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ARTICLE

Increase the Quality of Life through the Development of Automation

Anoushe Arab*

Education office of Zahedan, Iran

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ABSTRACT

This paper discusses needs for the automation of the underdevelopment communities. The novelty of this research is the link between production of microprocessors and increasing of the life quality. This study highlights the importance of efficient and economic architecture of logical circuits for the automation. The aim of this research is to produce a logical circuit, which includes suitable gates. The circuit will be embedded in the automatic devices as a microprocessor to cause programmed functions. This research reports analytically a workshop method to build the circuit. It uses an assembly card and required gates. Then, it suggests certain VHDL codes to drive a motor. The workshop presents the configuration schemes and connection board for every gate. In addition, it shows a schematic wiring diagram of the circuit. Finally, the economic analysis proves the mass production of the circuit will enhance the automation and consequently the quality of life. The outcome of this research is a helpful experience to the engineers, manufacturers and students of the relevant disciplines to resolve the inequality in the use of the modern technologies.

1. Introduction

During the recent decades an exciting evolution in the capabilities of microprocessors has been seen. The rapid spread of microprocessors in the daily life increased the necessity of embedding a microprocessor somewhere inside the machineries and tools. The advent of digital and automatization technologies for urban infrastructure, residential buildings and other urban spaces has increased the need for more inexpensive and functional logical circuits. Therefore, as today's urban life is becoming increasingly automated, great demands are placed on the logical circuits and microprocessors we use in the buildings, components of urban infrastructures such as automatic doors, automatic tellers, home security and control, bus and train ticket seller machines and so on. With some simple keystrokes as the only input, we expect the automated device to handle the rest to achieve the desired result.

The main question addressed by this paper is how shall we improve the quality of life in the underdevelopment communities with the help of automatization? Therefore the question is, how shall we produce a more efficient, economic and purposeful digital circuit for controlling a DC motor with special functional requirements?

The goal is to encourage regional/urban planners and entrepreneurs in the underdevelopment cities to increase the quality of urban life by emphasizing on digitalizing and automatizing of the urban life. For this reason, the aim of this research is to design and manufacture a more efficient and economic logical circuit card and microprocessor for digital control of DC motors via simple analog joysticks.

**Corresponding Author:*
Anoushe Arab,
Education office of Zahedan, Iran;
Email: anousheearab@yahoo.com

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The method of this research paper to achieve the goal has both theoretical and experimental bulks. Nevertheless, it has been given a lot of importance to report a workshop experience to produce a logical circuit.

This paper is structured in 5 parts as follows: Introduction, theoretical explorations, workshop experiences, methodology and discussions, and conclusions.

