MUP Design Project

P12: Automatic Washing Machine

Submitted By:

Group 108

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Problem Statement

P12: 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

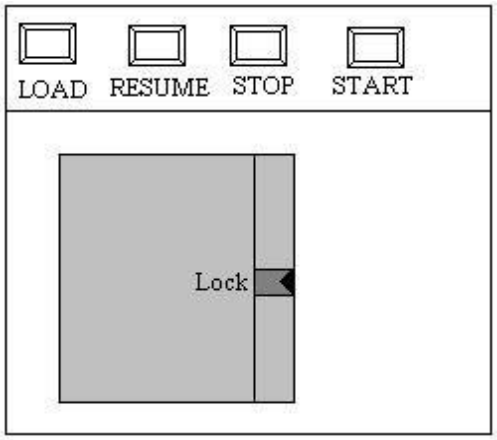
- The Washing Machine is a single tub machine.
- The Washing machine is made of a Revolving Tub and an Agitator. The Agitator is activated during the Rinse and Wash cycle; revolving tub is active only during the Dry cycle. The door of the washtub should remain closed as long as the agitator is active.
- 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:
1 press – light; 2 presses – medium and 3 presses – heavy.

To begin washing process START is pressed.

Pressing STOP can stop the process.



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.

Components Used

- 8086
- 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
- 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	Start Address	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	End Address	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
RAM	Start Address	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	End Address	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

Ports	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	

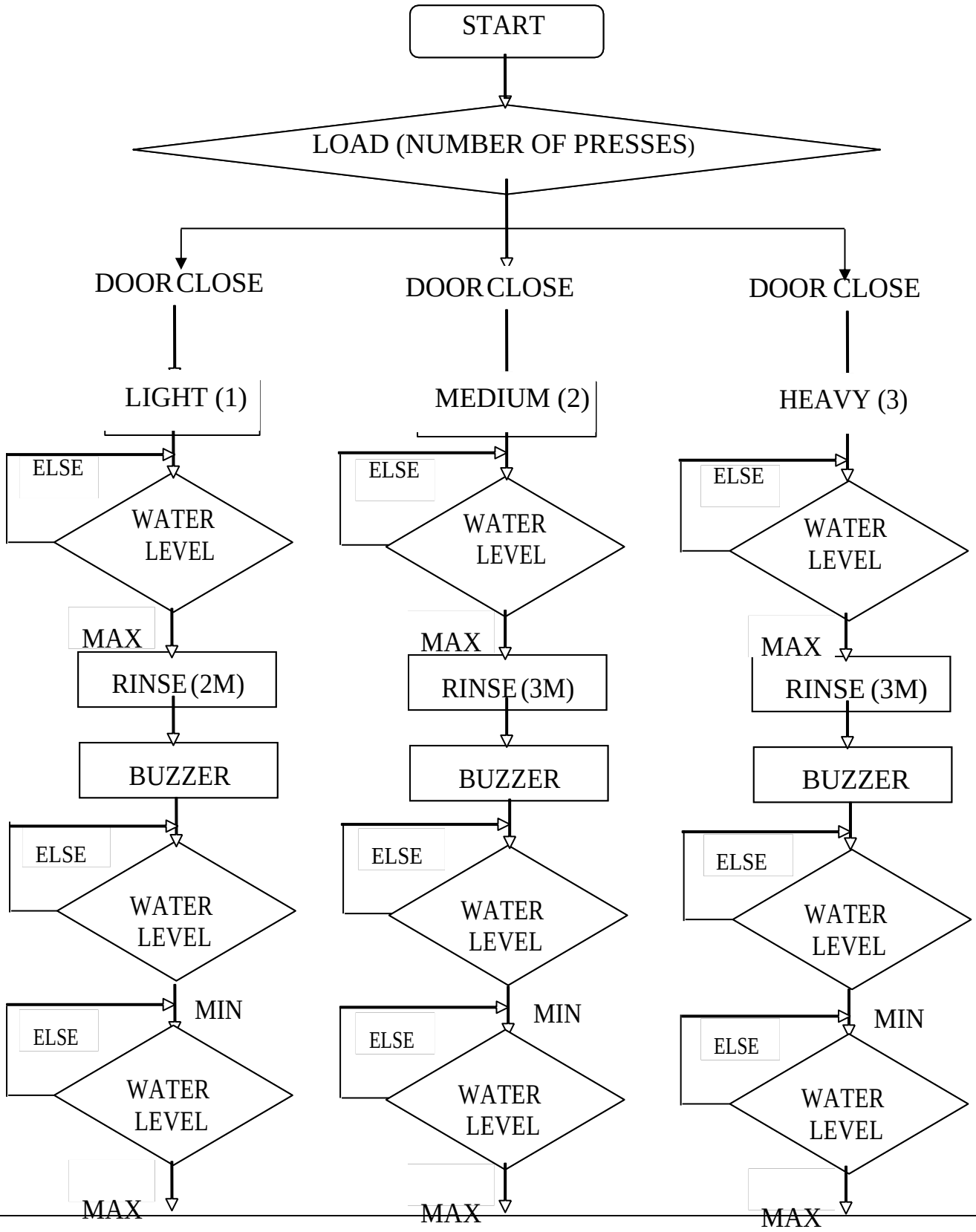
Port A	Port B	Port C
PA0- Start Button PA1- Stop Button PA2- Load Button PA3- Resume Button PA4- Door Lock Switch PA5- Water Max Switch PA6- Water Min Switch	PB0- Agitator PB1- Revolving tub PB2- Buzzer - Dry PB3- Buzzer - Wash PB4-Buzzer - Rinse	PC0-PC3: input–to–BCD–to–7 segment decoders

