International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Control System Model of Vertical Conveyor using Low Power FPGA Controller for Micro-Grid Applications

Ritu Sahu[1], Rishabh Shukla[2]

[1,2]Department of Power Electronic, Oriental College of Technology, Rajiv Gandhi Technical University, Bhopal, India

Abstract: ***In the present time, deployment of big modern building areas has been grown vertically. One of the most important requirements in these high rise buildings is the facility of small elevators for carrying a small or less weighted item to various floors of the building. For the reorganization we are using DC (direct current). This motor is mostly used for power convertor and controller which are compared with dc supply to the electrical motors. In this paper we are using direct current motor (DC) motor for elevator system which is suitable for using simulation model. For the successfully working, a prototype elevator been designed. Experiment is done for the movement of the elevator cabin in both upward and downward with and without load. Complete closed loop control has been implemented with Xilinx Spartan-3E Field programmable Gate array kit.***

Keywords: DC Micro Grid, DC (Direct Current) Motor, FPGA (field programmable Gate array), Elevator

1. Introduction

In the present days cities are growing vertically and in the high rise buildings vertical transportation is difficult. For the transportation of the goods within the building by using elevator a motor is used for hoisting the operation. Elevator control system is responsible for different type of services such as accelerating, decelerating, speed travel. By using the button signal it accept the input and by using the door opening, elevator car moving etc. it produce the output. The aim of the control in the system are-

- It minimizes the timing of transport.
- It brings the car lift to the correct floor.
- It provide smooth ride and maximize comfort transportation.
- It accelerates, decelerates the speed limits.

1.1. Different Types of Elevator Control

- **Controlled Elevator**

Old elevators are not in automatic landing position. Elevators are operated by the motor controller. These types of elevator controller have many relay. Many of the elevators are controlled by switches and by pulling the rope. Elevator interlock is allowed to move in and out of the door. After that, some of the elevator are introduced which are automatically levelled. Elevator could control their speed when it is nearest to the floor. This was the first step which is automatically controlled.

- **Hydraulic Controlled Elevator**

A hydraulic elevator consist of fluid with a pumping system moves the elevator car up and down. In this type of elevator, a tank or fluid reservoir supplies hydraulic oil. The pump forces the oil through a least resistance path and returns it to the reservoir when the valve is opened. When the valve is closed, pressurized oil (created by the pump) pushes the piston upside so that the car moves upward. And when the valve is opened, the fluid returns back to the tank, and hence the piston moves downwards.

- **Signal or Traction Controlled Elevator**

Traction elevators are lifted by ropes and gears, which pass over a wheel attached to an electric motor above the elevator shaft. Geared traction machines are driven by AC or DC electric motors. Geared machines use worm-gears to control mechanical movement of elevator cars by "rolling" steel hoist ropes over a drive sheave which is attached to a gearbox driven by a high-speed motor. A counter weight makes the elevators more efficient. Nowadays, some traction elevators are using flat steel belts instead of conventional steel ropes. Flat steel belts do not require any oil or lubricant as they are extremely light due to its carbon fibre core and a high-friction coating. Because of these qualities, elevator energy consumption in high-rise buildings can be cut significantly.

1.2. Different Types of Signal Control Hardware

- **Electronic ICs**

Electronic chip has the function are built in for definite purpose. It is designed to provide the highly reliability and optimized performance. Though manufacturer provides the large array chips, their operations cannot be customized to suit user needs. Thus for the purpose of testing new algorithm are fail dejectedly. ICs used to control the speed that has the purpose required to execute a full characteristic motor controlled systems. They include a rotor positions decoder and provide the functionalities like open-loop speed control, forward or reverse rotation, run enable and dynamic braking.

- **Microcontroller**

These are the dedicated ICs that have several desirable features for Motor control. These features include high speed ADC with sample and hold circuit, data storage unit, PWM channel, high resolution timer and interrupt. A high speed ADC with samples and hold circuit is must for high speed

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control of machines as the analog currents and speed signals are to be converted to digital signal for high speed processing in the microcontrollers. The inputs are captured with the capture unit by knowing the position signal available from the Hall sensors integrated in the motors.

- **FPGA**

A FPGA is a reconfigurable digital logic stage. Due to high density of LUT its support the parallel executions by the considerable amount of bits level operation. With FPGA, calculation would usually use large amount of CPU time to be accelerated. The FPGA has additional advantages of embedded multiplier which allow the faster multiples which accumulates the operation. FPGA also contains the CPU soft core, floating point unit, associated memory subsystem and SPI communication interfaces.

- **PLC Controller**

Programmable Logic Controller (PLC) is a digital computer used for the automation of various electro-mechanical processes in industries. These controllers are specially designed to survive in harsh situations and shielded from heat, cold, dust, and moisture etc. PLC consists of microprocessors and controllers that are programmed using software language.

