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SIMULATION OF A MICRO-CONTROLLER BASED WASHING MACHINE

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ABSTRACT
We simulate a programmable, sizeable, affordable and highly reliable software that can be used for controlling various washing operations and different kinds of fabrics. Simulation processes included the selection of the various memory and address chips, the counter, interface and display for the controller. Proof of Concept implementation of the micro-controller powered washing machine will execute effectively using in-circuit emulator which combines debugging with a board that simulates (or in fact, emulates) in real time.
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Keywords: Programmable, simulation, software, implementation, counter, washing machine and fabrics

1. INTRODUCTION

Improvement in technology, search for higher integration, invention of new ideas, and development in the world of electronics has brought about an increased demand for the automation control of most machinery and their processes. Two basic forms of electronic controllers are the Analogue Controllers and the Digital Controllers. Analogue Controller uses basic forms of operational amplifier circuit or other forms of control actions. The Digital Controllers are microprocessor based systems Microprocessor is a single chip that can be programmed to perform a great numbers of information or instruction tasks. The use of a Microprocessor with required software to control the operations of a washing machine is analyzed and stimulate in this project

1.1 Research Problem

Evaluating the hours spent in using hands, brushes for washing clothing materials, time wastage, disappointment and other complaints associated with the patronage of dry cleaning centres. It is the purpose of this project to design and analyse a control circuit for the operation of a washing machine.

2. RELATED ISSUES

Ancient people cleaned their clothes by pounding them on rocks or rubbing them with abrasive sands and washing dirts away in local streams. Brushes and hands were later introduced. The earliest washing machine was the scrub board invented in 1797 by American, James King in 1851. However it was still hand powered. In 1858, Hamilton Smith patented the rotary washing machine. The first washing machine designed for use in the home was built by William Blackstone of Indiana in 1874. The first electric-powered washing machine (the Thor) was introduced in 1908 by the Hurley machine company of Chicago, Illinois. Alva .J. fisher was the inventor 1949, recorded the invention of punched card control for washing machines First automatic washing machine was produced in 1951. 1978-1aunch of first microchip-controlled automatic washing machines. A washing machine is a machine designed to clean laundry, i.e. clothing and other household textile. It is generally restricted to machines that use water as the primary cleaning solution.

Mechanical washing machines basic principles of operation have remained unchanged. The first purpose is to suspend the material to be cleaned in water containing detergent The clothes and water are then "agitated" i.e. moved back and forth repeatedly The water is then pumped out and the clothes partially dried by spinning them rapidly in a low-speed centrifuge. Clean water is then added and the clothes and water agitated 10 remove any remaining traces of the detergent.

Virtually all contemporary washing machine are powered by electricity, though hand-powered or even steam-powered machines were common in earlier times Automatic washing machines became popular in recent times These automate the washing process by controlling the water and soap intake, draining and rotation of the drum in sequence.

Different types of material can be handled by using different programmed cycles for example, a wool material wash needs a low temperature and less agitation than a heavy soil cotton material wash. Most automatic washing machines control the sequence usmg all electromechanical cam timer, though recently fully electronic systems based 011 microprocessors have become more widely available.

2.1 Microprocessors
The first working model of an integrated circuit was developed by Jack St Clair kilby from Texas instruments. In 1959 at Fairchild, Jean Hoerni and Robert Noyce developed another set by the planar process. Integrated circuit were first produced in quantity around 1961. A rapid advancement occurs with a small scale integration (SSI), a single chip with gate implementing logical functions such as AND, OR and NOT in 1964 [I] Medium-scale integration (MSJ) appeared in 1968 while commercial large-scale integration (LSI) appeared in 1971. The first general-purpose microprocessor (the INTEL 4004) was Introduced in 1971. In 1972 Intel introduced the 8008, an 8-bit microprocessor. As sales progressed rapidly, a year later, the 8080 version was introduced. Matorola introduced the 6800 and signetics the 2650. In the third generation of microprocessor design came the Z80 from Zilog

2.2 Simulation
Computer simulation is the discipline of designing a model of an actual or theoretical physical system, executing the model on a digital computer. and analyzing the execution output. Simulation embodies the principle of "learning by doing"… To learn about the system, we must first build a model of some sort and then operate the model. Computer simulation is the electronic equivalent of a child type of role playing and it serve to drive synthetic environments and virtual worlds. In the task of Simulation, there are three primary sub-fields.