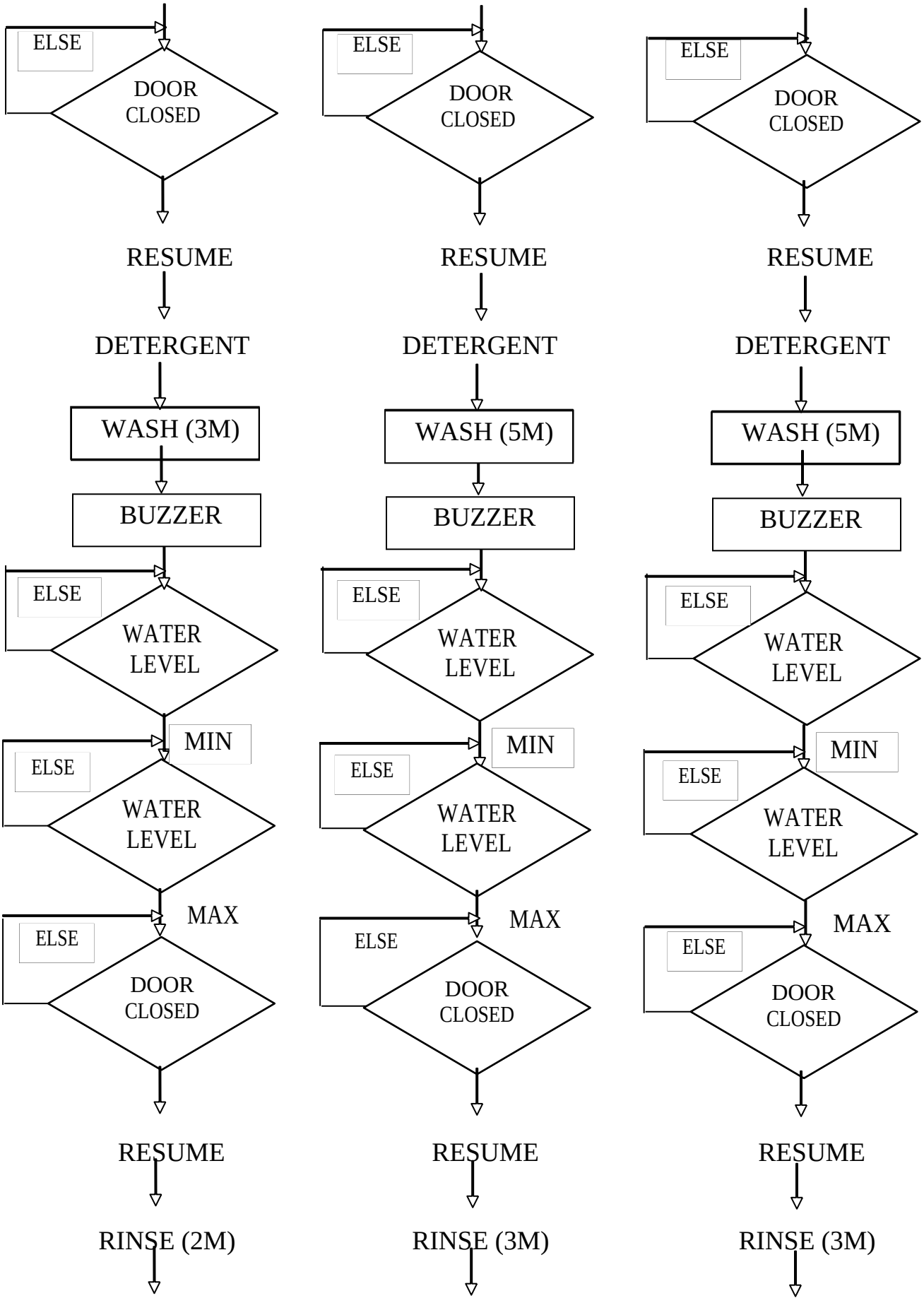
IVT Table

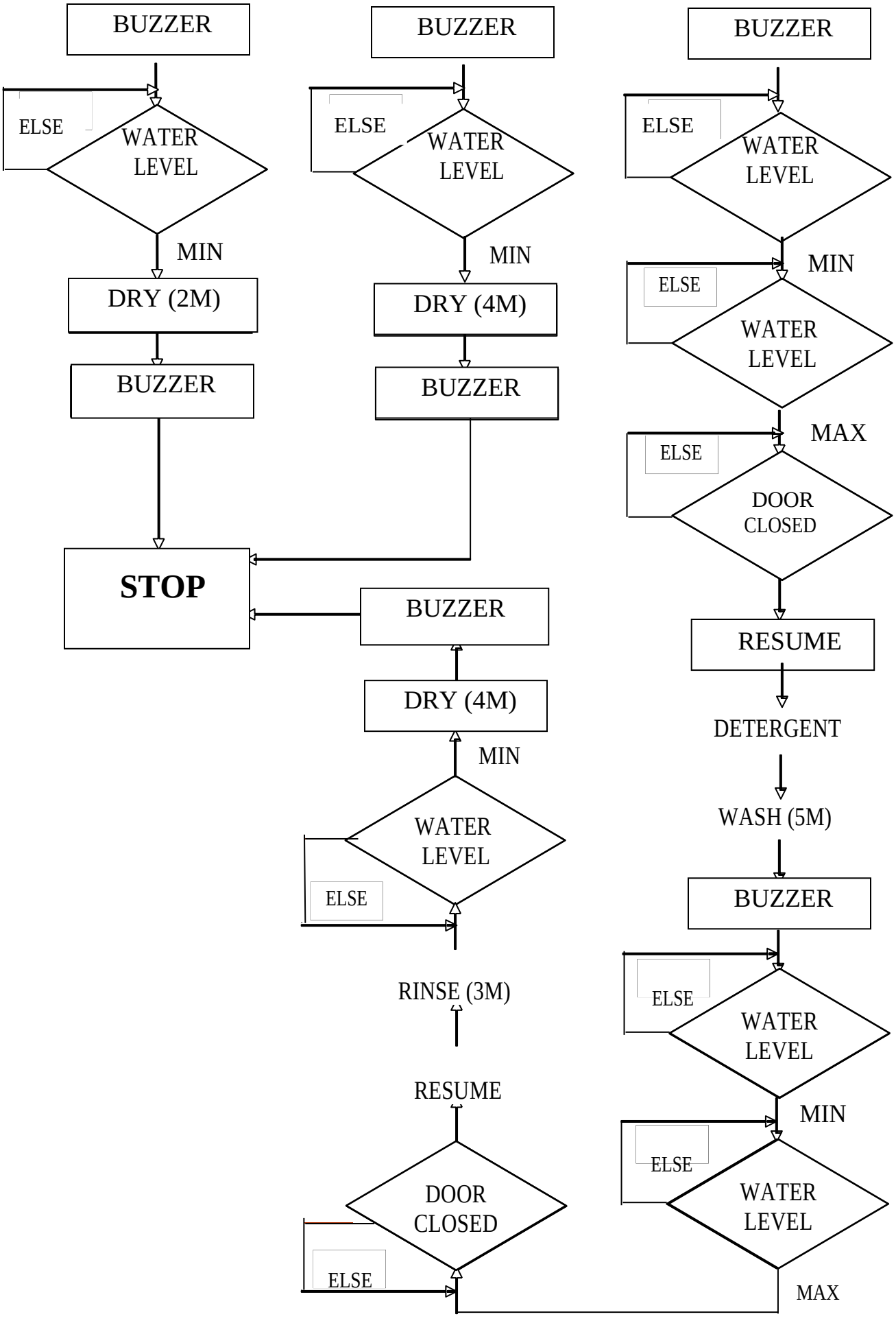
INT 2H (NMI) is used.

