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PLC VVVF ELEVATOR CONTROL SYSTEM

Author/s: Yujian Tang
Tianyu Gui

SAVONIA UNIVERSITY OF APPLIED SCIENCES

THESIS
Abstract

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Author(s) Yujian Tang, Tianyu Gui			
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Abstract

The aim of the thesis is to introduce the PLC VVVF elevator and its control system.

The thesis can be divided into three parts. The first part is about the overview of the lift: the kinds of the lift and the structure of the lift, it shows the knowledge about the components and the operating systems of the lift. The second part is about the PLC control system, it's about the operations of the lift from the introduction about the hardware and software of the PLC control system. And the third part is about the market of the lift, the situation of the world market about lift will be showed.

With the development of the technology, there must be some changes about the lift, for example, Bluetooth technology can be used in the lift, some new ways to sell the lift, some new motors can save the energy and show some new motor can use new energy. So the future trend of the lift is analyzed in the thesis. From this analysis, Chinese market will become one of the biggest markets in the world.

Keywords
PLC; Lift; Elevator; VVVF

CONTENTS

1 INTRODUCTION

The PLC control system, the programmable logic controller, a digital computing operation of electronic systems, is intended to be used in industrial environments and design.

It uses a programmable memory for its internal stored procedures, implementation of logical, sequential control, timing, user-oriented counting and arithmetic operations such instruction, and through digital or analog input / output it controls various types of machinery or production processes. It is the core of industrial control management.

1.1 Background of thesis

First, the lift system and programmable logic controller (PLC) is introduced. Then we elaborate what is the classification and characteristics of the lift control system. Lift control system is divided into two parts: speed and signal control.

Second, ensuring the overall structure of the system, using the PLC to control the lift speed and achieving the selection of the frequency. In the lift system software design, we designed the software flow, and introduced software development system.

Then, the situation of the lift in the world is the part of the research, the Chinses market has been chosen to the main market we should research. From this research, some advantages and disadvantages must be filled into the report. The future trend of the lift is also concerned as a part of the thesis to show the future of the lift.

1.2 Purpose of this thesis

The content of the subject under study is the transformation in the lift with automatic control systems Programmable Logic Controller (PLC). As most of the old-fashioned lift electronic control systems are less reliable, users seek to lift electronic control system transformation, in order to save money.

Therefore, the lift control technology research, to find a way for the transformation of the old-fashioned lift domestically, and thus improve the technical level and quality of domestic lifts, has very important significance.

Due to old lift systems have lots of problems, we decide to use the programmable logic controller (PLC) as the lift control system. The PLC system has powerful functions, low failure rates, and it can keep high reliability.

After the research about the lift market in the world, there are some problems about the Chinese lift. So analysis about the situation of the lift in China is essential is very important. And from the future trend of the lift, the new technologies shows in the thesis.

2 THE HISTORY OF THE LIFT

The lift is a vertical-direction vehicle which is indispensable for high-rise buildings, such as high-rise hotels, shops, homes, factories and warehouses. With the development of society and the increasing scale of the buildings, more and more lifts have higher requirements for speed, precision, speed range and characteristics of static and dynamic. (The design of lift control system, 2010)

2.1 Development of the lift

With economic development, building height has grown at the same rate of economic development. As the central nervous system of the building, the lift plays an integral role. The lift in the building works as the main means of transport, like other transport tools, and has become as an indispensable component in our daily life. (Development of domestic and foreign elevator, 2005)

A country's lifts total depends mainly on economic growth, urbanization, population density and so on. In the context of global economic downturn, the Chinese economy continues to grow at a higher rate, and constantly improves the level of urbanization. China has the largest lift market in the world. Since 1949, Chinese companies have produced more than 610,000 lifts. However, a Chinese lift is far from to get the saturation level. The world average record is that per 1,000 people has 1 lift. If we want to reach this level, at least, we have to produce 0.7 million lifts more. There is such a huge market demand for the development of Chinese lift industry. (Development of domestic and foreign elevator, 2005)

The Chinese lift industry already has a strong production capacity. Thriving lift market has attracted all over the world's famous lift companies, for example, the United States Otis, Schindler, Kone, Germany Thyssen, Mitsubishi, Hitachi, Toshiba, Fujitec and another 13 foreign-invested companies in the Chinese domestic market share reached 74%. (Developement of the lift, 2006) Advanced technology and management has an important role in Chinese lift businesses.