- Model Design
- Model Execution And
- Model Analysis

To simulate something physical, the first step is to create a mathematical model which represents that physical object. Forms of models include:

- Declarative
- Functional
- Constraint
- Spatial or Multimodel

The next step once a model has been developed, is to execute the model on a computer - that is, the need to create a computer program which steps through time while updating the state and event variables in the mathematical model Step through time can be done in many ways, (i) one can leap through time using event scheduling or employ small time increments using time slicing. One can also execute (simulate) the program on a massively parallel computer called Parallel and distributed simulation.

2.3 Why Simulation?
One may wonder whether simulation must be used to study dynamic systems. There are many methods of modeling systems not involving simulation, but simulation is essential in the following cases

1. When model is very complex with many variables and interacting components
2. The underlying variables relationship[s are non-linear.
3. The model contains random varieties.
4. The model output is to be visual as in a 3D computer animation

Another important aspect of simulation technique is that one builds a simulation model to replicate the actual system.

2.4 Steps Involved In Using Simulation

1. Define a problem in clearly and precise manner.
2. Introduce the variables associated with the problem
3. Construct a numerical model
4. Set up possible causes of action for testing
5. Run the experiment
6. Consider the results
7. Decide what cause of action to take

2.5 Merit of Simulation

a) It can be used to analyse large and complex real - world situations that cannot be solved by conventional quantitative analysis model.
b) With a computer, simulation is very fast, save times and human resource
c) It is relatively straightforward in solving complex problem and it is flexible
d) It allows the study of the interactive effect of individual components or variables in order to determine which ones are important

3. MODEL DESIGN

The design of electronics equipment controller required the perfect knowledge and understanding of the basic principle and operation of the machine. This chapter extensively explain the operation and process of control of the machine, the selection and characteristics of components and materials used, the power supply unit, the C P U the memory, the PPI, the counter and the display units.

3.1 Process Expected To Perform

Two major types of process are expected to be performed by the controller.

SET 1. The timing for the type of cloth to be washed.

1. Very light material
2. Light material
3. Heavy material
4. Very Heavy material

SET 2. The procedure for the washing in sequence with the operation of the washing machine and action taking place at the chamber.

PO - Inlet valve (it opens and allows water in)
PI - Outlet valve (allows water out
P2 - Low Heating mode by the heater.
P3 - High Heating mode by the heater.
P4 - Low motor speed with clockwise rotation.
P5 - Low motor speed with anti - clockwise rotation.
P6 - Motor at high speed.

The keypad is designed to control these two sets of operations by selecting either set I or set 2 It can also control the operation for either a normal washing or a start or stop of the routine and also a reset or repeat of the procedure

4. SELECTION OF PARTS (CHIPS)

4.1 C P U -THE Z-80

The Z-80 microprocessor has been selected for the following reasons First, it is among the most popular devices currently available, it is being used extensively in most micro computing systems. Secondly it possesses most of the features of an ideal device

4.1.1 Registers

One important feature of the Z-80 is the large number of 8- bit duplicated registers, which can be used for data handling. The duplicated registers are the accumulator A, the general purpose registers B, C, 0, E, Hand L and the tlags register F SP the stack pointer register is a 16---bit register, it allows the stack to address any section of the memory. The Z-80 possesses two index registers IX and IY, which allow indexed addressing

4.1.2 Control Circuits

It has four interrupt lines. They are RESET, NMI, INT and BUSRQ, which are all active low. The HALT executes a Halt instruction. The RFSH - refresh line The WAIT state is used to synchronise the Z-80 with a slow memory or external device The WR (write) and RD (read) lines are used to indicate the mode of the Z-80 The BUSAR acknowledge the signal supplied in response to BUSRQ interrupts. The M REQ (memory request) signal is used to indicate that data is been transferred to or from the memory.

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Chip select or chip enable - an input to a memory that connects the data lines to a data bus, hence activates the chip.

