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Designing an Elevator Controller Using VHDL

Abobkr.H. R. Mohamed[1], Masbah Alsnosi Masbah Eame[2], Saleman. A. A. Abobker[3]

[1,2]Deparmement of Electrical Engineering Higher Institute of Science and Technology Aljufra- Soukna
[3]Department of Electrical Engineering Higher Institute of Science and Technology Zellah

Abstract

In general, the success of an industrial establishment depends largely on the control strategy of supervision and control operation systems. This project aims to design an elevator controller for a four-storey building, to model an elevator controller that has 4 outputs, two of them (UP, DN) for motor direction and the others (RUN) to turn the motor on or off, while the other one is to close or open the door (Door). The controller has 4 bus inputs (3 down to 0) making a total of 16 inputs and a clock input. CUR_FLR to indicate the current floor (Sensors on the shaft of the elevator), REQ FLR to indicate the requested exit floor (Floor buttons inside the elevator's car), REQ UP and REQ DN to request the elevator's car and indicate the requested direction. There are outputs to run and direct the elevator's motor. The design of The Elevator is undertaken in Altera MAX+plus II software, using VHDL. The process of testing is carried out during modeling the process to ensure that the design is working as expected. Altera MAX+plus II software tool is used to synthesize the VHDL code which helps to compile the design.

Keywords: VHDL, Elevator, MAX+plus II, Floor

1. Introduction

Whilst the invention of steel made skyscrapers able to be done or achieved, the elevators made them practical when have been invented, envisage life without elevators in a big modern city, Business at the high building of World Trade Centers would be limited to a few world-class athletes. At the heart of an elevator is a very simple lifting machine [10].

An Elevator is a fundamental instrument for transportation vertically between level to level in skyscrapers and high-rise buildings in the modern society. Nowadays, it have been using elevator so much so that can be take it for granted. It is a daily transit space. The practice of elevating' has become transparent for those who live and work in the skyscraper city. It is because the advanced technology of elevator allows this smooth transition from one place to another floor to floor via intelligent software, enabling high-speed transportation, and providing reliable safety measures

Stairways are ignored and only uses in the emergency case. Office workers will not waste time traveling, thus they will keep more time working furthermore, making more money mostly in the true capitalist cities like London and New York [27].

"The first reference to an elevame it in the works of the Roman architect Vitruvi, w reported that Archimedes tc 287 BC-212 BC) built his first elevame probably in 236. In soume literary sources of later historical periodt, elevators were mentioned as cabs on a hemp rope and powered by hand or by animals. It is supposed that elevators of this type were installed in the Sinai monastery of Egypt" [26].

In the past the elevators used pulley and rope. A net also was used to lift a cargo. The use of the modern elevator with steam engine started when the industrial revolution began. Central steam engine was used to drive different machines which used for different purposes such as spinning, weaving and metal works, they were all driven by a central steam engine through line shafting, consists of long lines rotated shafts located overhead each machine, so the power is transmitted to the machine through a belt and pulley. At that time most of the mills were multistoried, so the materials between the floors require a hoisting machine, so the central steam engine drives the machine as the rest of the machines in the mill. It needed an operator to pull a rope which controls the rotation of the hoisting machine, by doing that the operator takes the ability either to start or stop the machine.

Elevator with a drum machine was restricted to low and high tall building. By 1870 a rope- geared hydraulic system was invented a piston acting through a system of sheaves (complex pulleys) raises and lowers the elevator. One foot of piston motion could result the elevator to move two, three feet or even more depending on the alignment of sheave and rope system.