Nowadays, the number of production and use of lifts has become the measure of a country's level of industrial modernization sign. In some developed countries, lift is quite common. Several world famous lift companies, such as the United States Otis, Schindler, Japan Mitsubishi and Hitachi, Finland Kone, their lift production accounted for 51% of the world market. (Zhou Yajun, 2008) At present, in addition to the AC replaced DC of the lift, with low-rise buildings there are increasingly used hydraulic lifts. In addition, residential lifts will be a new part of lifts.

2.2 PLC Application and development prospect of lift control

Currently, the lift control has three ways. The first is the relay based controller (electromechanical switching), the second is the Solid-State Logic Technology, the third is the PLC controller (computer based technology). The PLC is actually a dedicated computer, which uses scan time processing tasks, and relies on program running. It can ensure lifts work only with the right program. The traditional electrical control system of lifts is a relay-controlled system. The traditional way of lift control system has the disadvantages such as complicated circuits, high fault ratios, bad dependability and huge effects on the lift's running quality. Therefore, we have improved electrical control system of a relay-controlled lift in an apartment by using PLC. The result showed that the reformed system is reliable in operation and it is easy for maintenance. Programmable Logic Controller (PLC) is the first order logic control in accordance with the needs of developing specifically for industrial environment applications to operate the electronic digital computing device. Given its advantages, at present, the relay based controller has been replaced by PLC controller. At the same time, AC variable frequency motor speed control technology, the lift, drags speed has been a gradual transition from DC to AC frequency converter. Therefore, the PLC controller technology is used in VVVF lift has become popularity. (Xingyao, 1979.8)

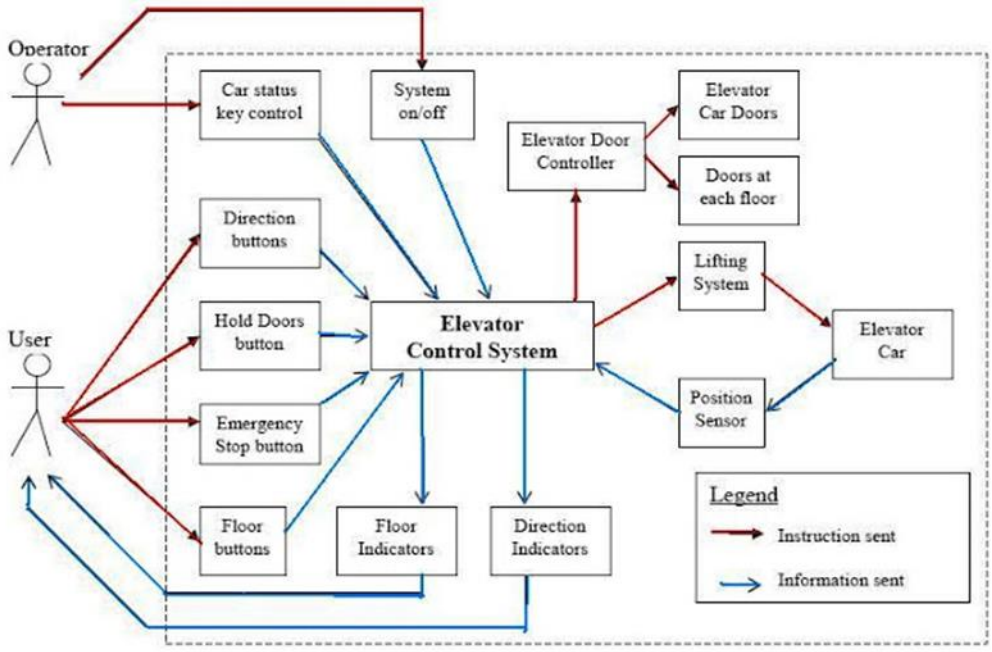

Figure 1: Simple Elevator Control System Inputs and Outputs (Basic Elevator Components, 2012)

The advent of personal computers has made microprocessor technology affordable for many other fields. Elevator Concepts utilizes a special type of industrial computer called a Programmable Logic Controller PLC to control the logic of more complex jobs. They are very dependable, compact, and simple to troubleshoot.

Computer based controllers are suitable for the following:

-All lifts types.
-All drive speeds (i.e. 0.5 m/s to 10 m/s).
-Lift groups of all sizes.

Figure 2: PLC controller (computer based technology) (Customized control Panel Builders, 2005)

2.3 PLC lift control advantages

A PLC lift can give so many benefits for their users. (Fusi, 1991.8)

1. Using PLC controller with the automatic control of lift operation, reliability of the lift greatly increased.
2. The control system structure is simple, simplifying the external circuit.
3. The PLC can be a variety of complex control systems, easy to add or change control functions.
4. The PLC have automated fault detection and alarm display to improve the operation of security and ease of maintenance.
5. For the group control the allocation and management, it can improve the efficiency of lift operation.
6. The lift do not need to change the control scheme when the hardware connection has some changes.

