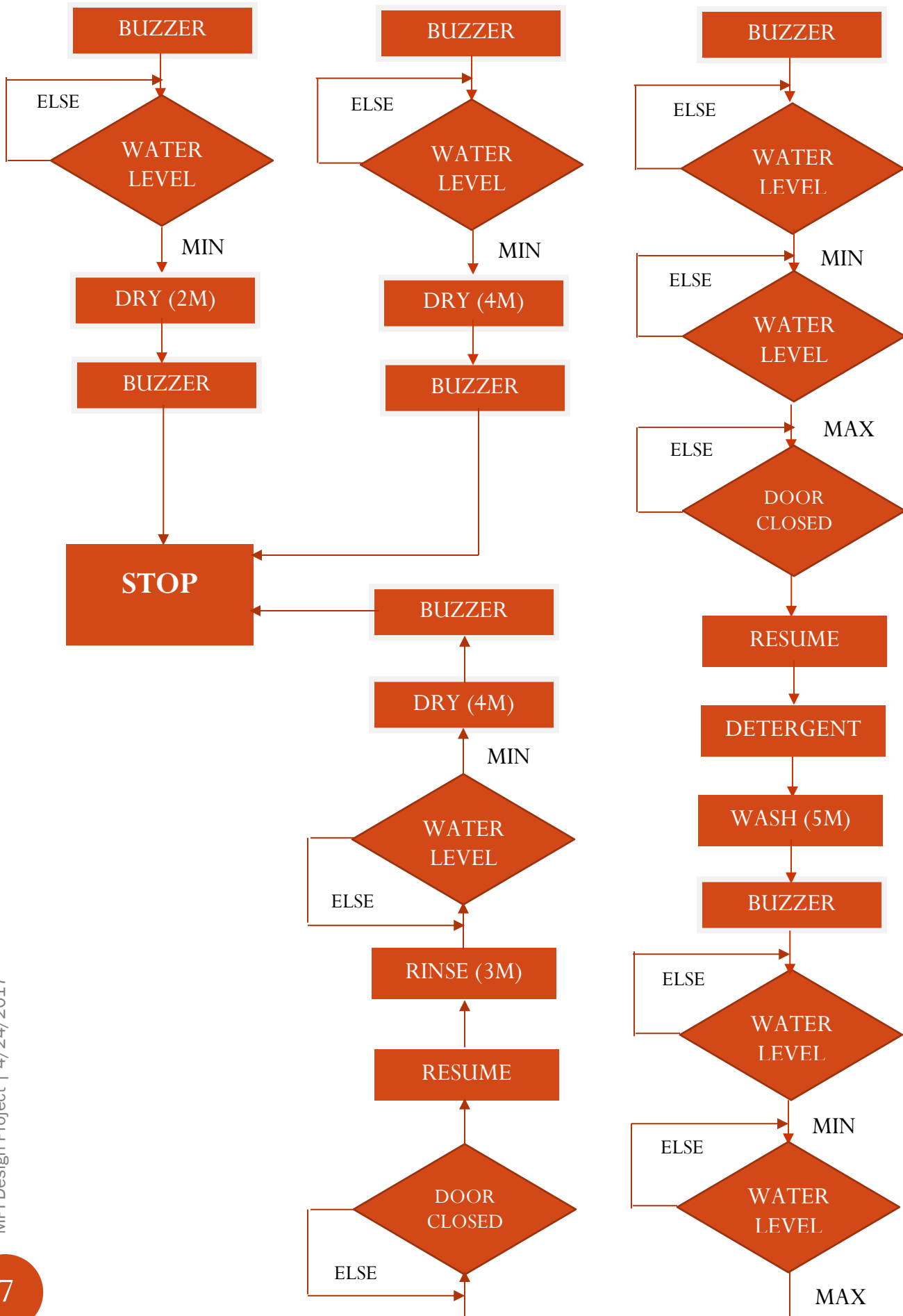- Agitator and revolving tub are modelled by DC motors.

IVT:

- INT 2H (NMI) is used.

ADDRESS	CONTENTS
00008H	IP (lower byte)
00009H	IP (higher byte)
0000AH	CS (lower byte)
0000BH	CS (higher byte)

```
.model tiny
.data
    STARTING_IP DW ?
    PORTA EQU 00H
    PORTB EQU 02H
    PORTC EQU 04H
    CREG_8255 EQU 06H
    CNT0 EQU 08H
    CNT1 EQU 0AH
    CNT2 EQU 0CH
    CREG_8253 EQU 0EH
    CREG0_8259 EQU 10H
    CREG1_8259 EQU 12H
    MODENO DB 00H
    STACK DW 100 DUP(?)