Both of these systems were in use by 1880. So the use of city water pressure in some location was useful, avoiding the usage of steam engine driven water pumps. To this time, the engineers developed also a plunger hydraulic elevator that was safe enough in tall buildings, where it is suffered from the same weak points that the drum machine has. This elevator demanded that a hole induced in the ground to the same depth that the height of the building to suit the jack. The development of the electric motor did not affect the elevator at first, when it was used to replace the steam engine that supplied the used pumps on the hydraulic systems. Drum machine that uses electric motor to drive the drum, was invented by Otis and the first such elevator of electric supplied was installed) in the Building of Demarest in New York 1889. The development of the traction machine led to a breakthrough in the design of the modern high speed elevator in 1900. The traction machine depends on the friction between the sheave of driving or pulley the metal cables, so the elevators can be used in the buildings of any height with the traction machine. Moderate elevators with a speed of less than 500 feet per minute uses a steam or electric power where the power is transmitted through the gears to the driving sheave or drum. But with high speed it is found to be very noisy because of the gear wear.

As solving for this problem the first gearless traction machine was installed in 1904 by Otis Company in Chicago, as result of that the use of high speed elevators was useful. So the machine works probably without gears, the sheave directly mounted on the motor. Then the machine works smoothly and without any noise up to the speed of 2,000 feet per minute. The engineering development in elevators was concentrated in how to control refinements so a smooth ride at high speed can be achieved. Then the development continued during 1920 until 1930 by different companies such as (Otis & westing house) to minimize the need of operators for the machine.[16, 23].

2. Types of Elevators

There are a few different types of elevators, and the methods that they use to lift or lower their cars have changed a little since Elisha Otis invented the safety elevator in 1853. Just the source of power what has changed, for operating the elevators and the superiority of their control equipment.

- Cable elevators. (Electric elevator)
- Hydraulic elevators.

2.1 Cable Elevators

Cable or electrical elevators basically exist in form of two types - traction or drum, within the elevator, cables are attached to the car, counterweights, vertical tracks and emergency safety brakes containing an equipment room that has electric motor and a winding drum which raises or lowers the elevator [19].

A. Traction Type

Commercial buildings need faster lifts due to its height and frequent use. Traction type elevation moves faster than the drum type of elevator. It uses the traction sheave instead of a winding drum. Unlike the drum type, traction elevator is commonly used in most commercial building because of its speed. The elevator is made of the traction sheave and counterweights linked up to the car of the elevator. It is usually arranged in such a way that the traction sheave unwind as fast as possible depending on the size.

There are two types of traction equipment;

- The gear traction type with a high speed motor and It has worm gear and a brake wheel within traction sheave.
- A gearless traction type is with a speed but slowly directs the DC motor that is attached to the traction sheave with a brake wheel on the motor shaft [2, 3, 12].

The Advantages of the Traction Elevator

- Quiet, smooth ride.
- Efficient performance and Fast speeds.
- Suitable for tall building applications

The Disadvantage of the Traction Elevator

- Usually heavy weight at the top of the hoist way.
- Higher installation cost.
- Equipments machine room required [24].

B. Drum Type

This type of elevator was first installed early years of the 20th century as a Winding Drum Elevator. It consists of a car attached with different cables around a winding drum to move a counterweight. The drum is grooved for cable movement where the counterweight cables unwind when the car cables wind and vice versa. Usually, the equipment room for this type of elevator is place in a basement or on the roof of a building [19, 21].

2.2 Hydraulic Elevators

A hydraulic elevator has similar design like the cable elevator, though it functions on the Pascal's Law of incompressibility of fluids (which is the Principle of Hydraulics). The hydraulic elevator generally is used in six storey buildings. It is lifted from below by a long metal shaft by the hydraulic power. Although, some modern hydraulic elevators may travel over six storey if it of the cable and counterweights type.

Any floor level of 50 to 100 feet away from the elevator shaft is where the equipment room is located for hydraulic elevators [3, 4].

The main components of the equipment room are as follows:

- Controller or relay panel (electronics necessary to run the elevator).
- Hydraulic power unit. The hydraulic power unit comprises of a reservoir for the oil supply, hydraulic pump, and valves to raise or lower the elevator car.