3 OVERVIEW OF LIFTS

Usually, as a motor-driven vertical lift, equipped with a box-shaped pod, used for multi-story buildings to move people or goods between floors (levels, decks) of a building, vessel, or other structure.

Lifts are generally powered by electric motors that either drive traction cables or counterweight systems like a hoist, or pump hydraulic fluid to raise by a cylindrical piston like a jack. (Development of domestic and foreign elevator, 2005)

3.1 Definition and introduction of lifts

In agriculture and manufacturing, a lift is a type of conveyor device which is used to move materials in a continuous stream into bins or silos. Several types of machines, such as the chain and bucket lift, a grain auger screw conveyors are using the principle of Archimedes' screw, or the chain and paddles or forks of hay lifts. (The introduction of the lift, 2008)

3.2 The type of lifts

Application (Zhengkang, China machine press):

a. Passenger lifts: Lifts are designed for passengers, equipped with safety facilities and some decorations.
b. Freight lift: Lifts are mainly designed for transporting goods.
c. Hospital lift: Lifts are designed for transporting beds, stretchers, medical vehicle lifts.
d. Dumbwaiter: Lifts are for libraries, office buildings, restaurants, transport books, paper and food.
e. Sightseeing lift: Lifts are for passenger sightseeing with transparency in the cableway.
f. Vehicle lift: The lifts are used to move vehicles.
g. Ship lift: Lifts are used on ships.
h. Construction lifts: Lifts are for construction and repair.

Other types of lift, in addition to the above mentioned common lift, there are some special-purpose lift, such as cold storage lift, explosion-proof lift, the lift is used by firefighters.

3.3 Main parameters and performance indicators of the lifts

(A) Performance indicators:

1) Security

A lift is used to transport passengers, so the most important is the safety of the lift. The safety of the lift is closely linked to design, manufacturing, installation, commissioning and maintenance processes. Some parts have problems, and it may cause safety risks or even some big accidents.

2) Reliability

Reliability of the lift is important. If a lift often doesn't work, it will affect people's normal life and production, causing great inconvenience to the people, unreliable and accident, are often the causes of insecurity. To improve reliability, firstly, increase the reliability of individual components of the lift must be increased.

Only when every component of the lift is reliable, the entire lift is reliable.

3) Stopping accuracy

Stop accuracy is also known as the leveling accuracy. GB/T10058-1997 the technical condition of the lift car leveling accuracy is provided in Table 10.

4) Vibration, noise and electromagnetic interference

Hyundai Elevator creates a comfortable living and working environment for passengers. It means requiring elevator running smooth, quiet, no electromagnetic interference.

5) The sense of comfort and fast

For lift, as a transport tool, the demand for speed is essential. It works fast and can save time, which is very important for passengers in the fast pace of modern life. But the excessive increase of acceleration can cause passengers discomfort. So when we are designing the lift, we should take into account these two contradictory factors, speed and comfort.

6) Energy-saving

Modern lifts should choose the way of drag reasonably, to achieve the goal of energy-saving.

(B) Main parameters:

1) Rated load capacity (kg): Manufacturing and design of lifts contained weight.
2) Car dimensions (mm): Width x depth x height.
3) Car type: Single or double doors, and other special requirements: the choice of colors, requirements of fan and telephone.
4) Car door: Fenced door, closed carved doors, closed-end dual-split doors, closed-end dual-split carved doors.
5) Opening width (mm): Net width of the car door and landing door fully open.
6) Opening direction: People in the hall to face the hall door, the door to the left direction of the left door, opened the door to the right direction for the right to open the door, two doors to the left and right sides, respectively, of the door opener, also known as the points door.
7) The traction mode: 1: 1 sling method, the speed of the car is equal to the wire speed. Semi around 2: 1 sling method, the speed of the car is equal to half the speed of the wire. Full around 1: 1 sling method, the speed of the car is equal to the speed of the wire.
8) Rated speed (m / s): Manufacturing design specified speed of the lift.

9) Electrical control system: It consists of control and drive system. These two forms, such as AC or DC motor drag, selective collective automatic operation or control lift inside the car.
10) Stop Layer (station) Station: The floor in the building site for access to a lift is called stations. (Yan, 2010)

3.4 The structure and components of the lift

(1) Traction system

The feature of a lift traction system is output power and power transmission, which makes lifts run. It is mainly made by tractors machine, hoisting wire ropes, guide pulley and the rope pulley. The traction machine makes the power for lift operation, which consists of electric motors, traction wheels, couplings, gearboxes and electromagnetic parking brake.