Address	Contents
00008H	IP (lower byte)
00009H	IP (higher byte)
0000AH	CS (lower byte)
0000BH	CS (higher byte)

Flow Chart


START
LOAD (NUMBER OF PRESSES)
DOOR CLOSE
DOOR CLOSE
DOOR CLOSE
LIGHT (1)
MEDIUM (2)
HEAVY (3)
ELSE
WATER LEVEL
MAX
RINSE (2M)
RINSE (3M)
RINSE (3M)
BUZZER
BUZZER
BUZZER
ELSE
WATER LEVEL
MIN
ELSE
WATER LEVEL
MAX


ELSE
DOOR CLOSED
RESUME
DETERGENT
WASH (3M)
BUZZER
ELSE
WATER LEVEL
MIN
ELSE
WATER LEVEL
MAX
ELSE
DOOR CLOSED
RESUME
RINSE (2M)
ELSE
DOOR CLOSED
RESUME
DETERGENT
WASH (5M)
BUZZER
ELSE
WATER LEVEL
MIN
ELSE
WATER LEVEL
MAX
ELSE
DOOR CLOSED
RESUME
RINSE (3M)
ELSE
DOOR CLOSED
RESUME
DETERGENT
WASH (5M)
BUZZER
ELSE
WATER LEVEL
MIN
ELSE
WATER LEVEL
MAX
ELSE
DOOR CLOSED
RESUME
RINSE (3M)


BUZZER
ELSE
WATER LEVEL
MIN
DRY (2M)
BUZZER
BUZZER
ELSE
WATER LEVEL
MIN
DRY (4M)
BUZZER
BUZZER
ELSE
WATER LEVEL
MIN
ELSE
WATER LEVEL
MAX
ELSE
DOOR CLOSED
RESUME
DETERGENT
WASH (5M)
BUZZER
ELSE
WATER LEVEL
MIN
ELSE
WATER LEVEL
MAX
STOP
BUZZER
DRY (4M)
MIN
WATER LEVEL
ELSE
RINSE (3M)
RESUME
DOOR CLOSED
ELSE

Code

```
.model tiny
; --- MACROS --- ;

; macro for rinse cycle
RINSE_CYCLE MACRO DURATION
        MOV AL, 00000001b
        OUT PORTB, AL ; turn on agitator
        MOV CX, DURATION
        CALL DELAY
        CALL RINSED
ENDM

; macro for wash cycle
WASH_CYCLE MACRO DURATION
        MOV AL, 00000001b
        OUT PORTB, AL ; turn on agitator
        MOV CX, DURATION
        CALL DELAY
        CALL WASHED
ENDM

; macro for dry cycle
DRY_CYCLE MACRO DURATION
        MOV AL, 00000010b
        OUT PORTB, AL ; turn on revolving tub
        MOV CX, DURATION
        CALL DELAY
        CALL DRIED
ENDM

; macro for consecutive rinse and wash cycles
RINSE_WASH MACRO RINSE_TIME, WASH_TIME
        CALL WATER_LEVEL_MIN
        CALL WATER_LEVEL_MAX
        RINSE_CYCLE RINSE_TIME ; RINSE cycle

        CALL WATER_LEVEL_MIN
        CALL WATER_LEVEL_MAX
        MOV CX, 1
        CALL DELAY ; user enters detergent during this delay period
```

```
        CALL RESUMED
        CALL DEBOUNCE_DELAY
        WASH_CYCLE WASH_TIME ; WASH cycle
ENDM

; macro for consecutive rinse and dry cycles
RINSE_DRY MACRO RINSE_TIME, DRY_TIME
        CALL WATER_LEVEL_MIN
        CALL WATER_LEVEL_MAX
        CALL RESUMED
        CALL DEBOUNCE_DELAY
        RINSE_CYCLE RINSE_TIME ; RINSE cycle

        CALL WATER_LEVEL_MIN
        CALL RESUMED
        CALL DEBOUNCE_DELAY
        DRY_CYCLE DRY_TIME ; DRY cycle
ENDM

; --- CODE --- ;

.data
        PORTA EQU 00h
        PORTB EQU 02h
        PORTC EQU 04h
        CREG EQU 06h
        MODE DB 00h

.code
.startup
        ; initializing 8255 using control word reg.
        MOV AL, 10010000b
        OUT CREG, AL

        ; reset port b
        MOV AL, 00h
        OUT PORTB, AL

        ; check if start button is ON (Active Low)
        START:
                MOV MODE, 00h
                IN AL, PORTA
                CMP AL, 11111110b
                JNZ START
                CALL DEBOUNCE_DELAY
                MOV AL, 00h
                OUT PORTC, AL
```

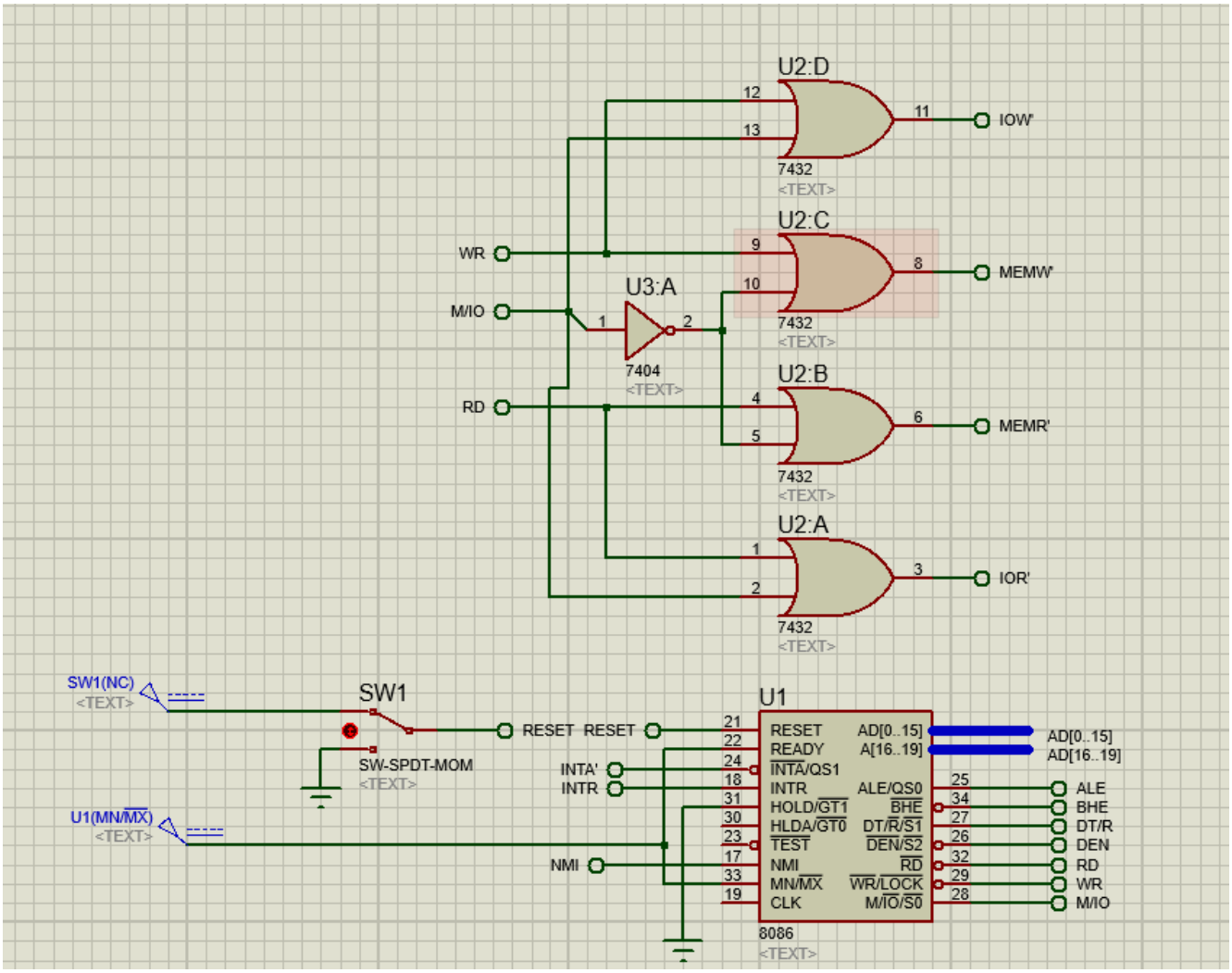
```
; check for number of load presses
LOAD:
        IN AL, PORTA
        CMP AL, 11101111b ; check if door is closed
        JZ DOOR_CLOSED
        CMP AL, 11111011b ; else if load button pressed
        JNZ LOAD
        INC BYTE PTR MODE
        CALL DEBOUNCE_DELAY
        JMP LOAD

; door is now closed
DOOR_CLOSED:
        MOV AH, MODE
        CMP AH, 00h ; should have greater than 0 presses
        JZ LOAD
        CMP AH, 03h ; should have less than 3 presses
        JLE MODE1
        MOV MODE, 00h
        JMP LOAD

; valid mode has been entered
MODE1:
        CMP MODE, 01h
        JNE MODE2
        MOV AL, 01h
        OUT PORTC, AL ; display mode number on 7 seg display
        JMP LIGHT

MODE2:
        CMP MODE, 02h
        JNE MODE3
        MOV AL, 02h
        OUT PORTC, AL ; display mode number on 7 seg display
        JMP MEDIUM

MODE3:
        MOV AL, 03h
        OUT PORTC, AL ; display mode number on 7 seg display
        JMP HEAVY

LIGHT:
        RINSE_WASH 2, 3
        RINSE_DRY 2, 2
        JMP COMPLETE
```