    TOP_STACK LABEL WORD
.code
.startup
    LEA SP, TOP_STACK
    ;---STORE THE ISR ADDRESS OF THE NMI(STOP) IN THE IVT
    MOV AX,0
    MOV ES,AX
    ;calculate vector address for interrupt 02H(NMI)
    MOV AL,02H
    MOV BL,04H
    MUL BL
    MOV BX,AX

    MOV SI,OFFSET [STOP_BUTTON]
    MOV ES:[BX],SI
    ADD BX,2

    MOV AX,0000
    MOV ES:[BX],AX
    MOV AL,10010000B        ;programming the 8255
    OUT CREG_8255,AL
    POLL_START:
    MOV AX,OFFSET [POLL_START]
    MOV STARTING_IP,AX
    ;CALL STORE_IP          ;this will store the IP address of the
next instruction in STARTING_IP
    MOV AL,00H
    OUT PORTB,AL            ;initially no output device in PORT
B(agitator,buzzer) should be ON



    START:                     ;polling the START button
```

```
        MOV AL,00H
        MOV MODENO,AL        ;**moving 0 into mode number
        IN AL, PORTA
        CMP AL, 11111110B
    JNZ START
    CALL DEBOUNCE_DELAY      ;after start button comes up then only
proceed
    MOV AL,00000000B
    OUT PORTC,AL

    LOAD:                    ;polling the LOAD button and DOOR_LOCK
switch
        IN AL, PORTA
        CMP AL, 11101111B    ;if DOOR is locked(means mode of operation
has been selected)
        JZ LOADEXIT
        CMP AL, 11111011B
        JNZ LOAD
        INC BYTE PTR MODENO  ;if LOAD button is pressed increase the
MODE number
        CALL DEBOUNCE_DELAY  ;one press of LOAD button should only
raise MODE number by 1
    JMP LOAD
    LOADEXIT:
    ;Storing the MODE in AH
    MOV AH, MODENO
    MOV BL, 00H
    MOV MODENO, BL
    CMP AH, 00H              ;checking if mode is selected before
closing of door
    JZ LOAD
    CMP AH, 03H              ;checking if mode number selected is valid
    JG LOAD
    MOV MODENO, AH
    OUT1:
    CMP AH, 01H              ;displaying on the 7 segment display
    JNE OUT2
    MOV AL, 01H
    OUT PORTC, AL
    JMP LIGHT
    OUT2:
    CMP AH, 02H
    JNE OUT3
    MOV AL, 02H