2. Theoretical Explorations

Human beings always use knowledge and technology to make their lives more comfortable. As far as societies rely more on knowledge, technology and fairness, they have been able to create a better quality of life. [22]. As today's society is becoming increasingly automated, great demands are placed on the products we use for a more qualified and comfortable life [6,8]. During doing a lot of things such simple individual issues, professional tasks or making decisions about the important and complex problems, we expect immediate assistance via automatic devices and tools [7,11,17]. With some simple keystrokes as the only input, we expect the automation to handle the rest to achieve the desired result [9,15,16]. Scholars have explored the link between progress in knowledge-based urban planning and improvement of urban life quality [10,26]. There have been several attempts to build small-size and lightweight microprocessors with simple logical circuits. The purpose has always been making things easy and accurate. This purpose consequently has improved human life quality [24]. Scientists believe that a characteristic of our era, which is the result of exploiting the achievements of the industrial revolution, is the spread of the digitalization and automatization technologies. On the other word in the new era, people use the automated tools in more circumstances. The industrial revolution changed the tools of manual labor, relied on the power of human beings into mechanical instruments and motors. Whereas the advances in the digital and automatic technologies change the mechanical instruments to automatic, light, small, efficient, inexpensive, and comfortable tools and motors [28]. Although it was expected that the advances in digitization and automatization would serve all human beings, regardless their geographical situations, this did not happen. Comparing countries with each other and even comparing the cities of a certain country with each other, especially in the underdevelopment countries, shows that the use of automation achievements is not equivalent. As a result, people in the underdevelopment cities and regions do not enjoy the benefits of automatic progress and their quality of life is less than minimum standards and sometimes unacceptable [23]. For these reasons, the necessity of the importing knowledge and technology for the production of logical circuits and microprocessors in all countries is understood [14]. At the same time, we know that any microprocessor-based system necessarily has some standard elements and gates such as memory, timing, input/output (I/O), analog to digital (A/D) converter, registers, resistors, diodes, interrupter, etc. [2]. Engineers and manufacturers of this industry, i.e. Baker and Allan et al have been researching on this subject and addressed the characteristics of gates and components that form a logical circuit [1,5]. Also, the standards and qualities necessary for the production of gates and components of logical circuits are the subject of research and analysis of numerous engineers and manufacturers. For example, Auch and Wright believe that major researches on the logical circuits have been carried out from a manufacturing standpoint, which considers less improvement of the productions [3,27]. From the practical point of view, we are facing always with this question: How shall gates and components of a logical circuit be interconnected and assembled to provide reliable services to users? Many engineers in different manufacturing companies, i.e. Patterson & Sequin have explored the right answers to the above question. They thought that it would be possible to put numerous electronic gates onto a single chip. They discussed the desirable architectural features in modem microprocessors. They concluded that: "*a processor design includes features such as an on-chip memory hierarchy, multiple homogeneous caches for enhanced execution parallelism, support for complex data structures and high-level languages, a flexible instruction set, and communication hardware*" [18]. A microprocessor needs an engine to work. An engine can be controlled digitally, analogously, or so-called mechanistic. The advantage of digital control is the ability to pre-program movements and control schemes. This makes it fast, precise and the movements can be repeated exactly the same way thousands of times a day. Another advantage of using a microprocessor for motor control is that communication of the motor control and the rest of the process takes place via the data bus already in the microprocessor. Analog control does not require advanced equipment. This option fits well when the steering does not need to follow predetermined schedules. Furthermore, we think on how shall the progress made in the manufacturing industry of logical circuits and microprocessors be used to serve the automation of the underdevelopment regions? The right answer to this question is important, particularly when scholars suggest the use of microprocessors to resolve the critical problems, i.e. the water crisis in the underdevelopment regions [22]. The production of standard electronic gateways and the assembly of those in digital circuits in the form of smaller, lighter, cheaper and more functional microproces-

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sors are the core attempts of the engineers and investors in this industry. Only as one sample see the research has been done by Paul and colleagues. They reported that: "*Workshop participants consistently called for the advancement of the components and interconnects required for developing smart goods. Persistent themes included reduced power, enhanced battery life, energy harvesting, smaller sizes, and lower cost*" [19]. We reviewed the opinions and experiences of engineers and manufacturers of logical circuits. We reviewed four issues, namely 1- the standards and quality of digital gateways, 2- components and gateways included in a logical circuit, 3- optimal connection and efficient assembly of components in a circuit, 4- and the optimal production of gates and microprocessors. According to this review, in the next section, we are going to analyze a workshop experience for generating a digital logic circuit for a microprocessor.

3. Workshop Experiences

3.1 Digital Control for DC Motor

This workshop experience is about the design of a circuit board for digital control of a small DC motor. The experience contains solutions, connection tables, assembly diagrams and descriptions of selected components. An economic calculation of 100 circuits is performed to prove the profitability of microprocessors' mass production in the underdevelopment regions. In addition, we developed program codes for programmable logic devices, PLD-circuits, and test programs. In the other words, the workshop experience aimed at designing and manufacturing an electronic card for digital control of a DC motor via a simple analog joystick. An automated system has an engine as an actuator. Control of the motor can be done in different ways, but we will concentrate on the procedure of digital control. This type of control has become very common and in this workshop we would use a standard processor, a digital standard circuit with required gates and a controlling principle. Solution methods have been chosen on the basis of the knowledge that we have acquired through the theoretical explorations and exercises in the subject areas. We should develop and realize a solution for controlling the DC motor with special functional requirements. The targets of the workshop were as follows:

(1) Design and improvement of a system that is in accordance with a given specification of requirements

(2) Different conversion principles for A/D and D/A converters and its performance

(3) Breaking down the problem into minor sub-problems and dividing our suggested electronic system into functional blocks

(4) Design principles for the testability of the system

In addition, the control specifications were:

(1) The control is available with analog joystick delivers voltages between 0 and 5 V.