The Advantages of the hydraulic elevator

- Elevator hoist way dimensions are optimized.
- Loads are distributed to load bearing walls, there are no overhead structural Requirements.
- No overhead machine room is necessary.
- Machine rooms can be located remotely.
- Installation costs are generally less than those for conventional traction roped systems

The disadvantage of the hydraulic elevator

- Limited speed and performance.
- High noise levels as compared to other systems.
- Machine room needed for pump unit and control system.
- Odor from heated oil.
- Environmental concerns due to significant use of oil.
- Poor ride quality as compared with other systems [25, 28].

3. Electronic design automation (EDA) and very high hardware description language (VHDL)

Electronic design automation (EDA) is at the center of technology advances in improving human life and use every day. Given an electronic system modeled at the electronic system level (ESL), EDA automates the design and test processes of verifying the correctness of the ESL design against the specifications of the electronic system, taking the ESL design through various synthesis and verification steps, and finally testing the manufactured electronic system to ensure that it meets the specification and quality requirements of the electronic system. The electronic system can also be a printed circuit board (PCB) or simply an integrated circuit (IC). The integrated circuit can be system-on-chip (SOC), application-specific integrated circuit (ASIC), or a field programmable gate array (FPGA).

In general, EDA can be partitioned into three distinct but broad categories that include logic design automation, verification and test; and physical design automation. Furthermore, verification software is usually the first EDA tool used in the overall design method for simulation of the initial design developed for the intended circuit or system.

The two principal HDLs (Hardware Description Language) currently used include very high-speed integrated circuits (VHSIC) hardware description language (VHDL) and Verilog hardware description language.

The EDA term is used for computer-aided design (CAD) of electronic chips or ICs in the field of electrical engineering. Modern industries have increased the usage of EDA programs as a result of continuous requirement of semiconductor technology.

As well as The EDA is considered as an umbrella which cover computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE); however, these software tools were developed to design the ICs and systems then verifying their behavior. [17, 11]

In modern control system design using CAD techniques, the design can be summarised by the following block diagram that shown below figure 1.

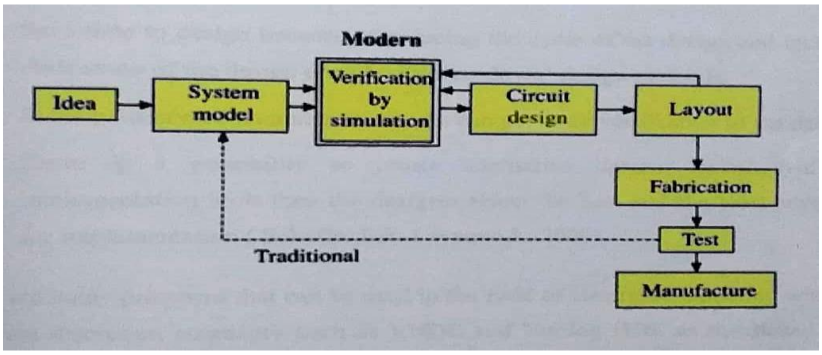

Fig 1: Modren Modelling and Simulation Methology Versus Traditional Approach

On the other hand, the traditional design route starts with idea, and then proceeds to paper circuit design stage. Finally, the prototype design will be tested and verified against the specification that required; however, there are many procedure to test the design (prototyping methods) such as Solder less Breadboard or Plug board, Springboard, Per board and Solder, Generic Printed Circuit Board multiple hole-per-pad, "Dead Bug," or "Ugly board"... etc. If the result of the simulation is found with a fault, a redesign will be carried out and all the process will be repeated again. The EDA soft ware tools enable the design and the evaluation of the complex digital circuit within the built-in computer workstation environment, where the delays are taken into account (hardware is not as a mathematical models), without the requirement of the hardware simulation. By using CAD, can be detect the faults by simulation without going through the costly stage of prototype construction [9]. EDA environment enables us to make any upgrade with the access to the common database. Some of the advantages of EDA include:

EDA advantages

- Easier to describe logic and easy to change the design toodes) rather than schomane implementation.
- Save time to design because of reducing the cycle of the design and increasing the abstraction of the design complexity "top-down' design methods
- In the presence of simulation tools, can be get more verification of the design.
- There is a possibility to create alternative designs using synthesis and implementation tools then the designer select the best and the most simplified one for implementation [22].