    OUT PORTC, AL
    JMP MEDIUM
    OUT3:
    MOV AL, 03H
    OUT PORTC, AL
    JMP HEAVY
    LIGHT:                   ;LIGHT MODE
        CALL WATER_MAX       ;sensing if water level is max
```

```
        MOV AL,01H          ;rinse cycle
        OUT PORTB,AL        ;activating the agitator
        MOV CX,2
        X1:CALL DELAY_1m    ;rinse cycle runs for 2 minutes
        LOOP X1
        MOV AL,00H
        OUT PORTB,AL        ;stop rinse cycle(i.e. stop agitator)
        CALL BUZZER_RINSE   ;play the buzzer for 1 minute

        CALL WATER_MIN      ;check if water has drained fully
        CALL WATER_MAX      ;check if water is at max level again for
wash cycle
        CALL CHECK_RESUME   ;check if resume button is pressed
        CALL DEBOUNCE_DELAY ;only when resume button comes up, proceed
        CALL DELAY_1m       ;ASSUMPTION: USER PUTS DETERGENT IN 1
MINUTE

        MOV AL,01H          ;wash cycle
        OUT PORTB,AL
        MOV CX,3
        X2:CALL DELAY_1m    ;wash cycle runs for 3 minutes
        LOOP X2
        MOV AL,00H
        OUT PORTB,AL
        CALL BUZZER_WASH    ;play the buzzer for 1 minute

        CALL WATER_MIN      ;check if water has drained fully
        CALL WATER_MAX      ;check if water is at max level again for
wash cycle
        CALL CHECK_RESUME   ;check if resume button is pressed
        CALL DEBOUNCE_DELAY

        MOV AL,01H          ;rinse cycle
        OUT PORTB,AL        ;activating the agitator
        MOV CX,2
        X3:CALL DELAY_1m    ;rinse cycle runs for 2 minutes
        LOOP X3
        MOV AL,00H
        OUT PORTB,AL        ;stop rinse cycle(i.e. stop agitator)
        CALL BUZZER_RINSE   ;play the buzzer for 1 minute

        CALL WATER_MIN      ;check if water has drained fully
        CALL CHECK_RESUME   ;check if resume button is pressed
        CALL DEBOUNCE_DELAY ;only when resume button comes up, proceed

        MOV AL,02H          ;dry cycle