(2) The joystick position should directly affect the engine speed with the following setups:

① Neutral position: stationary motor

② Maximum position: Maximum speed in clockwise rotation

③ Minimum position: Maximum speed in counterclockwise rotation

(3) The control card must be able to be connected to EXKIT as an interface between the microprocessor and the engine

(4) At low speeds, the engine should rotate without snatching.

(5) The joystick position should be presented on the display.

(6) The cost of component never exceeds 25 US$.

(7) The control card should be easy to troubleshoot and repair.

(8) Software for testing motor control or joystick mode must be produced.

(9) The documentation must be able to be used by technicians for further production as well as by the engineer for the improvement or modification of the design

(10) Calculation basis for planned production of 100 units

3.2 Design of the Required Digital Circuit

The Following figure exhibits the block diagram of our proposed circuit with the applied gates and components.

Joystick	→	Converter	→	Interface	↔	Computer
		↓				↓
		Display				Interface
						↓
						PWM
						↓
						Motor

Figure 1. Flowchart of the gates included in the circuit block

Following we describe every component in terms of its characteristics, functions, and connections schema.

Joystick

The joystick consists of two potentiometers, of which only one is used. The potentiometer is an adjustable resistor whose value changes depending on the position of the joystick.

Circuit ADC0804

In order to convert the analog signal from the joystick to

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a digital signal, an attribute A/D converter of the type flash model was used. The circuit ADC0804 operates according to the principle of successive approximation. This means that the joystick and A/D converter were supplied with the same voltage, which A/D then used the reference voltage. The joystick in turn delivered different voltages (depending on its location) to A/D, via the VIN (+) input, (pin number 6). VIN provided an operational amplifier that in turn provided the plus input of a comparator. To the minus input of the comparator was the output of the DA converter, which retrieved its value from the SAR, Successive Approximate Register. In the comparator, the value of the voltage was compared from the joystick with value from SAR.

The circuit was controlled by an oscillator, which started to swing when connecting a resistor and to sift 4 and 19. The entire circuit then became the clock frequency it internally needed.

In this workshop project, the A/D converter was run in so-called "free running connection", which means that it constantly read the voltage that was delivered from the joystick. To accomplish this, the inputs CS (Chips Select, sift 1) and RD (Read, sift 2) were connected and set to low. In addition, the input WR (Write, pin 3) and the output INTR (interrupt, pin 5) were interconnected. This loop caused WR to reset all the time and could start a conversion. When both CS and WR were placed, the first SR flip-flop began. When set to SAR a signal started the A/D conversion. When the A/D conversion was completed, the signal "clear" reset the second SR flip-flop. Via the signal INTR the A/D conversion was completed, through a 0 on this output signal. After an A/D conversion, the result would be in SAR. This result was then taken through a register out of the circuit connections D0 to D7. The following figure exhibits the structure of this circuit.

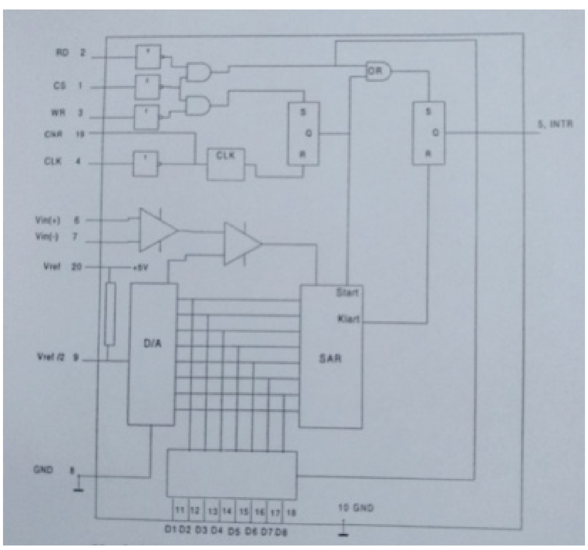

Figure 2. Construction of the A/D conversion ADC0804

Please see also the connection table of ADC0804

Address decoder (Palce 16V8)