2. DC Motor Control Mechanism for Elevator Movement

We can't drive a DC Motor (depends) directly with a Microcontroller, as DC Motors requires high current and high voltage than a Microcontroller can handle. Microcontrollers usually operates at +5 or +3.3V supply and it I/O pin can provide only up to 25mA current. Commonly used DC Motors requires 12V supply and 300mA current; moreover interfacing DC Motors directly with Microcontrollers may affect the working of Microcontroller due to the Back EMF of the DC Motor. Thus it is clear that, it not a good idea to interface DC Motor directly with Microcontrollers. The solution to above problems is to use H-bridge circuit. It is a special circuit, by using the 4-switches we can control the direction of DC Motor. The interfacing of DC motor using half-bridge circuit is shown in Figure 1. Depending upon our power requirements we can make our own H-bridge using Transistors/MOSFETs as switches. It is better to use readymade ICs, instead of making our own H-bridge.

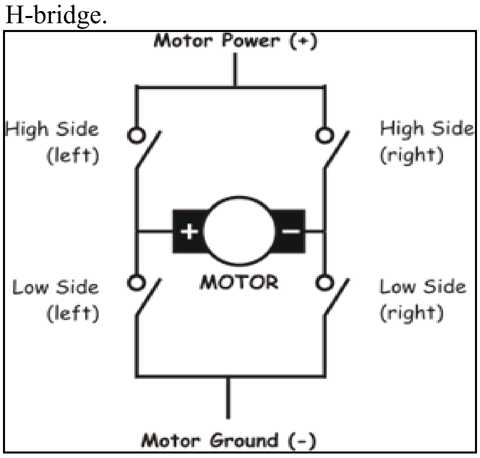

Figure 1: Interfacing of half bridge circuit with DC motor

L293 and L293D are two such ICs. These are dual H-bridge motor drivers, i.e., by using one IC we can control two DC Motors in both clock wise and counter clockwise directions. The L293D can provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V while L293 can provide up to 1A at same voltages. Both ICs are designed to drive inductive loads such as dc motors, bipolar stepping motors, relays and solenoids as well as other high-current or high-voltage loads in positive-supply applications. All inputs of these ICs are TTL compatible and output clamp diodes for inductive transient suppression are also provided internally. These diodes protect our circuit from the Back EMF of DC Motor. In both ICs, drivers are enabled in pairs, with drivers 1 and 2 are enabled by a high input to 1,2EN and drivers 3 and 4 are enabled by a high input to 3,4EN. When drivers are enabled, their outputs will be active and in phase with their inputs. When drivers are disabled, their outputs will be off and will be in the high-impedance state. This is represented in Table 1. Table 2 represent the DC motor control signal and motor status.

Table 1: Control Signals of L293d Driver IC

Input		*Output*
A	*Enable*	*Y*
high	high	high
low	high	low
X	low	High impedance (Z)

Table 2: DC Motor Status Vs Terminal Voltage Signals

IN1	*IN2*	*Motor Status*
low	low	stop
low	high	clockwise
high	low	Counter-clockwise (anti-clockwise)
high	high	stop

3. Literature Review

In reference [1] author describes the speed monitoring and control of the separately excited DC motor using soft computing technique based artificial neural network (ANN) controller. The scopes includes modelling of separately Excited DC motor, implementation of Artificial Neural Network Controller using FPGA and comparison of MATLAB/SIMULINK simulation result with the experimental result. Work on [2] the study on controlling motor terminal voltages using chopper method. The proposed system offers many advantages such as accurate speed control, synchronization and digital control possibility, which can be economically implemented with low-cost circuit. In reference [3] High performance DC motor drives are the robotic manipulators, electric trains appliances requires speed controllers to perform tasks these are the recent developments skills in science and technology provide a wide range scope of applications. We will vary the PWM signal from the microprocessor to the motor driver motor speed can be controlled back to desired value easily. In reference [4] author describe microcontroller based project here being also a, used for security purpose and in emergency condition. The use of microcontroller in this project is to store the data which is using in the programming for purpose of moving the elevator, process data that will be according to the user wishes. This paper describes the voice operated elevator which is also easy in language and important for user.