        OUT PORTB,AL        ;activating the revolving tub
        MOV CX,2
        X4:CALL DELAY_1m    ;dry cycle runs for 2 minutes
        LOOP X4
        MOV AL,00H
        OUT PORTB,AL
```

```
            CALL BUZZER_DRY
            JMP DONE_WASHING

     MEDIUM:                 ;MEDIUM MODE
            CALL WATER_MAX      ;sensing if water level is max
            MOV AL,01H          ;rinse cycle
            OUT PORTB,AL        ;activating the agitator
            MOV CX,3
            X5:CALL DELAY_1m    ;rinse cycle runs for 3 minutes
            LOOP X5
            MOV AL,00H
            OUT PORTB,AL        ;stop rinse cycle(i.e. stop agitator)
            CALL BUZZER_RINSE   ;play the buzzer for 1 minute

            CALL WATER_MIN      ;check if water has drained fully
            CALL WATER_MAX      ;check if water is at max level again for
     wash cycle
            CALL CHECK_RESUME   ;check if resume button is pressed
            CALL DEBOUNCE_DELAY ;only when resume button comes up, proceed
            CALL DELAY_1m       ;ASSUMPTION: USER PUTS DETERGENT IN 1
     MINUTE

            MOV AL,01H          ;wash cycle
            OUT PORTB,AL
            MOV CX,5
            X6:CALL DELAY_1m    ;wash cycle runs for 5 minutes
            LOOP X6
            MOV AL,00H
            OUT PORTB,AL
            CALL BUZZER_WASH    ;play the buzzer for 1 minute

            CALL WATER_MIN      ;check if water has drained fully
            CALL WATER_MAX      ;check if water is at max level again for
     wash cycle
            CALL CHECK_RESUME   ;check if resume button is pressed
            CALL DEBOUNCE_DELAY

            MOV AL,01H          ;rinse cycle
            OUT PORTB,AL        ;activating the agitator
            MOV CX,3
            X7:CALL DELAY_1m    ;rinse cycle runs for 3 minutes
            LOOP X7
            MOV AL,00H
            OUT PORTB,AL        ;stop rinse cycle(i.e. stop agitator)
            CALL BUZZER_RINSE   ;play the buzzer for 1 minute