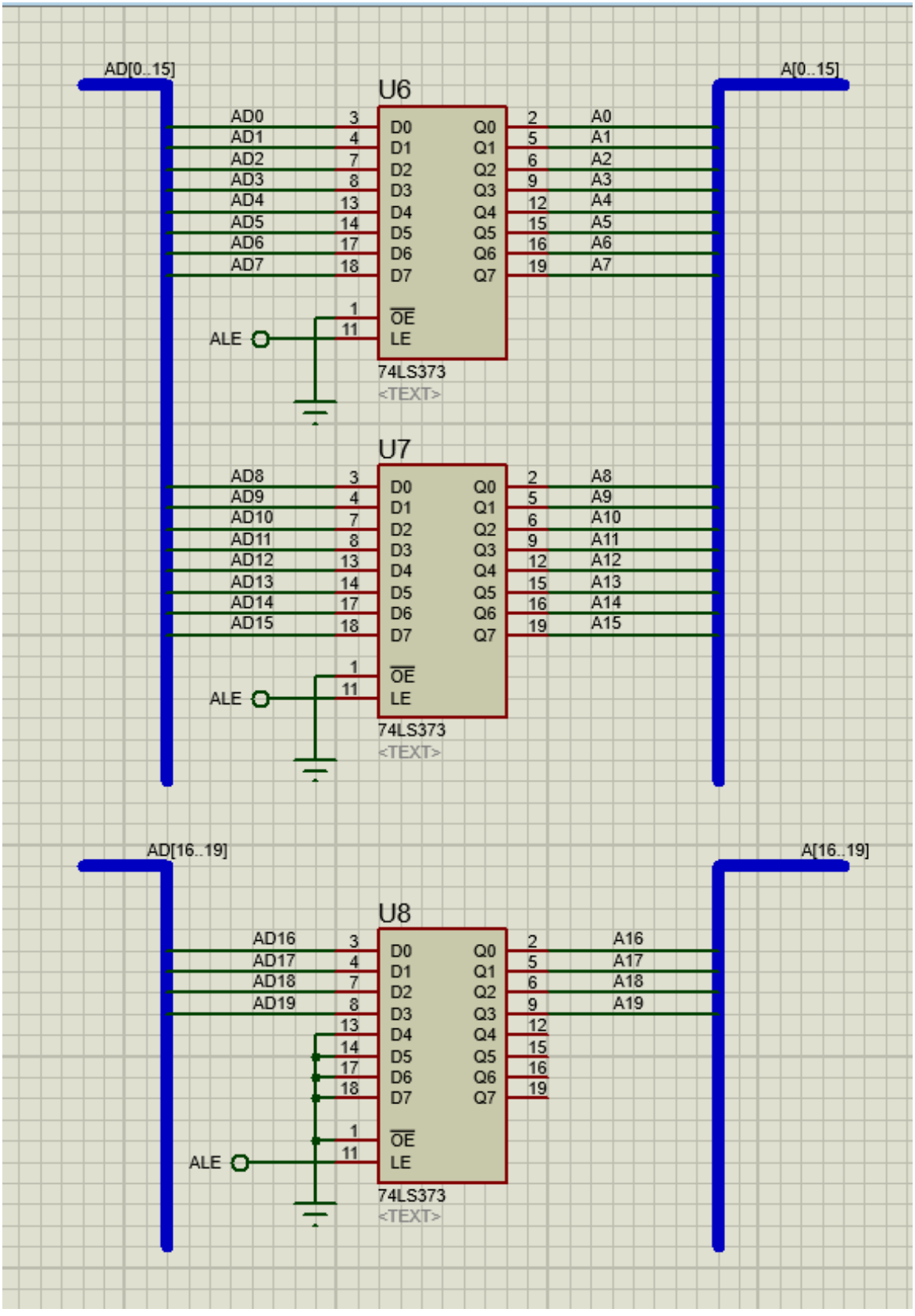
```
        MEDIUM:
                RINSE_WASH 3, 5
                RINSE_DRY 3, 4
                JMP COMPLETE

        HEAVY:
                RINSE_WASH 3, 5
                CALL RESUMED
                CALL DEBOUNCE_DELAY
                RINSE_WASH 3, 5
                RINSE_DRY 3, 4
                JMP COMPLETE

        COMPLETE:

.exit

; --- PROCEDURES --- ;

; introduce delay in the system- DURATION held in CX register
DELAY PROC NEAR USES BX DX
        L0:
                MOV BX, 0001h
        L1:
                MOV DX, 0FFFFh
        L2:
                NOP
                DEC DX
                JNZ L2
                DEC BX
                JNZ L1
        LOOP L0
        RET
DELAY ENDP

; ensure all buttons are unpressed
DEBOUNCE_DELAY PROC NEAR
        DEBOUNCE:
                IN AL, PORTA
                OR AL, 11110000b
                CMP AL, 11111111b
                JNE DEBOUNCE
        RET
DEBOUNCE_DELAY ENDP
```