There are many programs that can be used in the field of electronic modeling which use the hardware discretion languages such as VHDL and Verilog HDL as mentioned above. In this project report, the design of the Elevate will be carried out via VHDL approach. Both programs implement the top-down approach; however, at first the design described at register transfer level (RTL) then RTL can be translated into schematics or chip level using synthesis tools. The design procedure is almost as software programming, where the program is written in a high level language before transferring it to machine language. For this reason a hardware description language (HDL) were developed to be implemented in digital industry [18].

In this project, VHDL and MAX+plus II are used to model and simulate the Elevator design

❖ Design Styles

VHDL laz any other hardware description language, permits the designers to design a design in fiat, Bonom-up and Top-down methodology.

❖ Flat Design

In this case the design is normally simple and does not need a hierarchical aproach

❖ Bottom-Up Design

The traditional method of electronic design is bottom-up. Each design is performed at the gmelevel using the standard gates (Refer to the Digital Section or more details) with increasing complexity of new designs this approach is nearly impossible to maintain. New systems consist of ASIC or microprocessors with a complexity of thousands of transistors. These traditional bottom-up designs have to give way to new structural, hierarchical design methods. Without these new design practices it would be impossible to handle the new complexity.

❖ Top-Down Design

The desired design-style of all designers is the top-down design. A real top-down design allows early testing, easy change of different technologies, and a structured system design and offers many other advantages. But it is very difficult to follow a pure top-down design. Due to this fact most designs are mix of both the methods, implementing some key elements of both design styles. Figure 2 shows a Top-Down design approach which will be used in this assignment. [15, 18].

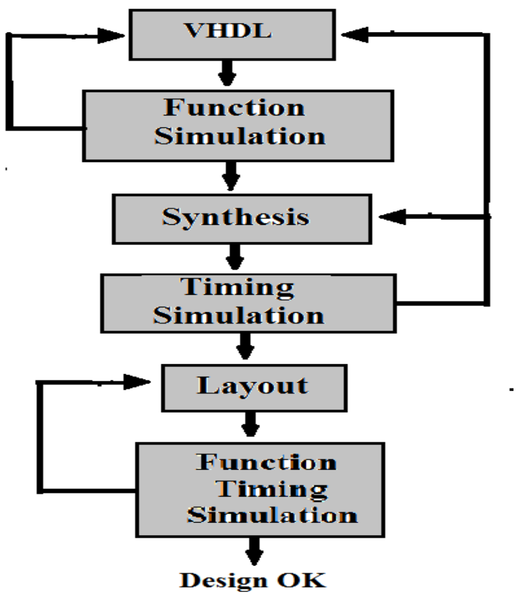

Fig 2: Illustration of the VHDL Design Process

4. Result & Discussion

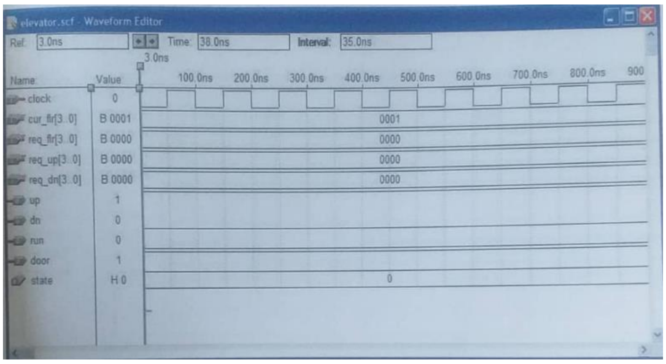

Fig 3: No Requests - Stays at Current Floor

The elevator's car at the Ground Floor (cur_flr="0001") with no requests. Stays at the current floor (State=STOP_UP).