            CALL WATER_MIN      ;check if water has drained fully
            CALL CHECK_RESUME   ;check if resume button is pressed
            CALL DEBOUNCE_DELAY ;only when resume button comes up, proceed

            MOV AL,02H          ;dry cycle
            OUT PORTB,AL        ;activating the revolving tub
```

```
        MOV CX,4
        X8:CALL DELAY_1m    ;dry cycle runs for 4 minutes
        LOOP X8
        MOV AL,00H
        OUT PORTB,AL
        CALL BUZZER_DRY
        JMP DONE_WASHING
    HEAVY:                  ;HEAVY MODE
        CALL WATER_MAX      ;sensing if water level is max
        MOV AL,01H          ;rinse cycle
        OUT PORTB,AL        ;activating the agitator
        MOV CX,3
        X9:CALL DELAY_1m    ;rinse cycle runs for 3 minutes
        LOOP X9
        MOV AL,00H
        OUT PORTB,AL        ;stop rinse cycle(i.e. stop agitator)
        CALL BUZZER_RINSE   ;play the buzzer for 1 minute

        CALL WATER_MIN      ;check if water has drained fully
        CALL WATER_MAX      ;check if water is at max level again for
wash cycle
        CALL CHECK_RESUME   ;check if resume button is pressed
        CALL DEBOUNCE_DELAY ;only when resume button comes up, proceed
        CALL DELAY_1m       ;ASSUMPTION: USER PUTS DETERGENT IN 1
MINUTE

        MOV AL,01H          ;wash cycle
        OUT PORTB,AL
        MOV CX,5
        X10:CALL DELAY_1m    ;wash cycle runs for 5 minutes
        LOOP X10
        MOV AL,00H
        OUT PORTB,AL
        CALL BUZZER_WASH    ;play the buzzer for 1 minute

        CALL WATER_MIN      ;check if water has drained fully
        CALL WATER_MAX      ;check if water is at max level again for
wash cycle
        CALL CHECK_RESUME   ;check if resume button is pressed
        CALL DEBOUNCE_DELAY

        CALL WATER_MAX      ;sensing if water level is max
        MOV AL,01H          ;rinse cycle
        OUT PORTB,AL        ;activating the agitator