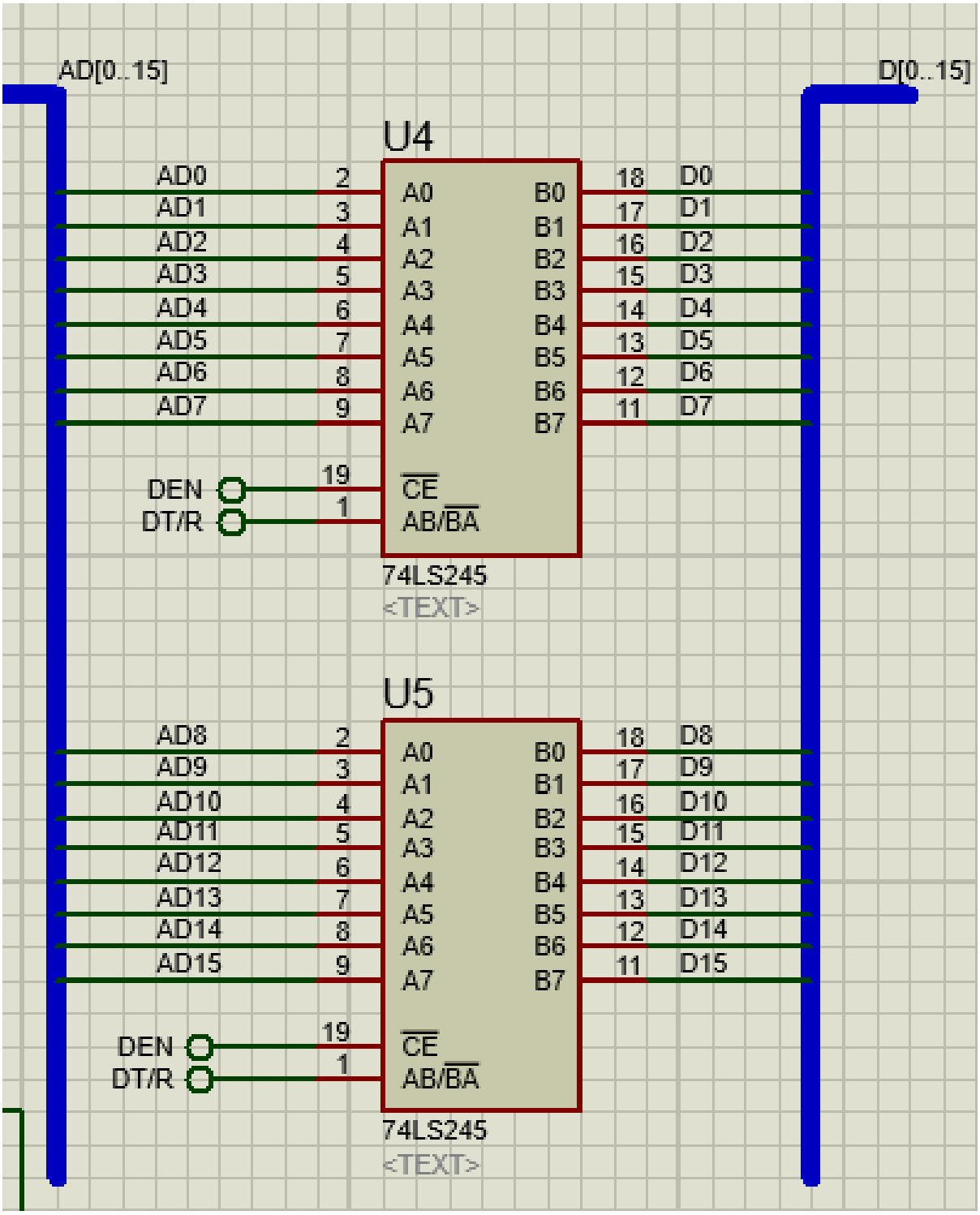
```
; check if water level is maximum and door is closed
WATER_LEVEL_MAX PROC NEAR
	MAX:
		IN AL, PORTA
		CMP AL, 11001111b
		JNE MAX
	RET
WATER_LEVEL_MAX ENDP

; check if water level is minimum and door is closed
WATER_LEVEL_MIN PROC NEAR
	MIN:
		IN AL, PORTA
		CMP AL, 10101111b
		JNE MIN
	RET
WATER_LEVEL_MIN ENDP

; check if resume button is pressed
RESUMED PROC NEAR
	RESUMEOFF:
		IN AL, PORTA
		OR AL,11100111b
	 CMP AL,11100111b
	 JNE RESUMEOFF
    RET
RESUMED ENDP

; rinse cycle completed
RINSED PROC NEAR
	MOV AL, 00h
	OUT PORTB, AL ; turn off agitator
	MOV AL, 00010000b
	OUT PORTB, AL
	MOV CX, 1
	CALL DELAY ; turn on buzzer for 1 minute
	MOV AL, 00h
	OUT PORTB, AL ; turn off buzzer
	RET
RINSED ENDP
```