Both cascade compensator and (PWM) generator are designed [5] by adopting the very high speed integrated circuit hardware description language (VHDL) and the Xilinx Spartan-3E field programmable gate array (FPGA). The results obtained are in close resemblance with those got from a MATLAB model for the same system. In reference [6], the paper proposed a way of implementing a phase locked loop (PLL) motor speed controller. The main emphasis is on the FPGA implementation of the digital PLL. The main advantages of the design procedure: it offers the possibility to experiment with different filters in the loop. The presented work in [7] is programmed on FPGA board Altera D.E 2.0.FPGAs flexible architecture reduces the processing speed, accuracy, robustness and hence increases the overall systems efficiency. In reference [8] the work introduces a new solution of elevator controlling system which is based on microcontrollers. The purpose of this work is to design an effective elevator control system, which can be reprogrammed in a fashion to minimize the congestion on a particular lane by directing the lift on a particular floor using time management scheme.

This paper presents a Fuzzy logic controller (FLC) design methodology to construct fuzzy controller on FPGA for DC motor speed control. [9]. The PWM (Pulse Width Modulation) technique is used to drive the motor with correct control signals. The proposed system allows the motor to run at desired speed even when the load on the motor varies. The motivation of this paper has been to devise a model for teaching VHDL language to embedded students. [10] With the DTC Space Vector Modulation (DTC-SVM) method, use constant switching frequency. Advance study and research on DC motor control by going through papers published in various journals.

This paper describes a reliable dynamic model to simulate Dc motor controller using FPGA. These applications require a very tight speed controlling to avoid serious problems. [11]. In this paper we studied the problem, analyzed it, and we found the solution and did simulation to check its outcomes. Our goals in this paper are to verify our solution and implement it using Field-Programmable Gate Arrays (FPGAs). In reference [12] the paper describes these AI tools and their application in the area of power electronics and motion control. The back-EMF zero-crossing detection scheme, which does not require the motors neutral voltage, which allow the removal of the true back-EMF directly from terminal voltage by properly selecting the PWM and sensing strategies [13-14]. The third vocal base scheme is one of mainly significant to back-EMF sense method. A wider speed ranges and smaller phase delay than the terminal voltages sensing methods [15].

4. Elevator System Model Design and Implementation

As shown in the Figure 2, is the simple diagram of the proposed elevator system control model. The model uses DC (direct current) motor for supplying the dc current. The direct current motor is coupled with the elevator system for the motion of the Elevator Control (EC). For the proper movement of the elevator we are using pulley and the pulley is couple with DC motor. The suspension cable is guided through a mechanical pulley for the proper movement of the system.

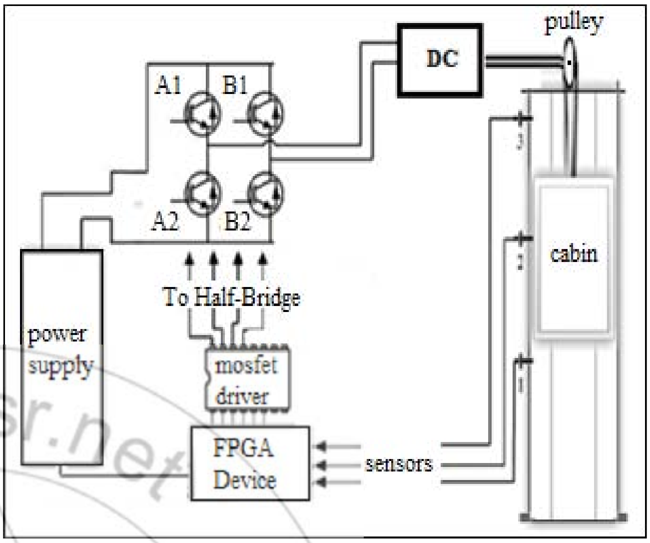

Figure 2: Block diagram of proposed elevator control model

We are using the magnetic sensor for identifying the position of the elevator CABIN i.e. floor level. In this design we are using FPGA controller for the design and development of the proposed elevator control.

The control design of elevator is achieved using FPGA device and the driver circuits. The mechanical model is developed using wooden board and card board as shown in Figure 3. The model has three floor positions for the elevator to take intermediate stops between the extreme low and the extreme top positions. Figure 4 shows the interfacing of the DC Motor with the driver circuit and the half-bridge circuit.