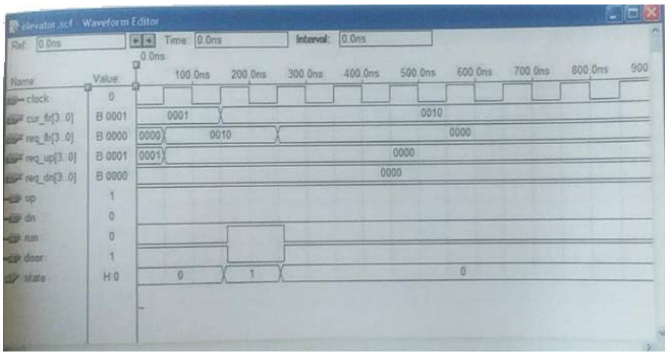

Fig 4: Request to the First Floor

The elevator's car at Ground Floor (cur fir "0001") a request up and request to exit at First Floor (req _flr= "0010"). Strat at STOP_ UP then GOING_UP then STOP_UP again when it reaches the requested floor.

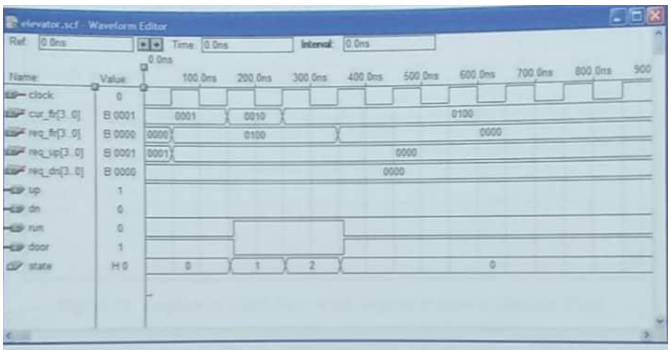

Fig 5: Request to the Second Floor

Starts at STOP_UP then GOING_UP then CONT_UP then STOP_UP again when it reached the requested floor; Second Floor (0100).

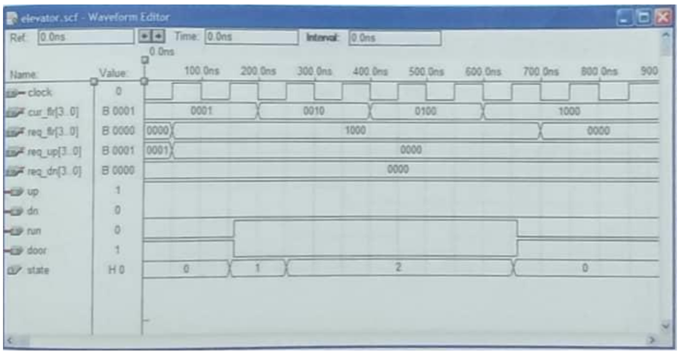

Figure 6, Request to Third Floor

✓ Same procedure as second floor.

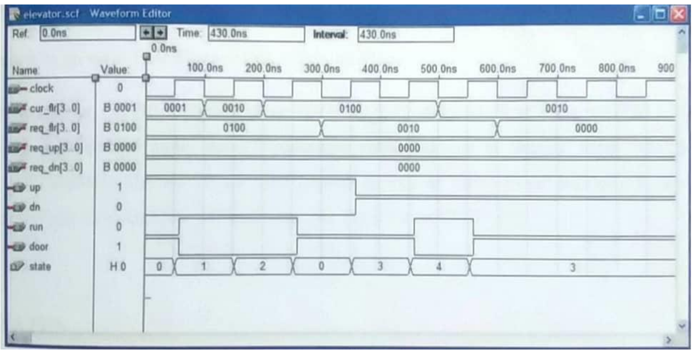

Fig 7: Request to Third Floor Then a request Button at Ground Floor

Starts at STOP_UP goes all the way through GOING_UP and CONT_UP to stop at the requested floor (Third Floor 1000) with STOP UP and then While the elevator at the third floor, some one pressed the up button at the Ground Floor. The elevator goes down to the ground floor to serve the request, it changes to STOP_DN then GOING DN then CONT DN till it reaches the Ground Floor and moves to STOP_DN