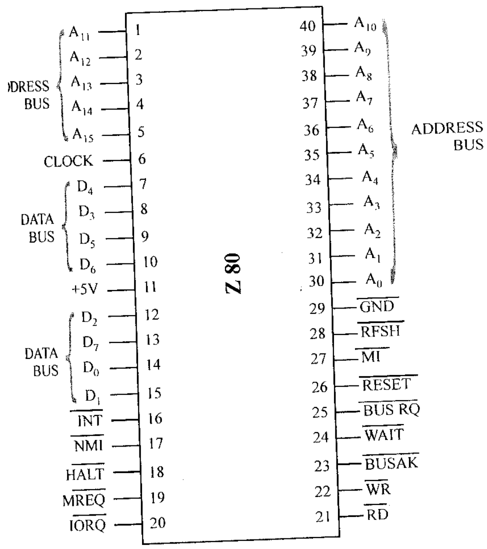

Fig. 1: pin-Out connections of Z-80

4.1.3 The Intel 8255 PPI

"Programmable peripheral interface" PPI is the Intel version of a PIO parallel Input/output interface chip or programmable input/output chip, which was used 111 the design of this project To connect an input or output device to a microprocessor data bus, latches for Input and output must be provided. The input latch keeps data valid long enough for the microprocessor to read the data Any general purpose parallel Input /Output interface must supply at least one input register, one output register, several status bits and interrupt logic. Eight I/O lines are not sufficient for most I/O applications. Mostly minimum of 16 or 24 lines are required General-purpose interface chips must provide several channels, A channel, or port, is an 8-bit connection that may be used either as input or output As much as it would have been desirable to provide as many I/O ports as possible.

The practical limitation is pin count. 40 pins maximum. For this reason not more than three ports can be provided. The Intel 8255 PPI has 24 Input / Output lines normally grouped into three ports, at least four lines on one of the ports must be used for control functions PPI is not programmable by line but groups of four lines It may be programmed in three modes Mode 0 allows each group of four lines to be Input or Output. Mode I programs eight lines as input or output within a group of 12 lines The remaining four lines are for control functions. Mode 2 called bi-directional buffer mode have eight lines available for data and five lines for handshaking (two per 8-bit). The addressing is performed in the usual manner.
The CS is the chip – select signal which tells the device that it is being selected. AO and A I are used in combination with the real and write lines to transfer information to or from the PPl registers.

4.2.1 RAM

The 6116 is a 2KB RAM containing a bi-directional data bus. This means that data comes and goes on the same set of data lines. It requires I1 address lines (2^{11} = 2048) to access one of 2048 locations. It is ideal for small memory applications that do not requires access times (time required to get data from a particular memory location) than l00ns. A larger memory will not fit into a 24 – pin package.

4.2.2 ROM

There are many types of ROM, ROM - Read-Only memory) programmed once at the factory. PROM - Programmable ROM (programmed once by the user and cannot be erased and re-programmed). EPROM - Erasable PROM (can be programmed and erased via ultraviolet light by the
User.) EEPROM - Electrically erasable PROM (can be erased with a signal instead of ultraviolet light). Or EAPROM - Electrically alterable PROM

4.3 Decoders / Demultiplexers

74138

A decoder is used to obtain many outputs from a small source- e.g. 2 input to 4 output, 3 to 8 and 4 to 16 The 74138 is a 16-pin DIP (Dual in line package) that is capable of decoding one of eight output lines from a 3-bit input word. The binary equivalent of the output we wish to decode is placed on the select inputs A, B, and C. Once the two enable inputs G2A and G2B have been pulled low, and the third enable input G I has been pulled high the selected output will go low.

4.3.1 Demultiplexers

The difference between a decoder and a demultiplexer is that a demultiplexer passes data to the selected output, instead of just taking it low or high.

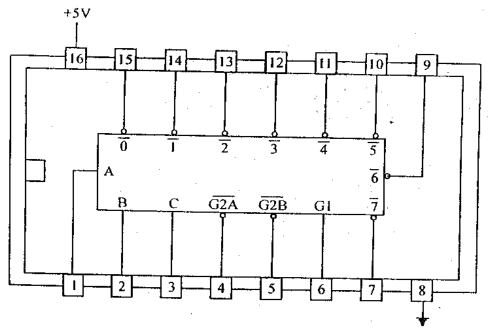

Fig. 2: 74138 Pin Connection

4.4 The Seven-Segment Display

The seven- segment display is an extension of the simple LED using seven LEDs, each constructed in the physical shape of a short bar, most alpha~-numeric and all of the Hex characters may be displayed by illuminating the appropriate segments