The Palce 16V8 circuit was used for address decoding of our address (60600X). The circuit had been programmed with its own VHDL code (see the part of PWM).The input signals were EXT, AS, LDS, A12, A13, A14, and A15. (For pin code configuration, see the following table). The signals EXT, AS and LDS were active low. The signal EXT was activated when the address started with $ 6- $ D (hex code). EXT was connected to the signal VPA (Valid Peripheral Address) which was a signal to MC68000. The VPA informed the CPU that the address bus contained an address for a slow periphery crash. Thus, the CPU needed to be synchronized with a slower circuit. When the CPU detects the VPA signal, the processor would be synchronized with the peripheral circuit, the VMA (Valid Memory Address). The CPA signal transmitted to the circuit so that data transferring could occur. EXT/VPA were generated from the address decoding in EXKIT. The signals AS (Address Strobe) and LDS (Lower Data Strobe) were the processor's control signals. Address lines A12-A15 in our case contained the number 6 (0110, binary), our unique address. Only one output was used, called CS. The output signal was active high and would become active when the correct address, i.e. "0110" (6) was set to A12-A15 and LDS was low. The following figure exhibits the connection diagram of the address decoder respectively.

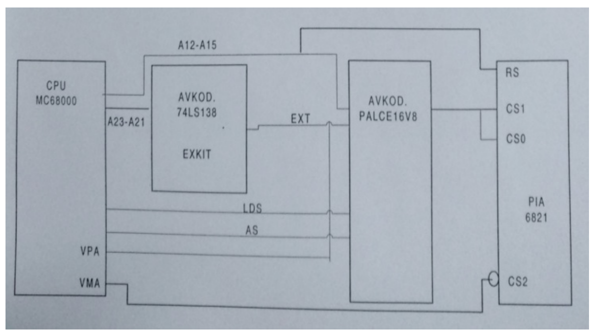

Figure 3. Connection diagram for address decoders

Interfaces PIA circuit (MC6821)

The PIA (peripheral interface adapter) circuit was used as an interface between the A/D converters, the CPU (MC68000), the PWM and control logic. Both definable ports of the PIA circuit were used for this purpose. Port A was defined as inputs connected to the A/D converter's eight outputs and port B stalled as output logic outputs. The A/D converter could also be connected directly to the CPU via the bus. For an interface circuit was needed for communication after the CPU, the PIA circuit was also selected for this purpose. The A/D converter performs free-flowing and could not be used for bus coupling. See the table exhibits the connections on the PIA circuit in part 3.3.

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Light signals for joystick mode

Visual presentation of the motor's direction and speed was solved with LEDs and a programmed logic circuit. To mark the engine speed and direction and thus the joystick position, a Palce 22V10 PLD circuit was programmed. By defining the output signals from the A/D converter into input signals and dividing them into 10 intervals of total 256 combinations, the PLD circuit delivered 10 output signals coupled to an active low LED (B1001H) protected by the 220 Ω resistor. The PLD circuit was programmed to shine with all the diodes when the joystick was in a neutral position. At maximum speed in each direction, half of the diodes were switched off on the corresponding side of the ramp and vice versa. The following table exhibits the configuration order of the diode.

PWM - Palce 16V8 (NAND)

Since we chose to extract the maximum signal from the counter outputs ($Q_A - Q_H$) and all inputs are high (225), we had to connect the wires via a NAND gate to deliver a low signal. This was solved with the following VHDL code.

