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With due regards.

**Problem Statement**

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 if the agitator is active. If the door is not closed the system should not start and should indicate that the door is open by sounding the alarm.

● 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.

● There are relays that control the opening and closing of relays to let in water via the inlet pipe and drain the water via the outlet pipe.

● At the beginning of the wash cycle the user should have 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.

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.

User Requirements & Technical Specifications Design an Automatic washing machine with a dryer that can handle three types of loads.

The Technical Specifications are as follows

● There are three kinds of loads: light, medium and heavy

o Light mode comprises of Rinse - 2 mins, Wash - 3 mins, Rinse - 2 mins, Dry - 2 mins o Medium mode comprises of Rinse - 3 mins, Wash - 5 mins, Rinse - 3 mins, Dry - 4 mins o Heavy mode comprises of Rinse - 3 mins, Wash - 5 mins, Rinse - 3 mins, Wash - 5 mins,

Rinse - 3 mins, Dry - 4 mins

● At the end of the complete wash, cycle buzzer is sounded

● There are 4 buttons for the user to control the washing machine: Load, Start, Resume and Stop

o Load: The number of presses of this button determines the load. 1 press - Light,

2 press - medium, 3 press - heavy o Start : Washing process begins when start is pressed. Has to be pressed after load is

decided o Stop : This can stop the process o Resume : This button can resume the process after it has been stopped or in case of any

other issue.

● The door remains locked during the entire wash process

Assumptions & Justifications

Assumptions:

1. The machine will pause only in case of inappropriate water levels during the water input or

water output process and resumes when the user resolves the issue. 2. The detergent is already added to the machine by the user.

3. The user doesn’t fiddle with the door within 1 minute of the starting of the process and for 1

minute after the ending of the process.

4. In case of any issue, the user will need to intervene and fix the issue.

Justifications:

1. The only type of issue that can occur is related to the source of water (filling and emptying of

water from the machine). The machine will sound an alarm if the water-filling/emptying process takes more than usual.

2. The detergent is added at the starting of the process because the door cannot be unlocked in the middle of the process to add detergent before every wash cycle. The detergent is initially

present inside a container and gets added to the tub before every wash cycle by the opening of a valve.

3. The metallic strips used in the bi-metallic door interlock take about 1 minute to get heated and

change shape during locking and unlocking of the door.

4. Any resolvable malfunction that might occur will be related to the source of water/jamming of

the paths for water i/p or o/p. Since these are not a part of the control circuit, they need to be fixed manually.

Components used with justification wherever required:

● 8086

● 8284(Clock generator)

● Water Level Sensor (FS-IR02) with convert board - 2 nos (Manual Attached)

o Sensor gives input to the convert board which gives a high output if the sensor is

submerged in water and low if not.

o Sensor o/p range(i/p to convert board) - 0-5V(<0.1V for low o/p and >4.6V for high o/p)

o Voltage o/p of convert board (5V if high, else 0)

o 4-pin connector to the convert board(GND,GND,VCC,o/p(of sensor))

o There are two sensors, one on top of the revolving tub and other at the bottom of it.

When the o/p of the top sensor goes high, it indicates that the water is full. When the bottom sensor goes low, it indicates that the water has been emptied.

**Liquid Level Sensor-FS-IR02 Pin Mapping**

**Num. Name Description**

1(Red) GND Probe\_GND

2(Yellow) GND Probe\_GND

3(Blue) VCC Probe\_VCC

4(White) OUT Signal Output

**Liquid Level Sensor-FS-IR02(Covert Board) Pin Mapping**

**Num. Name Description**

Left\_1 GND Probe\_GND

Left\_2 GND Probe\_GND

Left\_3 VCC Probe\_GND

Left\_4 IN Signal Input

Right\_1 OUT Signal Output

Right\_2 VCC VCC

Right\_3 GND GND

● Water-In, Water-Out, Lock and Detergent Relays - Used to display the status of Water-In, Water-Out, Lock and Detergent Valves on red and green LEDs.

● Magnetic Contact Reed Switch - For Door Sensor(Reed Switch Datasheet and product manual attached)

○ One end connected to Vcc and other to the Microprocessor o A magnet attached to the lid and the reed switch near the door’s contact on the body o When door closed magnet comes in contact with the reed switch which gets closed and

a high i/p is given to 8255

● Piezoelectric Buzzer(KPI 1410) (with RKi-4076 hardware)(Buzzer Datasheet and Hardware manual attached)

○ Gives continuous sound of different frequencies depending on the frequency of the i/p square wave. Hence, can be used for sounding buzzer/alarms with different sounds for different purposes o RKI-4076 hardware inputs: VCC,I/O,GND o Buzzer operating voltage - 3-16 VDC o Max Rated Current - 7mA at 12VDC o Resonant Frequency - 4.0 (+/-) 0.5 KHz o RKI-4706 Operating Voltage - 3-5V