The end of the hoisting wire connects to the car and counterweight respectively, rely on the frictions between wire rope and sheave to drive the car up and down. Role of guide wheel spacing is separated from the car and counterweight. Rewinding can also increase towing power. (Gensheng, 2002)

(2) Guide system

The guide system consists of guide rail and the guide rail frame. The role is to restrict the freedom of the car and counterweight, making car and counterweight move along the rail. (Gensheng, 2002)

(3) Door system

The door system is made by the car door, door, gate, linkage and other components. Car door located at the lift entrance, consists of components, such as doors, door Rails. Layer door is located at the entrance of the station. Door opener located in the car, is the power source of the car and the layer door. (Gensheng, 2002)

(4) Car

The car is the components to transport passengers or freight. It is made up of car and car body. The support mechanism of the car is car frame, the car is made up of the columns, beams and helical lever and so on. The car body is made up by the car wall, car roof, ventilation and illumination devices, car decorations, car control buttons and so on. The size of car inner space is determined by the rated load and nominal guest number. (Gensheng, 2002)

(5) Weight balancing system

The weight balancing system consists of counterweight device and the weight compensation device. Counterweight device is made up by counterweight frame and counterweight block. The counterweight is to balance the weight of the car and the part load. The weight compensation system is compensated with a high-building lift car and the lateral traction rope's length change the effect of the balance design. (Gensheng, 2002)

(6) Power drag system

The electric drive system is made up by traction motors, power supply system, speed feedback device, speed control device, etc. The function of the part is to control speed. Traction motor is the power source of lift, according to configurations that you can use AC motors or DC motors. The power supply system is to provide power for the motor. The speed feedback system provides the speed control system signal about the speed of the elevator. Generally, the tachometer generator or pulse generator can be connected to the motor. Speed control system controls the speed of the traction motor. (Gensheng, 2002)

(7) Electric control system

Electric control system consists of the control device, operating device, leveling device and display device and other components. Control device follows the logic of the lift function, control the operation of the lift, and set the control cabinet in the room. Operating devices, control lift running by button box (inside the elevator) and the call button (on the hall door). Leveling device provides the signal to control the leveling, and control device for accurate leveling. Leveling, it refers to when the car closes to a floor, to make car sill and door sill at the same level. The Hall position indicator displays the location where the car is and is used to display the location of the door, hall position indicator also indicates the running direction of the lift. (Gensheng, 2002)

(8) Safety protection system

The security system is to protect mechanical and electrical, which can ensure the safety of lifts. In machinery, over speed governor and safety gear can prevent the lift over speed, buffer can absorb the impact of descending car or counterweight, and there is another protective device to cut off the power supply. Electrical safety is reflected in all the operation of the lift. (Gensheng, 2002)

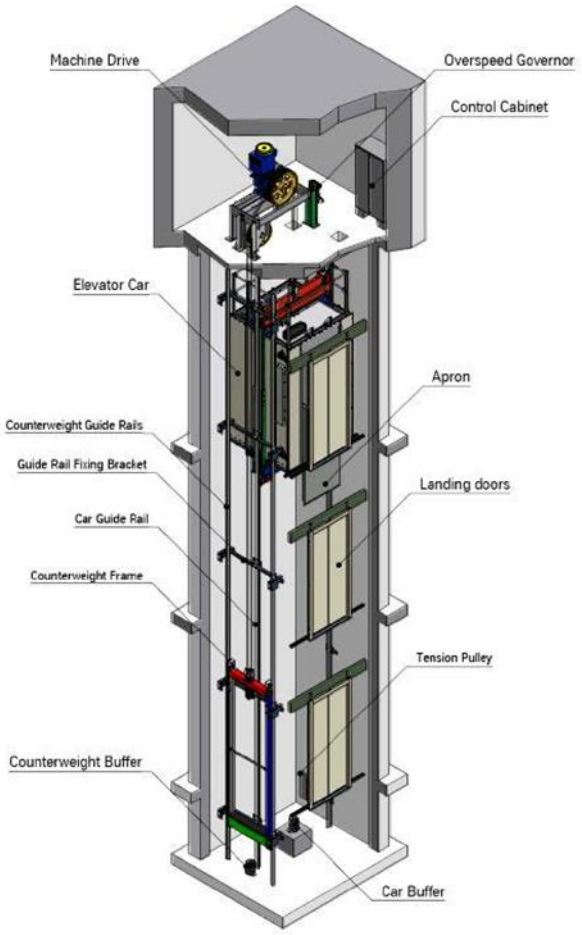

Figure 3: The basic structure of the elevator (Basic Elevator Components, 2012)

The standard elevators include the following basic components:

1. Car.
2. Hoist way.
3. Machine/drive system.
4. Control system.
5. Safety system.

3.5 Overall design

The design for the PLC lift control system is to determine the components of the lift and what kind of program this design followed.