If (10='1' and 11='1' and 12='1' and 13='1' and 14='1' and 15='1' and

16='1' and 17='1') then max≤'0';

Else max≤'1';

End if;

We ignore here to write the full-VHDL code. The counter we used (SN74HC590) had RCO value that was ahead of the outputs. If we were to use the RCO signal from the counter, we would not be able to extract the maximum value from the counter. To be able to use the maximum value from the counter, we had an 8-input NAND gate. By using the outputs from the counter to the inputs of the NAND gate, we got the maximum value. The following figure exhibits the configuration scheme of our NAND gate.

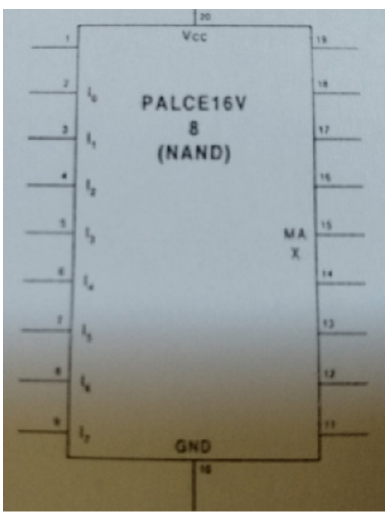

Figure 4 . Configuration scheme of the NAND gate

3953 Full-Bridge PWM Motor Driver

We could control a DC motor in two ways when using the gate of 3953, namely phase and enable control. When using the phase input, we had a stable output, which varied depending on the duty cycle. When using the enable input, we had an output voltage that was not as linear as one had at the phase input. Another disadvantage of enable was that there was no stable current at low output current. Following figure also a table in part 3.3 exhibit the connection order of this gate.

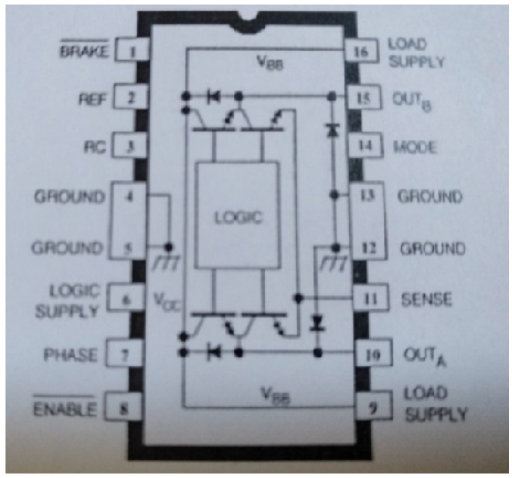

Figure 5. Configuration scheme of the 3953 Full-Bridge PWM Motor Driver

Synchronous counter, SN54HC590A

This gate was chosen because it met our requirements and was relatively inexpensive. The SN54HC590A was a synchronous counter and contained an 8-bit memory register, whose outputs were parallel. Separate clocks were required for memory registers (RCLK) and the binary counter (CCLK). If you wanted to cascade several counters, the RCO' (ripple-carry output) which was connected to the next counter's CCKEN' (count enable) should be connected. The following figure exhibits the configuration scheme of the Synchronous counter gate, SN54HC590.

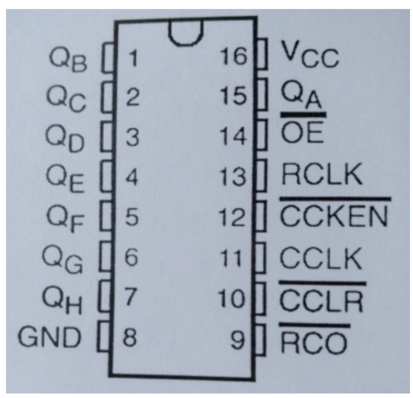

Figure 6. Configuration scheme of Synchronous counter, SN54HC590A

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An active low signal should be phased out when the counter had finished counting (at 255). We called this the maximum signal. Our solution was that from the outputs ($Q_A - Q_H$) pulled these lines to a PLD made for a NAND gate. The alternative was to remove the maximum signal from RCO directly. The following figure is the map of the connections.