        MOV CX,3
        X11:CALL DELAY_1m    ;rinse cycle runs for 3 minutes
        LOOP X11
        MOV AL,00H
        OUT PORTB,AL        ;stop rinse cycle(i.e. stop agitator)
        CALL BUZZER_RINSE   ;play the buzzer for 1 minute

        CALL WATER_MIN      ;check if water has drained fully
```

```
        CALL WATER_MAX        ;check if water is at max level again for
wash cycle
        CALL CHECK_RESUME     ;check if resume button is pressed
        CALL DEBOUNCE_DELAY   ;only when resume button comes up, proceed
        CALL DELAY_1m         ;ASSUMPTION: USER PUTS DETERGENT IN 1
MINUTE

        MOV AL,01H            ;wash cycle
        OUT PORTB,AL
        MOV CX,5
        X12:CALL DELAY_1m     ;wash cycle runs for 5 minutes
        LOOP X12
        MOV AL,00H
        OUT PORTB,AL
        CALL BUZZER_WASH      ;play the buzzer for 1 minute

        CALL WATER_MIN        ;check if water has drained fully
        CALL WATER_MAX        ;check if water is at max level again for
wash cycle
        CALL CHECK_RESUME     ;check if resume button is pressed
        CALL DEBOUNCE_DELAY

        CALL WATER_MAX        ;sensing if water level is max
        MOV AL,01H            ;rinse cycle
        OUT PORTB,AL          ;activating the agitator
        MOV CX,3
        X13:CALL DELAY_1m     ;rinse cycle runs for 3 minutes
        LOOP X13
        MOV AL,00H
        OUT PORTB,AL          ;stop rinse cycle(i.e. stop agitator)
        CALL BUZZER_RINSE     ;play the buzzer for 1 minute

        CALL WATER_MIN        ;check if water has drained fully
        CALL CHECK_RESUME     ;check if resume button is pressed
        CALL DEBOUNCE_DELAY   ;only when resume button comes up, proceed

        MOV AL,02H            ;dry cycle
        OUT PORTB,AL          ;activating the revolving tub
        MOV CX,4
        X14:CALL DELAY_1m     ;dry cycle runs for 4 minutes
        LOOP X14
        MOV AL,00H
        OUT PORTB,AL
        CALL BUZZER_DRY