Seven - segment display may be connected directly to four binary data lines, via a suitable decoder circuit, such that the status of the data lines is automatically displayed as a Hex digit. The decoder consist of logic circuitry which decodes the four-bit binary Input into the appropriate seven-bit code to drive the seven-segments of the display. The single seven-segment display determine which type of cloth is to be washed by the timing for different types of fabrics

Table 1: Seven Segment Display Timing

Seven Segment Display	**Decoding Time**	**Type of Cloth to be Washed**
0	15s	Very light materials
1	30s	Light materials
2	60s	Heavy materials
3	120 s	Very heavy materials

The double seven-segment display shows the procedure level for the process or action taking place at the washing chamber i e. the output of the Intel 8255 PPI for P_o to P_6 and the corresponding mode of the washing machine.

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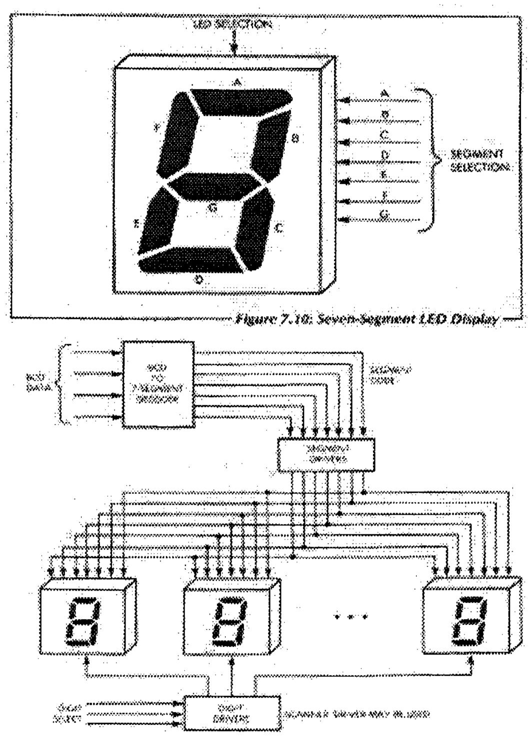

Fig. 3: Seven-Segment Display

4.5 The Keypad

The keypad is used as selector for either the time setting, which also determine the type of material to be washed as earlier discussed. Or as a selector for the procedure taking place inside the washing machine. Pressing the key for set I will enable you to know the type of material as discussed earlier. The single seven-segment display, displays this. The key for set 2 links you with the procedure and it is shown by the double seven segment displays.

Start I (stI) is for normal washing or starting of the procedural routine Start2 (st2) is a reset button that repeats the procedure.
The others keys and the function served are.
(I) View the int. program
(2) View the output (D) program
(3) View the input program
(4) View the control program
(5) View the output (S) program
(6) View the delay program
(7) Overall view
(8) Return to first page

5. SOFTWARE DEVELOPMENT

Developing a program involves coding the algorithm into a programming language

5.1 Simulating Digital Logic By Program

Every microprocessor is equipped with a basic set of logical instructions such as AND. OR, and NOT It is capable of implementing by software the equivalent of any logic function normally implemented in hardware with these gates. Since all logic functions can be accomplished with these three primitives, the processor should be able to accomplish any logic function normally done by hardware. Sequential or combinational logic can be replaced by a program equivalent However, replacing gates by programs on a one-to-one level will lead to gross inefficiency Programming must be approached in a completed different way. A program does not have to copy the hardware solution. It is aimed at replacing complete functional modules with programmed solutions. The programmed and random logic controls are only equivalent at the functional level. A programmed implementation has several advantages; lower cost, speed of implementation, ease in debugging, and flexibility.

5.2 Programming

Solving a control problem required that the problem" s solution be expressed as an algorithm An algorithm is a step-by-step specification of a sequence of operations that will solve a problem An algorithm can be expressed in any form and any language. For a particular processor, the algorithm must be converted to a form that the processor can execute directly i.e. a machine executable language. The set of instructions that implements the algorithm is called the program.

6. PROCESS CONTOL SYSTEM

The action or process-taking place in the washing machine is classified into various groups for a better understanding of the operation of the controller.