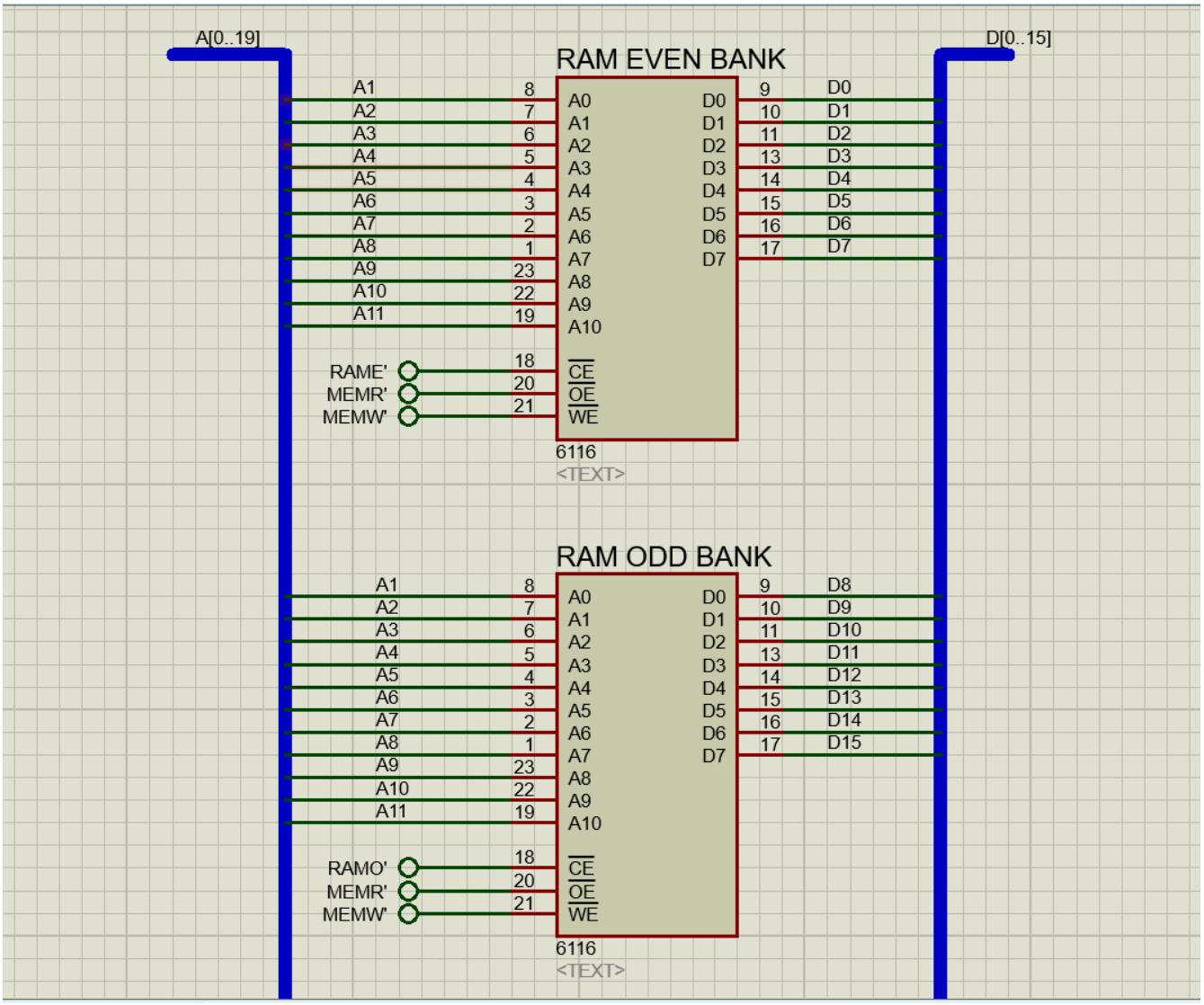
```
; wash cycle completed
WASHED PROC NEAR
        MOV AL, 00h
        OUT PORTB, AL ; turn off agitator
        MOV AL, 00001000b
        OUT PORTB, AL
        MOV CX, 1
        CALL DELAY ; turn on buzzer for 1 minute
        MOV AL, 00h
        OUT PORTB, AL
        RET
WASHED ENDP

; dry cycle completed
DRIED PROC NEAR
        MOV AL, 00h
        OUT PORTB, AL ;turn off revolving tub
        MOV AL, 00000100b
        OUT PORTB, AL
        MOV CX, 1
        CALL DELAY ; turn on buzzer for 1 minute
        MOV AL, 00h
        OUT PORTB, AL
        RET
DRIED ENDP

END
```