        JMP DONE_WASHING

    DONE_WASHING:
        JMP POLL_START

    ;INF:
    ;JMP INF
```

```
    STOP_BUTTON:                  ;this procedure is an ISR for NMI(STOP
button)
        MOV BP,SP
        MOV AL,00H
        OUT PORTB,AL
        OUT PORTC,AL
        MOV AX,STARTING_IP ;this will put in stack the IP address of
the starting line of program
        MOV [BP],AX
        IRET                      ;now the IP address popped will be of the
starting line of program
.exit

STORE_IP PROC NEAR            ;this procedure will store the IP address
    MOV BP,SP                 ;of the label POLL_START
    MOV AX,[BP]
    MOV STARTING_IP,AX
    RET
STORE_IP ENDP



DEBOUNCE_DELAY PROC NEAR      ;this procedure checks all the buttons and
    DEBOUNCE:                 ;returns only of all the buttons are up
        IN AL,PORTA
        OR AL,11110000B
        CMP AL,11111111B
        JNZ DEBOUNCE
    RET
DEBOUNCE_DELAY ENDP

DELAY_1m PROC NEAR            ;this procedure is used to generate a
delay of 1 minute
    PUSH CX                   ;for simulation purpose 1 minute(virtual)
= 10 seconds(real)
    MOV BX,00E5H
    L2:MOV CX,0FFFFH
    L1:NOP
        LOOP L1
        DEC BX
        JNZ L2
    POP CX
        RET
DELAY_1m ENDP

WATER_MAX PROC NEAR           ;this procedure checks if water level is
max
                              ;water level is max when the pressure
sensitive switch(WATER_MAX) is pressed
    CHECK1:
        IN AL,PORTA
        CMP AL,11001111B
```

```
        JNE CHECK1
        RET
WATER_MAX ENDP

WATER_MIN PROC NEAR          ;this procedure checks if water level is
min
                             ;water level is min when the pressure
sensitive switch(WATER_MIN) is pressed
    CHECK2:
        IN AL,PORTA
        CMP AL,10101111B
    JNE CHECK2
    RET
WATER_MIN ENDP

BUZZER_RINSE PROC NEAR       ;this procedure activates a buzzer after
rinse cycle in complete
    MOV AL,10H
    OUT PORTB,AL