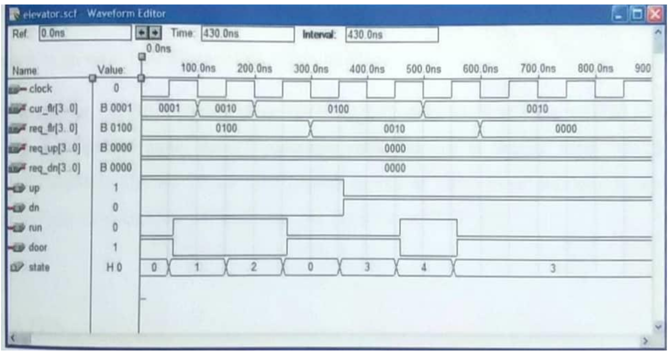

Fig 8: Request to Second Floor Then a request Down to the First Floor

Same as all, it starts at STOP_UP then checks for requests above, moves to GOING_UP and CONT_UP to STOP UP at requested floor then checks again for request, if there is any requests above, it takes the same transitions GOING_UP, CONT_UP and STOP_UP When it reaches the requested floor. If there are no requests above and there is a roquest below, moves to STOP_DN and starts the satne transitions in the opposte directson.

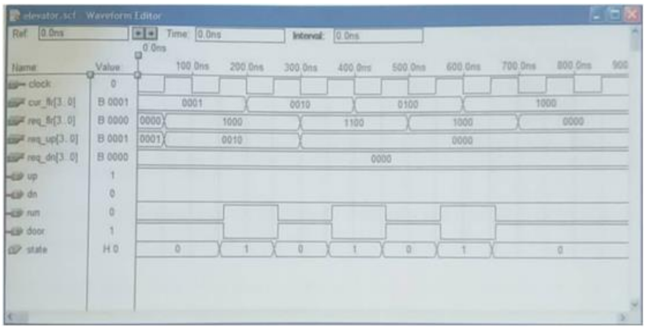

Fig 9: Two Active Requests to Diffrent Floors

A request from Ground Floor to exit at Third Floor and while the elevator on the move, a request to go up at First Floor to exit at Second Floor.

Ground Floor (STOP_UP) moves up (GOING_UP) stops at First Floor (STOP_UP) to pickup a passenger going up, 2nd passenger requested exit at Second Floor (req_flr = "1100") GOING_UP, STOP_UP first request to exit at Third Floor still active and the elevator moves to GOING_UP and stops the Third Floor STOP_UP

STATES

STOP_UP	GOING_UP	CONT_UP	STOP_DN	GOING_DN	CONT_DN
0	1	2	3	4	5

5. Conclusion & Recommendation

Modern integrated circuits are enormously complicated, often containing many millions of devices. Design of these ICs would not be humanly possible without software assistance of every stage of the process. The tools used for this task are collectively called electronic design automation (EDA), among these tools is VHDL, which used to describe the behaviour of an electronic circuit or system, from which the physical circuit or system can then be implemented. MAX+plus II is fast and reliable EDA environment, makes the process of designing ever easier.

Generally this experimental task can be certainly considered as successful as all the aims were reached.

MAX+plus II along VHDL were used to design and test the functioning of the elevator design the results were satisfactory and are as expected just with a minor discovery of a finite amount of delay in the simulations between the input and output due to program processing the inputs given to it.

Overall, the design functions as required of its specifications. The future of elevator technology may be elevators that use magnetic levitation instead of cables and are powered by linear induction motors.

The outcome of this project is satisfactory, as shown from the test result that the developed source code reflected the behaviour of the Combination Elevator as the specification.

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