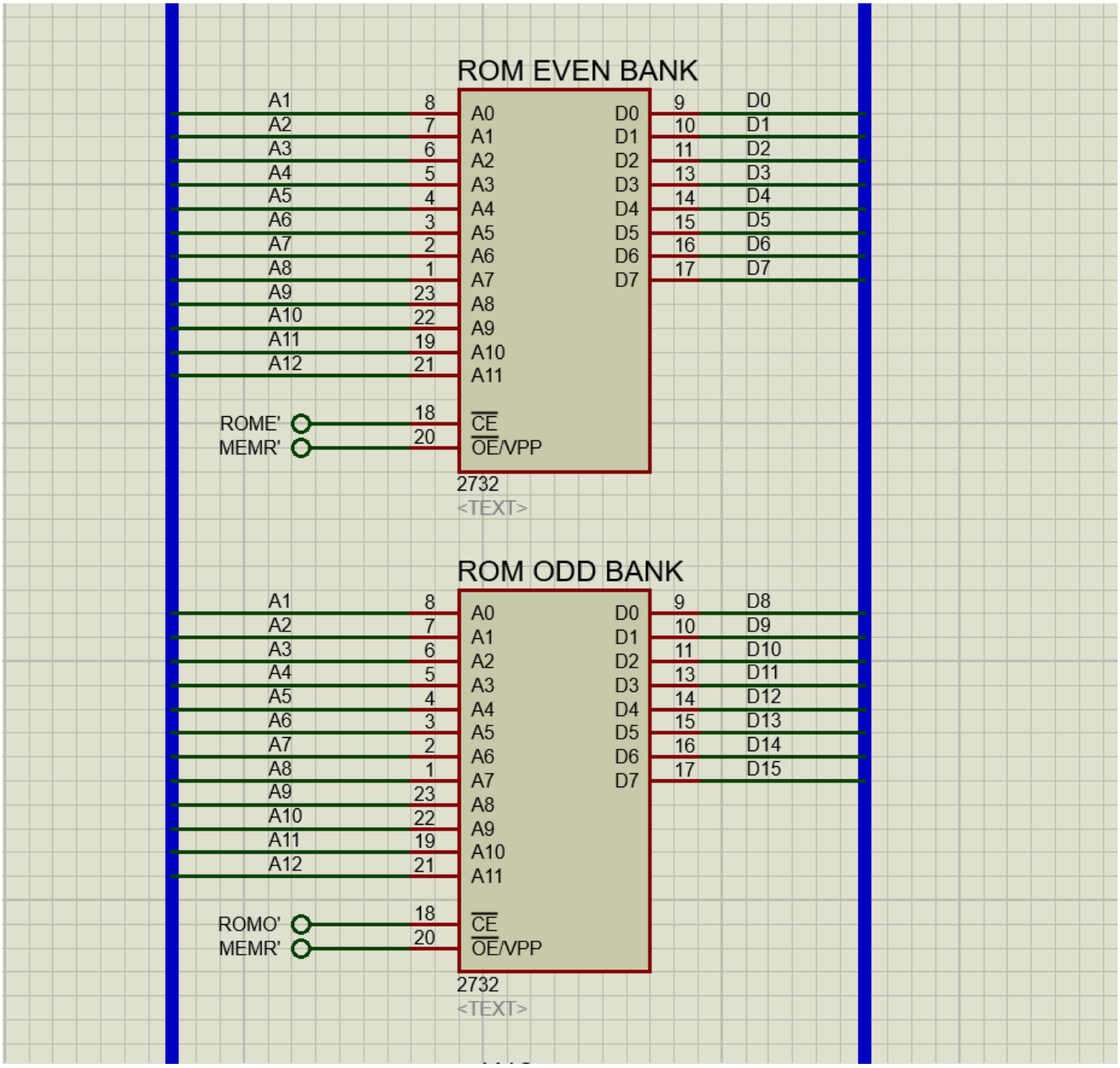
Circuit Diagram

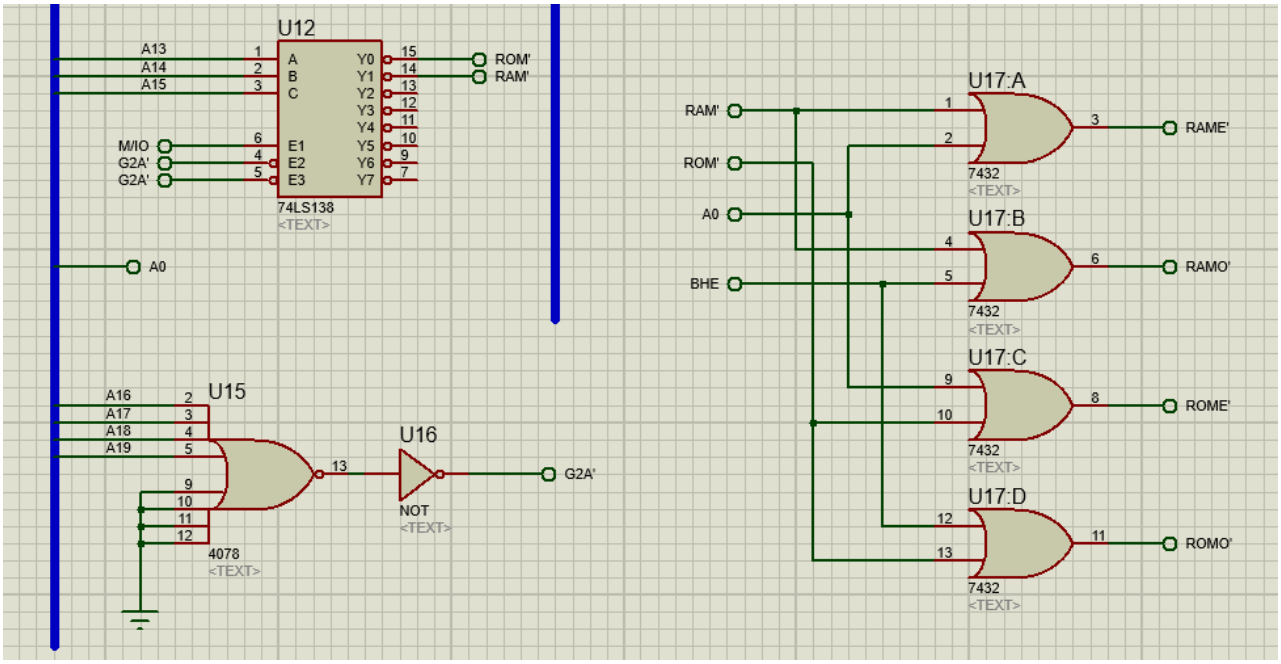


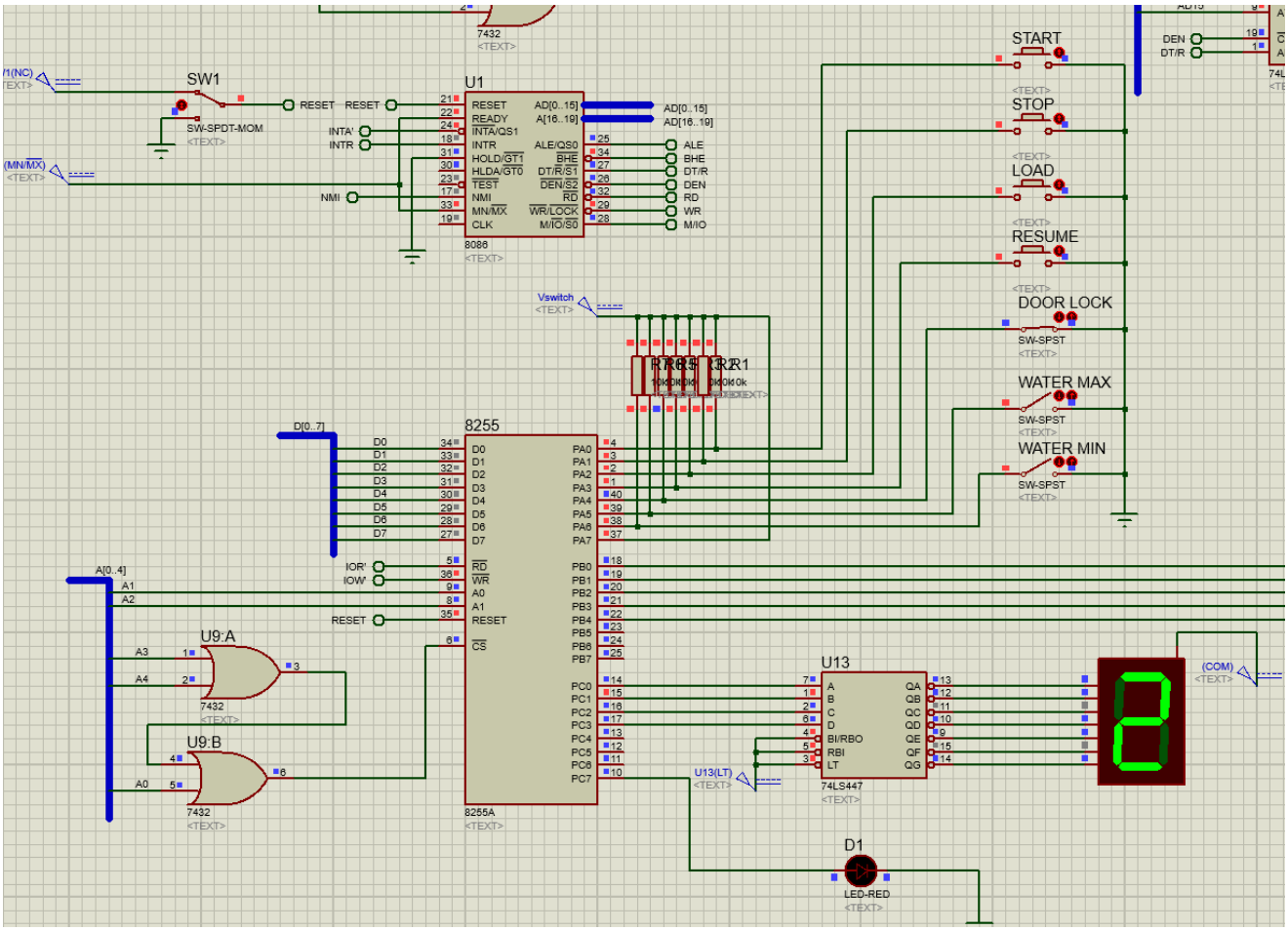

AD[0..15]
A[0..15]
U6
AD0
AD1
AD2
AD3
AD4
AD5
AD6
AD7
3
4
7
8
13
14
17
18
D0
D1
D2
D3
D4
D5
D6
D7
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
2
5
6
9
12
15
16
19
A0
A1
A2
A3
A4
A5
A6
A7
1
11
OE
LE
ALE
74LS373
<TEXT>
U7
AD8
AD9
AD10
AD11
AD12
AD13
AD14
AD15
A8
A9
A10
A11
A12
A13
A14
A15
AD[16..19]
A[16..19]
U8
AD16
AD17
AD18
AD19
A16
A17
A18
A19