    CALL DELAY_1m
    MOV AL,00H
    OUT PORTB,AL
    RET
BUZZER_RINSE ENDP

BUZZER_WASH PROC NEAR        ;this procedure activates a buzzer after
wash cycle in complete
    MOV AL,08H
    OUT PORTB,AL
    CALL DELAY_1m
    MOV AL,00H
    OUT PORTB,AL
    RET
BUZZER_WASH ENDP

BUZZER_DRY PROC NEAR         ;this procedure activates a buzzer after
dry cycle in complete
    MOV AL,04H
    OUT PORTB,AL
    CALL DELAY_1m
    MOV AL,00H
    OUT PORTB,AL
    RET
BUZZER_DRY ENDP

CHECK_RESUME PROC NEAR       ;this procedure checks if resume button is
pressed or not

    CHECKR:
        IN AL,PORTA
        OR AL,11100111B
        CMP AL,11100111B
```
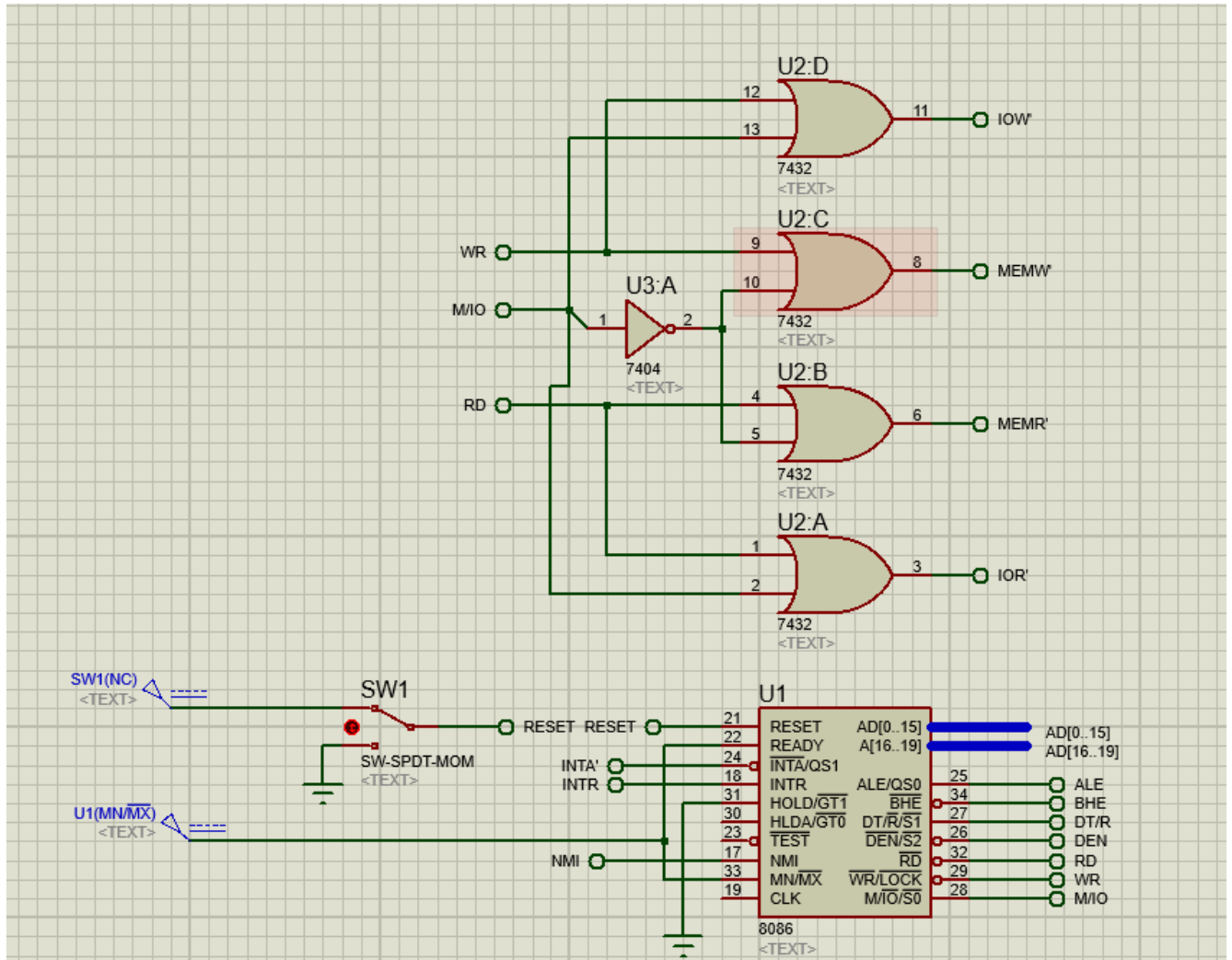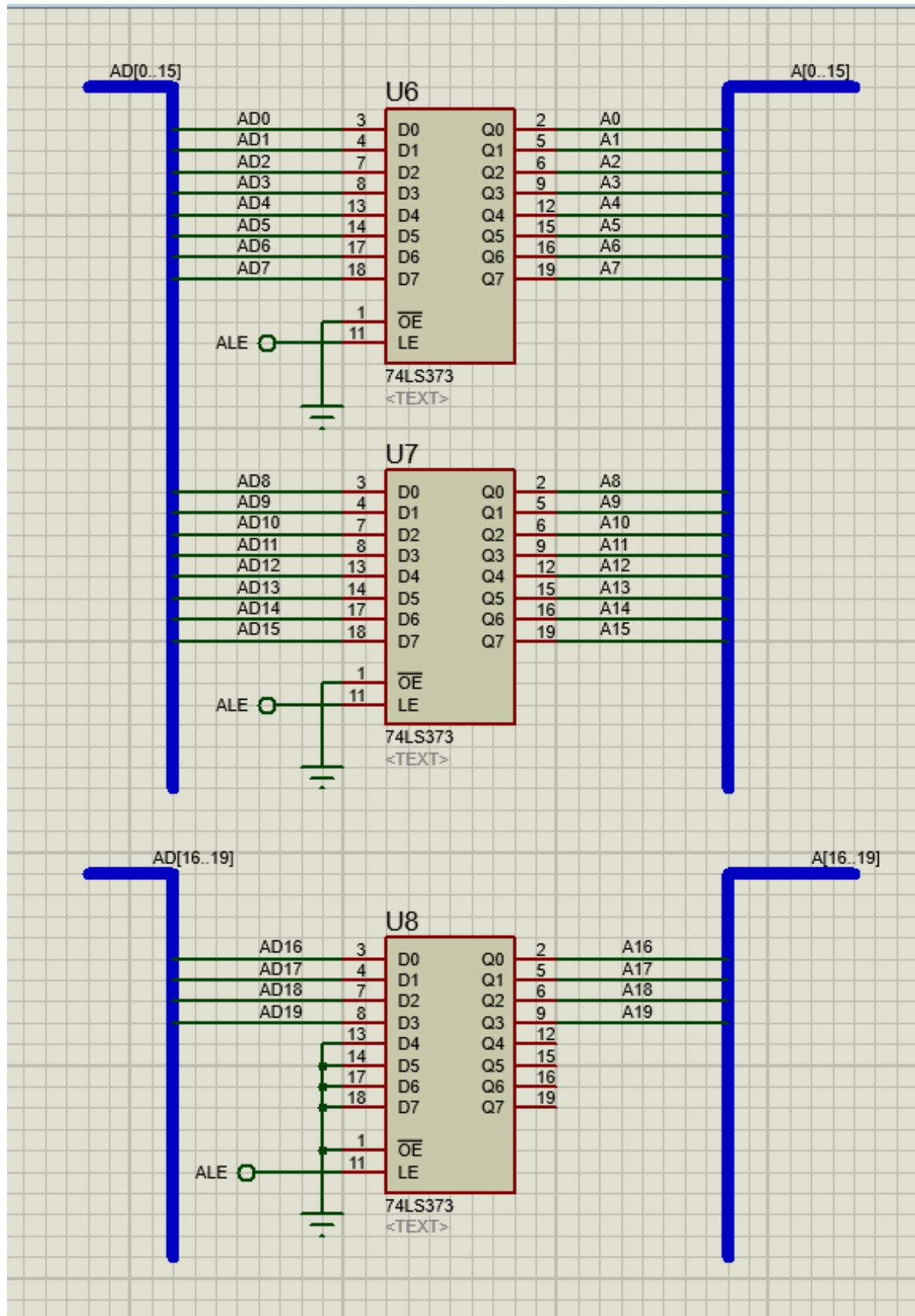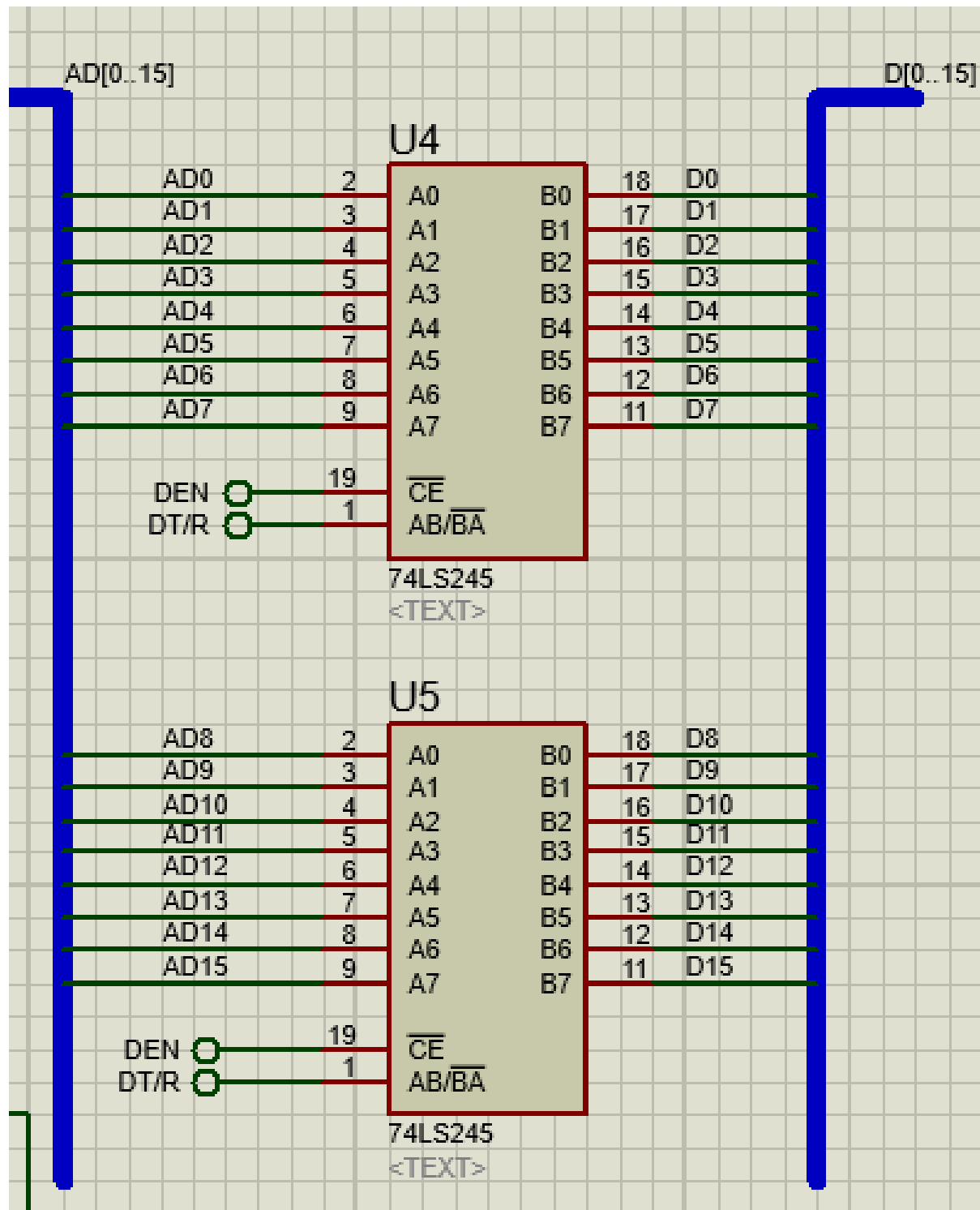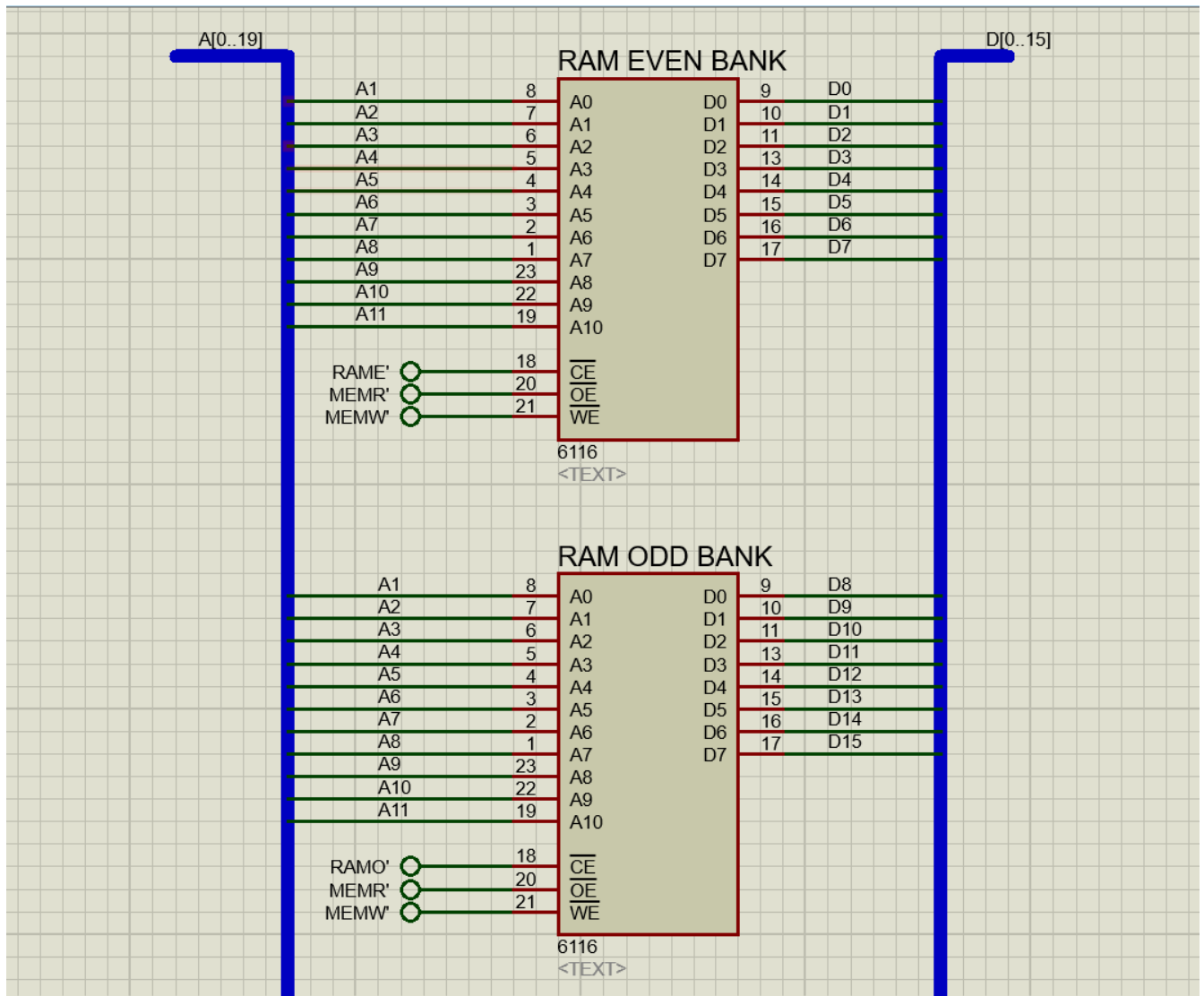
```
        JNE  CHECKR
    RET
CHECK_RESUME ENDP


end
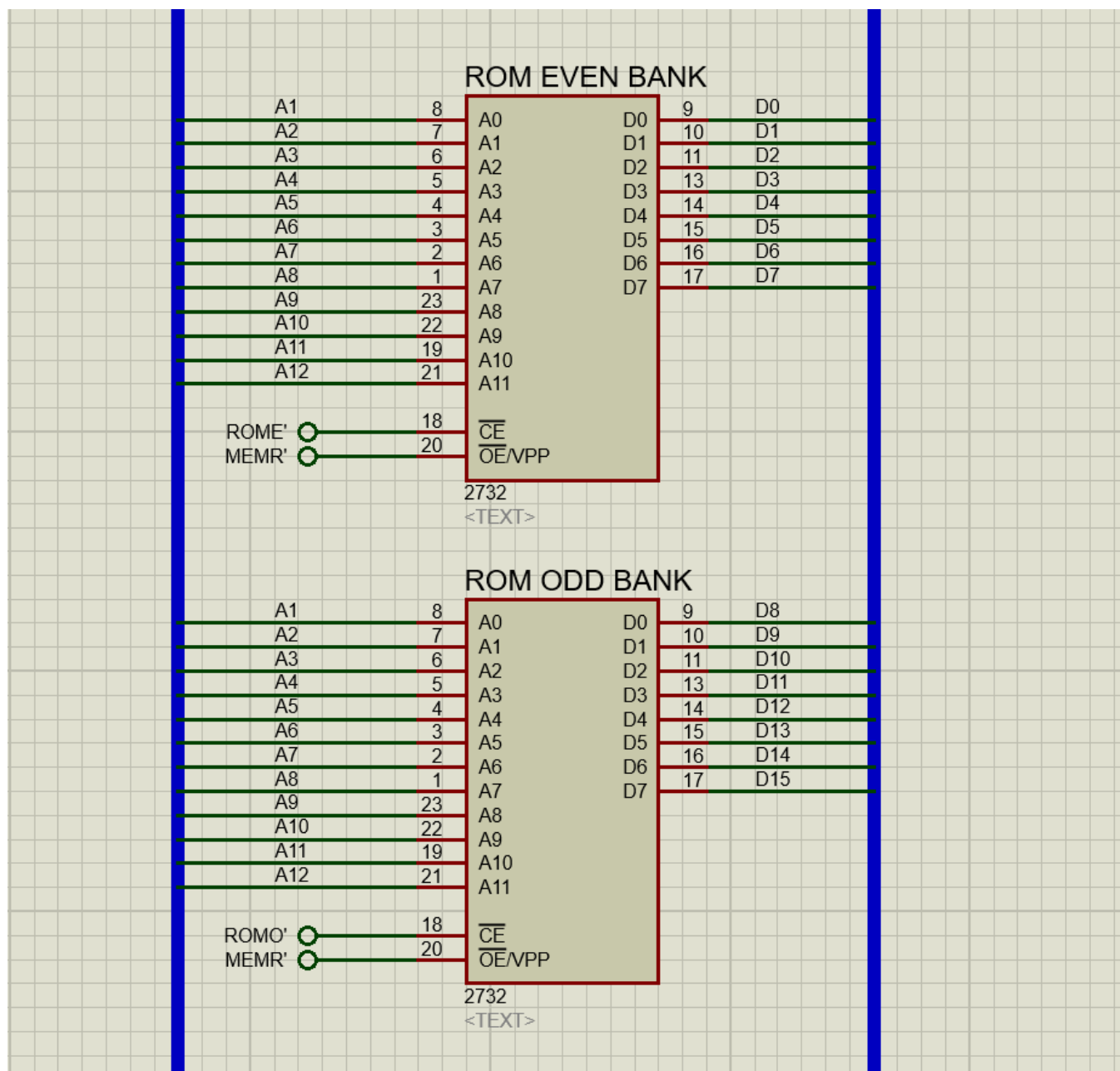```

## ROM EVEN BANK

| | | | | | |
|---|---|---|---|---|---|
| A1 | 8 | A0 | D0 | 9 | D0 |
| A2 | 7 | A1 | D1 | 10 | D1 |
| A3 | 6 | A2 | D2 | 11 | D2 |
| A4 | 5 | A3 | D3 | 13 | D3 |
| A5 | 4 | A4 | D4 | 14 | D4 |
| A6 | 3 | A5 | D5 | 15 | D5 |
| A7 | 2 | A6 | D6 | 16 | D6 |
| A8 | 1 | A7 | D7 | 17 | D7 |
| A9 | 23 | A8 | | | |
| A10 | 22 | A9 | | | |
| A11 | 19 | A10 | | | |
| A12 | 21 | A11 | | | |

ROME' — 18 — $\overline{CE}$
MEMR' — 20 — $\overline{OE}$/VPP

2732
\<TEXT\>

## ROM ODD BANK

| | | | | | |
|---|---|---|---|---|---|
| A1 | 8 | A0 | D0 | 9 | D8 |
| A2 | 7 | A1 | D1 | 10 | D9 |
| A3 | 6 | A2 | D2 | 11 | D10 |
| A4 | 5 | A3 | D3 | 13 | D11 |
| A5 | 4 | A4 | D4 | 14 | D12 |
| A6 | 3 | A5 | D5 | 15 | D13 |
| A7 | 2 | A6 | D6 | 16 | D14 |
| A8 | 1 | A7 | D7 | 17 | D15 |
| A9 | 23 | A8 | | | |
| A10 | 22 | A9 | | | |
| A11 | 19 | A10 | | | |
| A12 | 21 | A11 | | | |

ROMO' — 18 — $\overline{CE}$
MEMR' — 20 — $\overline{OE}$/VPP

2732
\<TEXT\>

--------------------------------- *THE END* ---------------------------------