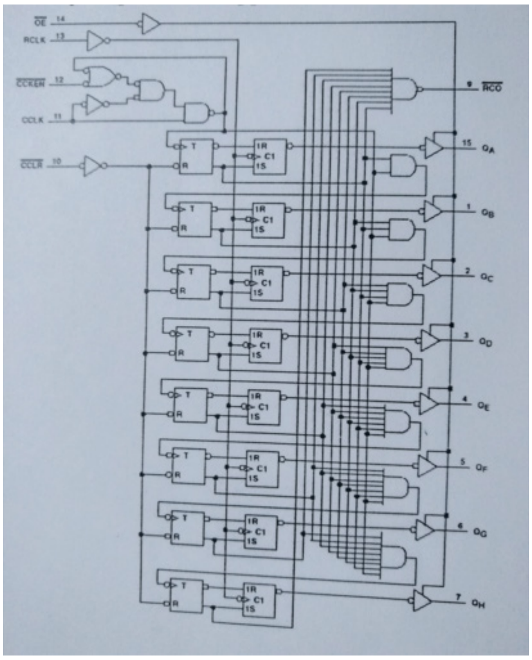

Figure 7. Map of the synchronous counter connecting lines

74HCT688, Comparator

74HCT688 which we used in our construction was an 8-bit comparator. It was a high speed semiconductor circuit of CMOS type and compared to 8 binary or BCD words. The following figure exhibits the configuration scheme of the 74HCT688.

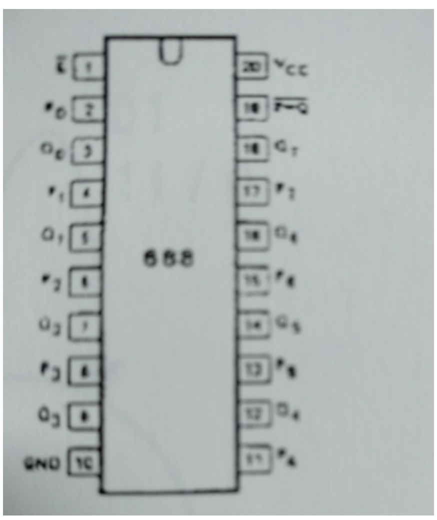

Figure 8. Configuration scheme of the 74HCT688

The inputs (P_0-P_7) were drawn from the outputs ($Q_A - Q_H$) of the counter, the number to be compared came in on the legs Q_0-Q_7. These were the issues from PIA outputs PB0- PB7. At the same number, the comparator output P′=Q' (leg 19), which produces a low output signal, was activated, which went further into the control logic. Enable (E') was active low and drawn to the soil. The following table shows the connection board of the 74HCT688

Control logic (PALCE16V8)

The control logic was done in a PLD (PALCE16V). The reasoning was a Mealy-machine where the output signal was to be changed coincidentally as input signals. The clock input (CLK) was drawn to the common clock on the connector similar to the reset signal. The maximum input came from the NAND gate when the counter had counted up to 255 which then gave 0 out. The following figure exhibits the configuration scheme of the control logic.

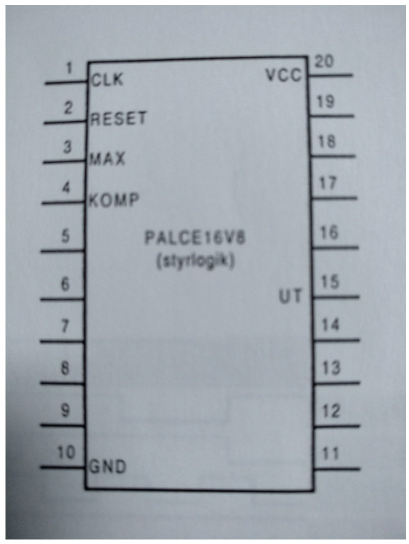

Figure 9. Configuration scheme of the control logic (PALCE16V8)

The following figure exhibits the format comp maximum out when the control logic was run.