3.5.1 Determine the overall scheme

PLC lift control systems and other types of lift control system can be divided into two parts, signal control system and drive control system. Figure 4 is the lift PLC control system diagram, major hardware, including PLC main unit and expansion, mechanical systems, car dashboard, hall button, floor indicator, car door operator, speed control devices and the main drive system.

For the control system, the core parts of PLC main units are hall buttons, shaft devices and the protective signal. From the input, PLC control system received the signal, then car dashboard shows the operations and the order is sent to the main drive system.

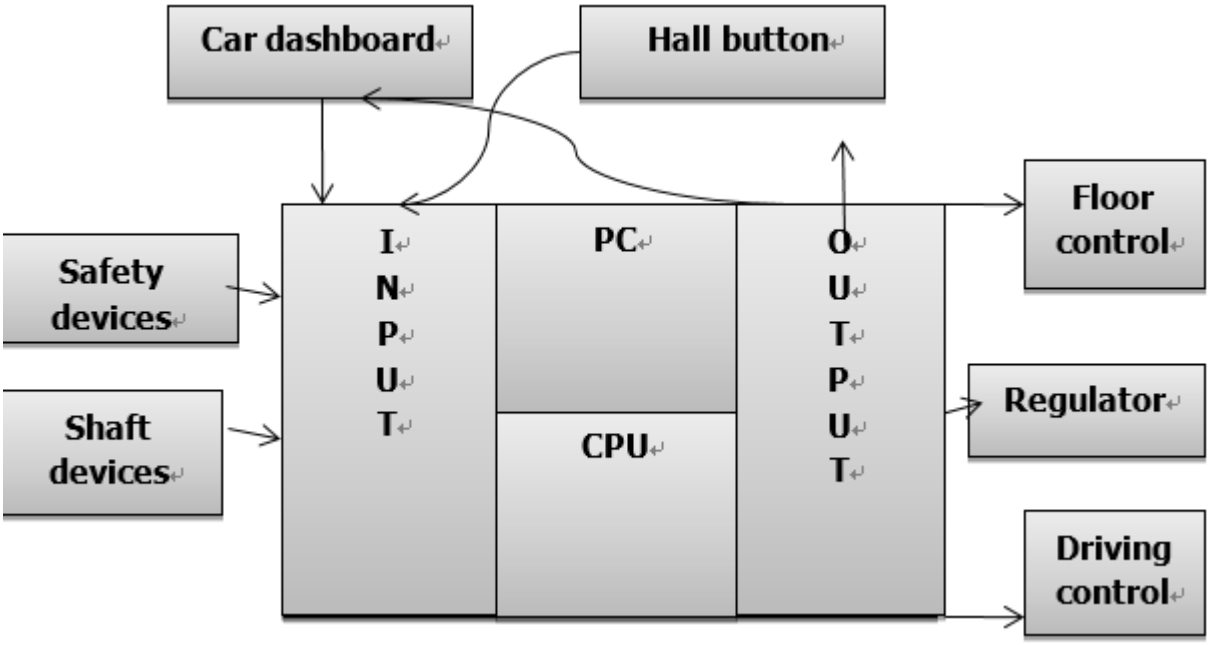

Figure 4: The lift PLC control system diagram (Small elevator PLC Intelligent Control System, 2008)

3.5.2 Design ideal

(1)Signal control system

Generally, PLC software controls the signal of the lift. Lift signal control system is as shown in Figure 5, the signal enters into a PLC control system: runway selection (as automatically, with or without driver, maintenance, and prevent fire,), control the operation, signals in the car, call from the floor, security information, switch door signal, leveling floor signal.