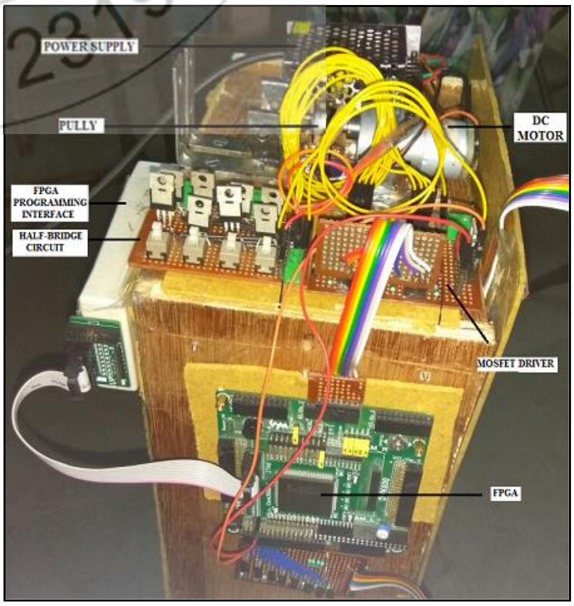

Figure 3: Mechanical Model of the Elevator

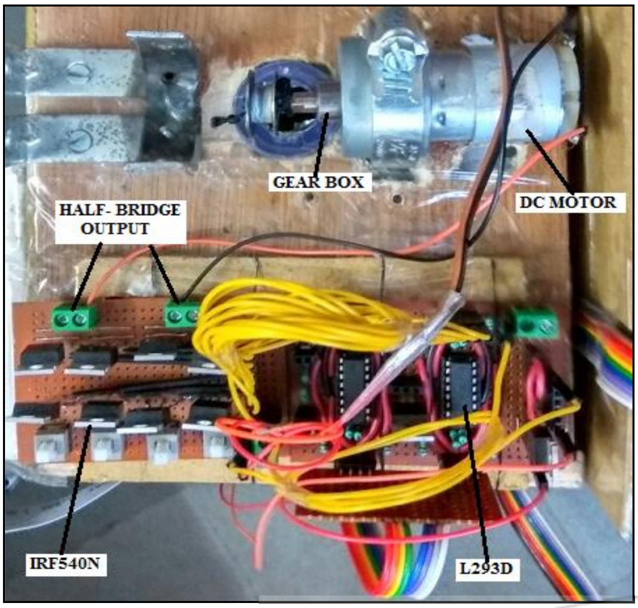

Figure 4: Driver IC and Half-Bridge Circuit Interfacing

The Model has 4-input switch interfaces for user control. The movement of the lift cabin can be controlled by selecting the input lift control button of that particular level / floor. The stopping level positions are shown in Figure 5. All levels have a magnetic sensor to locate the position of the cabin when reached to a particular level.

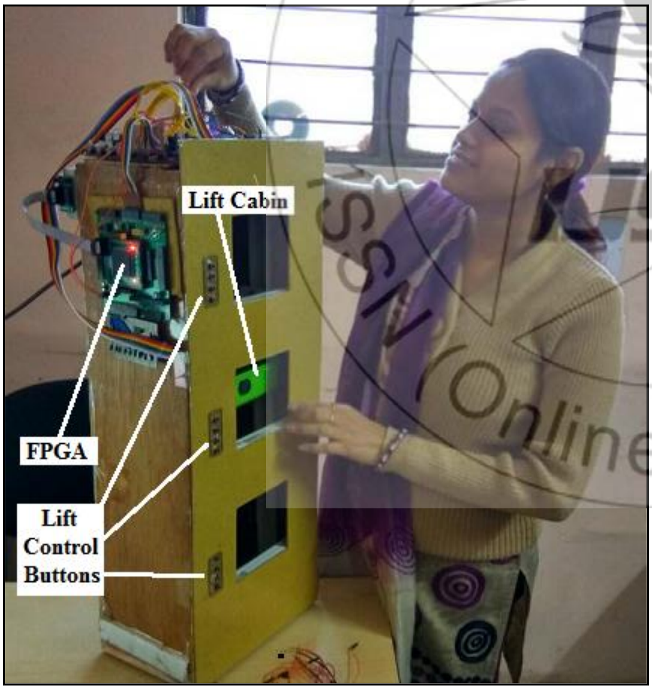

Figure 5: Different levels to stop elevator cabin and lift control buttons

The FPGA based hardware utilization summary of the proposed Lift controlled model is presented in Table 3. This table summarizes the amount of logic components that are required for the control design realization of the present model.

Table 3: Hardware Utilization Summary of FPGA

SPARTAN-3E XC3S500E-PQ208	*Total*	*Lift Control Design*	
		Used	*%*
Slices	4656	401	8
Flipflops	9312	210	2
LUTs 4-Inputs	9317	749	8
Bonded IOBs	158	22	13

5. Conclusion

The purpose of this thesis was to develop a flexible, configurable, compact and high performance brushless DC motor control system. To design a compact motor control system was one of the goals of this study, because volume and weight of the components are very important for a lot of systems. To succeed this goal, this study is based on the system on chip concept. Current and position controllers are implemented in a single FPGA chip in the scope of this concept. An electronic board was designed and manufactured within the scope of this thesis. Board includes the digital and power electronic circuitries together. FPGA design was implemented and tested in this board. However; this FPGA design can be moved to another FPGA chip or board easily.

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