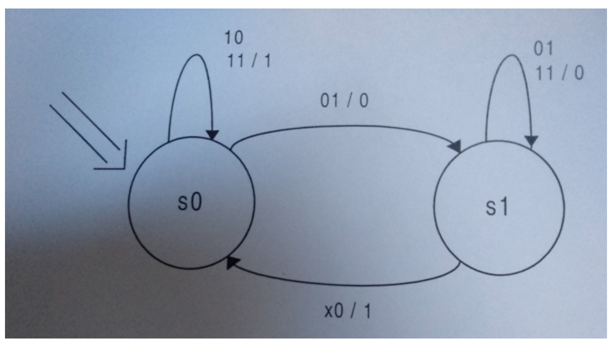

Figure 10. Diagram condition for control logic

At the same time, the following figure shows the sim-

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ulated condition, we supplied with the help of the simulator.

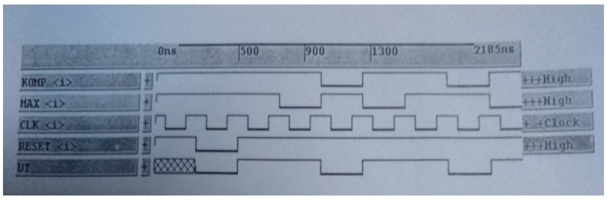

Figure 11. Simulation of the control logic of the format: comp max/out

3.3 Schematic Wiring Diagram of the Circuit

The following map exhibits the wiring connections of the components of our logical circuit on the assembly board.