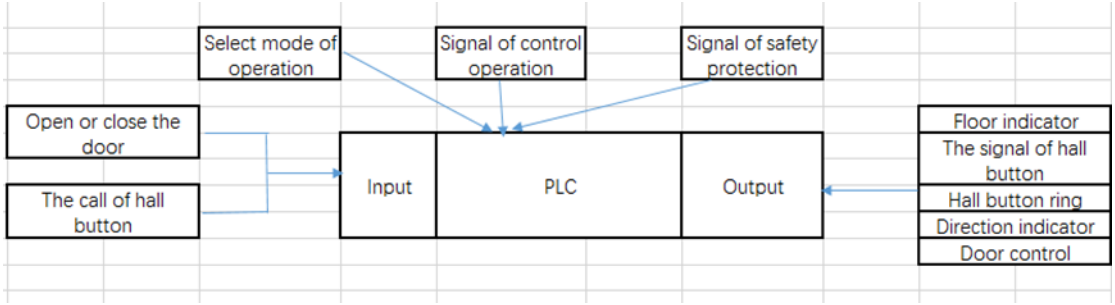

Figure 5: PLC lift control system diagram (Design of AC variable frequency speed elevator system, 2001)

(2) Functions of lift control system

Lift control system is to implement the following functions:

1) Directions decided by the signal, forward priority implementation.
2) When driving in case of call signals, forward section, does not stop the car when reversing.
3) Within the selected signal, the call signal own function of memory, deletes the signal after the implementation.
4) Call signal, directions, car location is indicated by the car dashboard.
5) When reaching the floor, the door can be delayed opening automatically or manually, (in the process of closing) when the next floor is in the same direction, the door will open and take the passengers.
6) If there is any signal from car dashboard, the door will be delayed to close automatically and then will be delayed to move the car automatically.
7) When there is no signal form car dashboard, the door will be closed after 5s automatically, but can't automatically move
8) When the lift is running, it cannot be manually opened or the called from the same floor to open, the car cannot move when the door is open. (Changchu)

4 THE SELECTION OF HARDWARE

Hardware is the core thing in the design process and it also needs some divided processes to get the best program.

4.1 Diagram

According to the design requirements, the design of the electrical control system of main circuit diagram is as shown in Figure 6. M1 and M2 are the traction motors and motors, AC contactor KM1~KM4 is, by controlling the operation of two electric motors, to control the car and hoist way doors and lift control. FR1 and FR2 are overloaded protection, thermal relays, is used for lift operation, disconnecting the main circuit when overloaded. FU is fused to prevent over current.

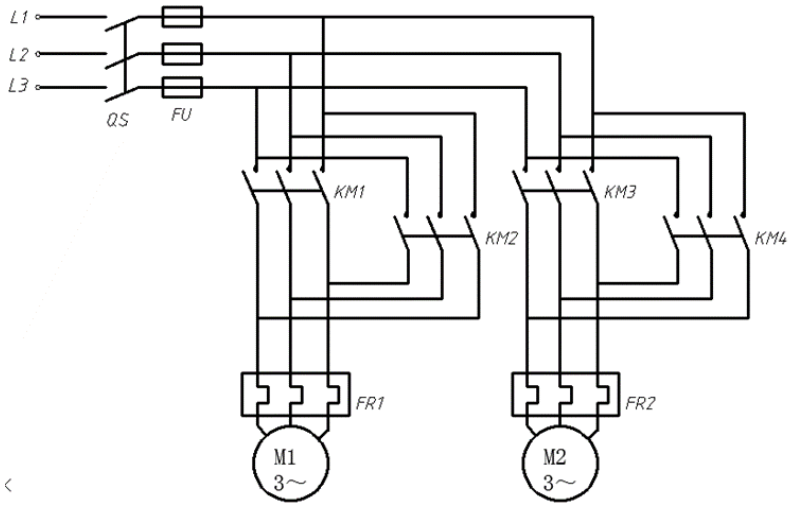

Figure 6: The PLC control system diagram (Chaoying, 1998.5)

4.2 PLC System hardware design

The hardware design can determine the values of the system and the base of the system.

4.2.1 PLC Basic principles of control systems design

Any kind of control system is to achieve the technological requirements, improving efficiency and quality of production. Therefore, when designing a PLC control system, the process should be guided by the following principles:

A) Meet control requirement for controlling object

Full of PLC function should be used to meet the requirements for control of the controlled object, is the primary criteria for designing PLC control system and one of the most important principles in the design. (Fusi, 1991.8) It requires designers to do some researches and collect data from the installed place, collect domestic and foreign information which is the similar situation.

B) Ensure the PLC control system is safe and reliable

There are some important principles to make sure PLC control system runs with long-term security, reliability and stability. (Fusi, 1991.8) It requires designers to take full account of system design, component selection, software programming to ensuring that the control system is safe and reliable. For example, ensure that the PLC programs can not only run under normal conditions and in some unusual cases (such as sudden intermittent power on, press button by mistake), the lift can work properly.