6.1 Action Taking Place At The Washing Chamber

The following process are needed at the chamber

- Inlet value - which allows water in
- Motor with 2 speeds and also with both clockwise and anticlockwise movement.
- Outlet value - which allows water out
- low heating mode by the heater
- High heating mode by the heater

The action at the washing chamber can be represented by letter $P_0 – P_6$ and the sequence of operation tabulated as shown below
P0- inlet value
PI - outlet value
P2- 1ow heating mode
P3- high heating mode
P4- low motor speed with clockwise rotation
P5- low motor speed with anticlockwise rotation
P6- motor at high speed

Table 2: Sequence of Operation of Washing Machine

Action at the washing chamber							Process monitoring System	
Po	P1	P2	P3	P4	P5	P6	M	S
-	-	-	-	-	-	-	NOP	00
1	-	-	-	-	-	-	K_1	01
-	-	1	-	1	-	-	K_2	02
-	-	1	-	1	-	-	K_2	03
-	-	-	-	-	-	-	NOP	04
-	-	1	-	-	1	-	K_2	05
-	1	-	-	-	-	-	K_3	06
1	-	-	-	-	-	-	K_1	07
-	-	-	-	1	-	-	K_4	08
-	-	-	-	1	-	-	K_4	09
-	-	-	-	-	-	-	NOP	10
-	-	-	-	-	1	-	K_4	11
-	1	-	-	-	-	-	K_3	12
-	1	-	-	-	-	1	K_5	13
-	1	-	-	-	-	1	K_5	14

The process above shows that for a (-) not in operation a l-action takes place
M-mode of the washing machine
S-seven-segment showing process.
Nop~-no operation
K1-water allowed in
K2-washing mode
K3-water allowed out
K4- Rinsing mode
K5- Spinning mode

System software:
Mode 0 - Basic Input/output
Mode I - Strobed Input/output
Mode 2 – Bi - Directional Bus

When the IBM computer IS powered up, or a system reset occurs, all ports will be set to input mode. The modes for Port A and B can be separately defined, while port C is divided into two portions. All of the output registers, including the status flip-flops, will be reset whenever the mode is changed... modes may be combined so that their functional definition can be tailored to almost any I/O structure. For instance, Group B can programmed in mode 0 to monitor simple switch closings or display computational results, Group A could be programmed in Mode I to monitor a keyboard or tape reader on an interrupt - driven basis output.

6.2 Cost Estimation
The Estimated cost of the Project

Table 3: Cost Estimation

Description of part	Quantity	Unit price ₦	Total amount ₦
220v/ 30v a.c.	1	500.00	500.00
IN 400 bridge rectifier	1	250.00	250.00
600 µf capacitor	1	150.00	50.00
4.7kΩ resistor	2	10.00	20.00
LM 7805 5v monolithic regulator	1	100.00	100.00
LM7809 9v monolithic regulator	1	100.00	100.00
LM 7812 12v monolithic regulator	2	100.00	100.00
D 313 power transistor	2	80.00	160.00
12v 9v zener diodes	2	40.00	80.00
10 kΩ resistor	1	10.00	10.00
470 Ω resistor	1	10.00	10.00
470 µf capacitor	2	50.00	100.00
560 Ω resistor	1	10.00	10.00
SN 7404 Hex inverter	1	150.00	150.00
SN4017 DEC Counter	1	150.00	150.00
SN 4069 Hex inverter	1	150.00	150.00
Z 80 CPU	1	500.00	500.00
8255 PPI	2	500.00	1000.00
6116 RAM 16 k	1	800.00	800.00
2732 EPROM 32 k	1	800.00	800.00
74138 3 to 8 line decoder	1	150.00	450.00
7 Segment display	3	150.00	450.00
2 H. P. motor	1	2000.00	2000.00
Washer	1	12,000.00	12,000.00
Others unclassified			10,000.00
TOTAL			**29, 000.00**

7. CONCLUDING REMARKS

Developing the program for the process and non-availability of needed relevant materials for the write up were the major problems encountered. The erratic power supply affected and reduced the pace of the research. Browse the Internet for help on relevant materials was tedious. Simulation is a new dimension in technology, especially in the area of microprocessor-based system that will require intensive research and encouragement. It can be used as an educational tool. This project will execute effectively using in-circuit emulator another dimension in microprocessor based system. The in-circuit emulator (used for debugging systems) is a program plus a board that simulates (or in fact, emulates) in almost real time.

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