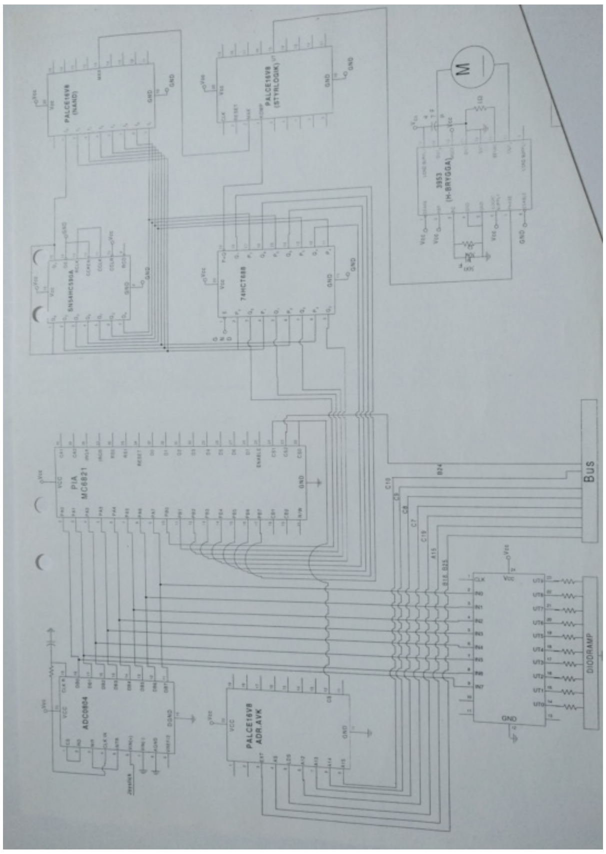

Figure 12. Schematic map of the wiring components of the circuit

4. Methodology and Discussions

We applied the method of theoretical exploration concerning the main issues of logical circuits and microprocessors' buildings to make a framework for our case studies. We also applied a case study strategy with the help of our workshop experience. The workshop practiced the optimal production of a specific logical circuit. We reviewed the ideas of the scholars, who suggest that the current methods of regional/urban development shall be revised to resolve the urban crises and to improve the quality of life [21]. They suggested that one solution way to improve the quality of life is to increase the automatization in the communities. We also recognized that the automatization requires optimal production of the microprocessors. The production of intelligent and efficient digital logic circuits, as well as the production of microprocessors, should be economical so that the underdevelopment countries can also improve the quality of life through the increasing of automatization. The building of high-performance and more cheap microprocessors requires many careful choices of gates and digital circuits. It also requires right and optimal assemblies, connections, testing, embedding in the devices and exact applications. We selected the ADC0804, Palce16V8, MC6821, Palce22V10, 3953 Full-Bridge, SN54HC590A, 74CT688, Registers, Resistant, Bar graph display, etc. according to our determined specifications and goals. Technical difficulties in the design of the digital circuit ranged from architectural issues to those in their integration. Our pilot experience aimed at unit modularization and easy assembly of the circuit. It also aimed to build a digital system architecture to ease the predetermined functions in the limited space of the device. We innovated by introducing the product that was practically in small sizes, which performed more fast types of motions and progressed its motor control. We must prove the accuracy of logical circuit systems and their functions constantly in mixed functioning circumstances. In the workshop experience, we introduced a dynamic verification, a novel micro architectural technique that could significantly increase the burden of correcting in microprocessor designs. Therefore, we used the software for control and testing of the assembled logical circuit. In order to easily test the function of control systems, a menu-controlled program has been developed. The program was run on the host computer and was remotely operated via UART communication and terminal software on a Windows based PC. The software could test the entire control system with the joystick and test each part separately. When testing the joystick, its position was displayed decimally on the screen. The engine was tested by entering the values between 0 and 9 where 5 represented a stationary position. The program also included a demonstration function with simulated driving. The engine shifted between maximum forward speeds and backwards. All subprograms could be interrupted with a keystroke (x), whereby the menu was redrawn and a new option could be selected. The functional checker confirmed the precision of the processor's behavior, only letting right marks to commit.

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Manufacturing a microprocessor requires capital investment in the form of a foundry and considerable recurring expenses in terms of masks, materials, testers, manpower, etc. There are ways also to use a relatively recent technology node. Nevertheless, our economic analysis is at the lab stage. Overall the design cost of the logical circuit architecture and assembly could be dramatically reduced because of our careful and purposed choices. The following table reports our economic analyzing for producing 100 logical circuit cards.

Table 1. Price list for 100 cards

Name	Number	Price/US$
Pattern card	100	733.24
Bar graph display	100	93.22
ADC0804	100	205.31
Palce16V8	300	785.64
Palce22V10	100	261.90
PIA6821	100	216.76
H-bridge (3953)	100	314.27
Counter (74HC590)	100	52.37
Connector	100	374
Straight stylus (2*36	20	35.20
220pF	100	14.14
1000pF	100	14.14
47mF	100	6.6
1 Ω	100	2.6
220 Ω	1000	41
10 kΩ	100	4.1
27 kΩ	100	4.1
Total price		3165

As the table indicates the initial price of one card/microprocessor is equal to 31.65$. The mass production strategy yet reduces the price of one unit. The mass production is now the norm for digital circuits and processors consumers. The mass produced digital circuits embedded in the microprocessors and automatic devices are sold at a premium, with prices much basic. The approach works by augmenting the cost of production of functional microprocessors. Our workshop experience proved that the logic circuit architecture is important when manufacturing low-priced microprocessors. Inexpensive microprocessors can support the development of digital urban buildings and infrastructures and, as a result, improve the quality of urban life.

5. Conclusions

This paper, which was a theoretical and workshop work, emphasized the growing attention of contemporary societies to the promotion of quality of life using digitization and automation technologies. For this reason, the production of high-performance and economic digital circuits and microprocessors was analyzed in theory and practice. We reported a production project of a logical circuit for microprocessors embedded in an automatic device as a workshop experience. Regarding the performed economic analysis, we proved that the mass production of this microprocessor could lower its cost by even more than our workshop experience, which produced only 100 units. The work on this project has given great insight into board wiring architecture and circuit design. We could state that the work of designing the card has required hard work. However, the outcome has been successful. The produced circuit fulfilled the requirements, we specified in the requirement specification. Our production has examined all important aspects of integrated circuit design, fabrication, assembly and test processes as they relate to quality and reliability. The principle and outcome of this practical research work are useful to industrial engineers, computer scientists, and integrated circuit manufacturers. This paper is also helpful for upper-level undergraduate, graduate and continuing-education students in the disciplines of digital logical circuits and embedded microprocessors. We hope this work will encourage the underdevelopment communities to enhance the quality of life with the help of the digital circuits and microprocessors.

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