C) Simple, economical, easy operation and maintenance

A new project is to improve the quality and quantity of the product, bringing huge economic and social benefits, but investment, technical training, maintenance of equipment in new projects will also lead to increased funding. (Fusi, 1991.8) Therefore, at the premise of meeting the requirements, on the one hand pay attention to constantly expand the effectiveness of public works. On the other hand, it must be attention to constantly reduce costs. This requires that the designer should not only make the control system simple, economic, but also to make the control system convenient to use and maintain, low cost, not pursuit of automation and high targets blindly.

D) Meet the needs of development

Due to the continuous development of technology, control systems will also not stop to improve. When designing control system, the future development and improvement of the control system must be considered by the designers. This requires when selecting PLC input / output modules, I/O

point numbers and memory capacity, with leaving appropriate space to meet future production development and process improvement. (Fusi, 1991.8)

4.2.2 Programmable logic controller model options

In order to complete the tasks, based mainly on the lift control input / output points and the amount of memory to determine the PLC model. This system is a four-story lift, set select control mode. Required input / output points are estimated:
PLC constitutes a four-level simple electrical control system. Drag the lift up and down by an electric motor, when electric motors are transferred clockwise, the lift rise, reverse decline. It can be shown in Figure 7.

1. A call up button K1 and indicator light H1 are in the first floor.
2. The second floor has the call up button K2 and indicator H2 and call down button K4 and led H4.
3. In the third floor, there are call up button K3, led H3, call down button K5 and indicator H5.
4. The fourth floor has call down button K6 and indicator H6.
5. A four-layer switch SQ1~SQ4.
6. Inside the lift, there are four-story call button K10~K7 and indicator H10~H7; open button SB5 and close button SB6 can control the lift open or close by magnet KM3 and KM4.

Ascend and descend the car is by a contractor KM1 and KM2, upward and downward memory and two LED, and control the frequency of converter output signal.
There are 20 input points, 17 output points. Input / output points for S7-200 CPU226 are 24/16. (Chaoying, 1998.5)

4.2.3 Input / output points distribution

The design of the PLC external wiring diagram shown is in Figure 7. CPU226CN sensor supply 24V (DC) can output 600 mA current accounts in this design, PLC capacity is to meet the requirements, CPU226CN output relay contact capacity 2 A, the voltage is in the range of 5 ~ 30 V (DC) or 5 ~ 250 V (AC).

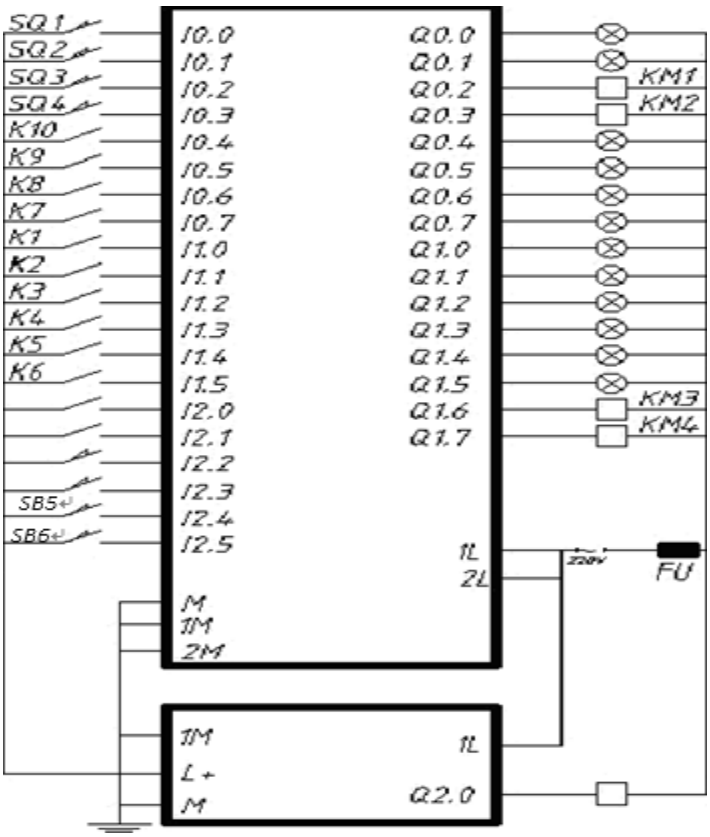

Figure 7: PLC external wiring diagram (PLC control system, 2007)

4.3 Converter options

With the decline of converter price, AC frequency control converter has been applied to many areas. Because of the many advantages of frequency, AC frequency control of lift industry is also widely used. Currently the special converter design for lift control is good functionality and flexible operation, but the price is relatively expensive. Therefore, this design does not use special converter, but uses a common converter. With proper configuration, design, and programming, you can achieve the same effect of converter control. This is one of the features of this design.
At present, there is a wide variety of general purpose converter and converter brands are also used in the lift industry. The structure of its control systems are not the same, but its overall control is pretty much the same. (Minxun, 1998.5)