● Door Latch (Bi-metallic Interlock)(Product manual and relay datasheet attached)

○ Used in traditional washing machines to lock the door o Allows us to lock and unlock the door using a control signal and DC to AC relay o Relay used - FOTEK SSR 40DA

▪ DC CONTROL SIGNAL

▪ Input Operating Voltage (DC) = 3-32 VDC

▪ Output Operating Voltage(AC) = 24-380 VAC

▪ PCB mountable

● Agitator/Revolving Tub Motors and Motor Drivers(Motor and motor driver datasheets attached):

o Motors : Crouzet 801405 BLDCs

▪ Max Speed : 10000rpm

▪ Peak torque : 500mN-m o Motor Drivers : Allegro A4915 Motor Drivers o Enable us to switch the motors on/off with a digital control signal

● 8255 – Interface 8253, agitator, revolving tub, water level sensor, buzzer, user interface buttons, the door and water in and water out relays

● 8259 – Interrupt from stop whenever stop button is pressed.

● 8253 – 2 nos. To generate Clock for agitator and revolving tub. Also to generate input square wave with 50% duty cycle for buzzer hardware(RKI-4076)

● 2716 – 2 nos. Smallest ROM chip available is 2K and as we need to have even and odd bank and ROM is required at reset address which is at FFFF0H and 00000H - where there is the IVT

● 6116 – 2 nos. Smallest RAM chip available is 2 K and we need odd and even bank. We need RAM for stack and temporary storage of data

● LS 138 – 2 decoders, to generate chip select signals for 8255 and 8253s

● LS 373 – 3 latches, used for demultiplexing the address lines

● LS 245 – 2 latches, used for demultiplexing the data lines

● required gates – or, not, and

● Buttons – 4 nos. Used as user interface in the form of start, stop, resume and load

● Green LED - 6 nos. - Used to display the active status of valves, door lock closed, agitator and revolving tub.

● Red LED - 4 nos. - Used to display the inactive status of valves and door lock open.

Address Map:

Memory Map:

ROM1 – 00000H – 00FFFH

RAM – 02000H – 02FFFH

ROM2 – FF000H – FFFFFH

I/O Map:

8255 – 00 – 06H

8253(1) – 10 – 16H

8253(2) – 20 – 26H

8259 – 30 – 36H

Design Summary Complete design shown with proper labelling (design attached)

**8255 Base Address:** 00h **Ports:** Port A: Output Port B: Input Port C: Lower Input Higher Output

**Outputs:** PA0: I/P to lock (to latch the lock) PA1: Water-In Valve (Relay device) PA2: Water-Out Valve (Relay device) PA3: Process End (Dry Cycle End - Buzzer Sound 1) PA4: Alarm (Door Open - Buzzer sound 2) PA5: Detergent Valve (Relay) PA6: Issue (Inappropriate water levels) PA7: NC

PC4: 8253(1) Gate2 PC5: 8253(2) Gate1 PC6: 8253(2) Gate0 PC7: STOP EN’

**Inputs:** PB0: Water-Full Sensor PB1: Water-Empty Sensor PB2: Resume PB3: Door Sensor (High when gate is closed) PB4: Output from 8253(1) counter-2 (for CNTR signal-Agitator) PB5: Output from 8253(2) counter-0 (for CNTR signal-Revolving Tub) PB6: Output from 8253(2) counter-1 (for any intermediate issue) PB7: NC

PC0: Load PC1: Start PC2: NC PC3: NC

**8253(1) : Base Address : 10H**

**CNT 0 :** Used for generating freq 100Hz

Mode 3 Clk : 2.5MHz PCLK Count: 25000 Out : 100 Hz square wave used as clk in CNT1

**CNT 1:** Used for generating freq 1Hz

Mode 3 Clk : 100 Hz Count: 100 Out : 1 Hz square wave used as CLK **CNT 2:** Used for counting timings for Wash & Rinse cycle

Mode 1 CLK : 1 Hz ( 8253(1) OUT1 ) AND with STOP EN (to pause the counter when stop is pressed) Count: 120s,180s, etc.(depending on mode) Out : PB4

**8253(2): Base Address: 20H**

**CNT 0:** Used for counting timings for Dry cycle

Mode 1 Clk : 1 Hz ( 8253(1) OUT1 ) AND with STOP EN (to pause the counter when stop is pressed) Count: 120s,180s, etc.(depending on mode) Out : PB5 **CNT1:** For checking malfunction

Mode 1 Clk : 1 Hz ( 8253(1) OUT1 ) AND with STOP EN (to pause the counter when stop is pressed) Count : 600 Out : PB6 **CNT 2:** For alarm and buzzer

Mode 3

Clk : 1 Hz ( 8253(1) OUT1 ) AND with STOP EN (to pause the counter when stop is pressed) Count : (depending on the event sound is decided) Out : BUZZER FREQ

**8259 : Base Address: 30H**

IR0: STOP Input Vector Numbers : 80h - 87h

Flow Chart Note:- is output 1 function in the flow chart, polls for the output of the respective counter for the cycle and changes only once the count ends.