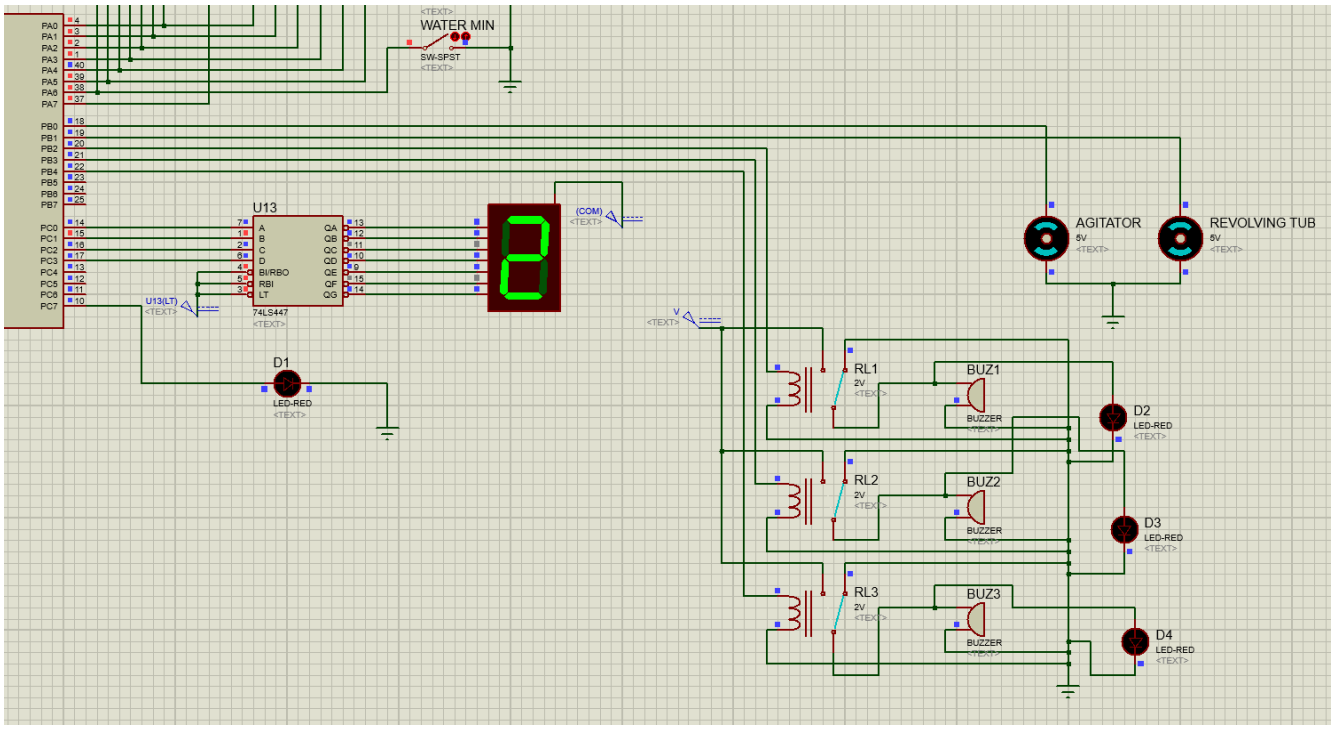

AD[0..15]
D[0..15]
U4
AD0
AD1
AD2
AD3
AD4
AD5
AD6
AD7
DEN
DT/R
2
3
4
5
6
7
8
9
19
1
A0
A1
A2
A3
A4
A5
A6
A7
CE
AB/BA
B0
B1
B2
B3
B4
B5
B6
B7
18
17
16
15
14
13
12
11
D0
D1
D2
D3
D4
D5
D6
D7
74LS245
<TEXT>
U5
AD8
AD9
AD10
AD11
AD12
AD13
AD14
AD15
DEN
DT/R
2
3
4
5
6
7
8
9
19
1
A0
A1
A2
A3
A4
A5
A6
A7
CE
AB/BA
B0
B1
B2
B3
B4
B5
B6
B7
18
17
16
15
14
13
12
11
D8
D9
D10
D11
D12
D13
D14
D15
74LS245
<TEXT>


A[0..19]
D[0..15]
RAM EVEN BANK
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
8
7
6
5
4
3
2
1
23
22
19
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
D0
D1
D2
D3
D4
D5
D6
D7
9
10
11
13
14
15
16
17
D0
D1
D2
D3
D4
D5
D6
D7
RAME'
MEMR'
MEMW'
18
20
21
CE
OE
WE
6116
<TEXT>
RAM ODD BANK
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
8
7
6
5
4
3
2
1
23
22
19
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
D0
D1
D2
D3
D4
D5
D6
D7
9
10
11
13
14
15
16
17
D8
D9
D10
D11
D12
D13
D14
D15
RAMO'
MEMR'
MEMW'
18
20
21
CE
OE
WE
6116
<TEXT>


ROM EVEN BANK
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
8
7
6
5
4
3
2
1
23
22
19
21
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
ROME'
MEMR'
18
20
CE
OE/VPP
D0
D1
D2
D3
D4
D5
D6
D7
9
10
11
13
14
15
16
17
D0
D1
D2
D3
D4
D5
D6
D7
2732
<TEXT>
ROM ODD BANK
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
8
7
6
5
4
3
2
1
23
22
19
21
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
ROMO'
MEMR'
18
20
CE
OE/VPP
D0
D1
D2
D3
D4
D5
D6
D7
9
10
11
13
14
15
16
17
D8
D9
D10
D11
D12
D13
D14
D15
2732
<TEXT>


U12
A13
A14
A15
M/IO
G2A'
G2A'
A0
ROM'
RAM'
74LS138
U15
A16
A17
A18
A19
4078
U16
NOT
G2A'
U17:A
U17:B
U17:C
U17:D
RAM'
ROM'
A0
BHE
RAME'
RAMO'
ROME'
ROMO'
7432


SW1
SW-SPDT-MOM
U1
8086
8255
8255A
START
STOP
LOAD
RESUME
DOOR LOCK
WATER MAX
WATER MIN
SW-SPST
U9:A
U9:B
7432
U13
74LS447
D1
LED-RED
Vswitch
AD[0..15]
A[16..19]
D[0..7]
A[0..4]


WATER MIN
SW-SPST
U13
74LS447
A
B
C
D
BI/RBO
RBI
LT
QA
QB
QC
QD
QE
QF
QG
(COM)
U13(LT)
D1
LED-RED
AGITATOR
5V
REVOLVING TUB
5V
RL1
2V
RL2
2V
RL3
2V
BUZ1
BUZZER
BUZ2
BUZZER
BUZ3
BUZZER
D2
LED-RED
D3
LED-RED
D4
LED-RED

----------END----------