Stop ISR:

Issue: Used in case there is inadequate water supply from the external source, or a case when water cannot be emptied from the tub.

Variations in Proteus Implementation with Justification:

1. Stop interrupt using 8259 does not work in proteus – Stop signal is used as NMI 2. ROM in only 00000h – as proteus allows to change reset address. 3. 2732 is used as 2716 – not available in Proteus. So, we had to use 8KB of ROM from 00000h to

01FFFh in Proteus instead of 00000h to 00FFFh for IVT. 4. Using a gate-based circuit for memory – does the same as LS 138 here 5. 8259 not there – justification is as per point 1.

6. The water level sensors in proteus have been simulated using two push buttons (pressing the

water full button indicates that the top water level sensor is submerged. Similarly, pressing the water empty button indicates that the lower water-level sensor is not submerged in water(water has drained out)) (holdable) since the water level sensors that have been used aren’t available in proteus.

7. The i/p to lock(PA0) in the proteus design goes to an LED and relay(electrical) circuit to show

when it’s high and when it’s low since the door latch cannot be simulated in proteus. In proteus simulation, whenever the​ lock is on, a green LED glows and whenever the door is unlocked, a red LED glows. However, in the design, the i/p to lock(PA0) goes into a solid-state relay as a control signal to open and close the lock(bimetallic interlock).

8. A simple motor is used instead of an agitator and a revolving tub(with motor drivers) as they are

not available in Proteus.

9. Door sensor i/p to 8255 is simulated using manual push buttons since magnetic contact reed

switches(used in the design) aren’t available in proteus

10. An LED is used to represent the sounding of the buzzer in Proteus design because it is not

possible to use a buzzer enable signal to sound the buzzer.

11. Reset in 8086 is connected to a switch as 8284 is not available in Proteus

12. The water-in, water-out and detergent valve signals in the design go to water-in, water-out and detergent valve relays respectively. However, in proteus, these signals have been simulated using LED and relay(electrical). Whenever a valve is open, a green LED glows and when the valve is closed, a red LED glows.

13. LS138 is not used for memory decoding in Proteus, because only 1 ROM and RAM has been used

whose decoding is carried out through OR gates.

Firmware Implemented using emu8086 attached.

Proteus Simulation- Procedure

1. Press the Load button according to the instructions given in the problem statement to select the

wash mode. 2. Press the DOOR SENSOR button. This will lock the door and is indicated by lighting up the Green

LED and turning off the Red LED. 3. Press the Start button, indicating that the Load button has been pressed for the required

number of times and the door has been locked. Failing to lock the door before pressing the START button would trigger the alarm, indicated by sounding the buzzer. 4. After the start button is pressed, the WATER-IN LED switches from red to green, indicating that

the water has started flowing into the machine. 5. Now, press the WATER FULL button, conveying that the upper water level sensor is submerged in water and hence, the water is full. If the WATER FULL is not pressed for 10 minutes, then it is assumed that there is an issue with the water flow, and the alarm(buzzer) is sounded conveying the same to the user. 6. After this, the corresponding cycle of the given load mode gets started and the agitator or the

revolving tub will start revolving. This continues until the time of the current cycle is reached. 7. After the cycle is done, the WATER-OUT LED switches from red to green, indicating the water in

the tub is being emptied. 8. Now, press the WATER EMPTY button, conveying that the lower water level sensor is not

submerged in water and hence, the tub is empty. 9. This completes one cycle (Rinse/ Wash/ Dry) of the entire wash process. 10. Repeat from Step 5 for the execution of the remaining cycles. 11. Before the dry cycle, the WATER FULL need not be pressed, as all the water is drained out before

the dry cycle and the tub need not be filled again. 12. After completion of all cycles, the buzzer gets sounded for 10 seconds indicating the end of the

complete wash process.

**Note**: The user needs to wait for around 5-10 seconds between each button press because Proteus usually doesn’t run in real-time simulation. This causes a mismatch between the frequencies of 8086 and other IO devices.

List of Attachments

1. Complete Hardware Real World Design – example.pdf 2. Manuals

a. FS-IR02 and FS-IR02 convert board b. Reed Switch Door Sensor : ORD213 c. KPI 1410 : Piezoelectric Buzzer d. RKI-4076 : Buzzer Hardware e. Bimetallic Interlock : Door Latch f. FOTEK SSR 40DA : Relay of Door Latch g. Crouzer 801405 BLDCs h. Allegro A4915 Motor Drivers : Motor Drivers 3. Proteus File – washing\_machine.dsn 4. EMU8086 ASM File: – washing\_machine.asm 5. Binary File after assembly – washing\_machine.bin

6. Flowcharts - Main - Flowchart.pdf, Issue - Flowchart.pdf, Stop ISR - Flowchart.pdf