4.3.1 General converter overview

In the early 1980s, general converter achieved commercialization. In the last 20 years, a change from analog to digital control by using BJT and IGBT have been the two large development processes.

i. Capacity expansion

In the early 1980s, BJT and PWM converter were generalized. In the early 90s, the BJT converter capacity reached 600 KVA, 400 KVA and below these two capacity has been serialized. Most of the

switches, a few years ago, began to adopt IGBT. Only three or four years passed, when IGBT converter capacity has reached 1800 KVA (Zhengkang, China machine press). IGBT capacity expansion of the inventor's capacity will be expanded.

ii. The miniaturization of structures

Modular main circuit power circuit in inverter, control circuit using large-scale integrated circuit (LSI) and digital control technology, structural design using "flat installation technology" and a series of measures, promoted the miniaturization of variable frequency power supply unit. Additionally, a mixed type power integrated devices used thick film mixed integrated technology, and put power bridge, drive circuit, detection circuit and protection circuit together, making up an " Intelligent Module". This device has insulation, metal basement structure, so anti-electromagnetic interference capacity is strong. Protective circuit and distance of a detection circuit and the power switch is small. Because of rapid and reliable protection, the signal transfer is very fast. (Zhengkang, China machine press)

iii. Functionalist and intelligent

With a big progress of power electronics and control technology, high performance and multifunction of Inverse is the direction. Especially computer applications for Converter functionalist and high performance are to provide a reliable guarantee. People have had a large number of practical experience about an AC electric drive control, and integrated software functionality. Increasing software functionality of general purpose Inverse functional and high performance is to provide a chance to "upgraded" original production machinery and techniques to which were unattainable in the past, giving them a highly new model of software control. (Zhengkang, China machine press)

There is a kind of "control" universal converter. Such as the design of the Yaskawa VS-616G5 Inverse is: it has 1) no PG (speed sensor) V/f control; 2) PG v/f control; 3) free PG vector control and 4) PG four kinds of control methods such as vector control. Through the Control Panel, you can control one of the above four kinds of control methods, in order to meet the needs of users. (company)

iv. Applications continue to expand

General purpose Inverse is through analog control, digital control, digital and analog hybrid control, until the evolution of the digital control, the converter reached realization of multi-function and high performance, and made them suitable for all kinds of production machinery, all types of growing adaptability of the production process. First, general Inverse is used only for fan, energy-saving of pump load and high speed winding machines coordinated operation in chemical fiber industry, and so far, its application has been extended to the following:
1) Handling machinery, from resistant load carrying vehicles, from conveyor belt to crane, hoist, and warehouse, parking

2) Metal processing machinery, until high speed grinder from all kinds of cutting machine tools and CNC machine tool,
In other areas, it can be said that its scope of application is wide and will also continue to expand. Such as agricultural machinery, food machinery, woodworking machinery, printing machinery, all types of air conditioning, all kinds of household appliances and even the street fountains. (Zhengkang, China machine press)

4.3.2 Inverse power output-driven technology trend

There has been the remarkable progress in using variable-frequency drive technology about the inverter in recent years. From the trend of technical developments, the following aspects must be mentioned:

A. IGBT applications

In recent years, IGBT has been advancing rapidly. Its notable features are high frequency of switching, simple drive circuit. When used in General Inverse, the following significant results appear:

1) The improved efficiency of carrier wave (20 KHz or higher), significantly reduce the noise of load motor and it achieves low-noise-operation. The metallic ringing sound of the motor is due to vibrations which the human ear cannot perceive and they "disappear". (Zhou Yajun, 2008)

2) Also, because of the improved carrier wave's frequency, the motor currents (especially low speed of the current) tend to be more waveform sine, thus reducing motor torque ripple and motor loss.

3) Because of IGBT is voltage-driven, thus simplifying the driving loop, so the entire unit is more compact, has higher reliability and lower costs.

4) If IPM is the main switch, the effect of the above changes will be more noticeable.

B. Grid side converter PWM control inverter

The vast majority of general-purpose inverters in the current market, grid side converter is using an uncontrolled diode rectifier. Although general-purpose inverters are simple and low costs, it also has its defects. For example, the line current waveform has serious distortion, the impact of the grid power factor, harmonic loss, and regenerative motor braking energy back to the grid and so on.

Now a new type of PWM control mode of self-commutated converter has been developed, and it has been successfully used in the converter network side converter. Electric formal structure and the inverter are identical, each arm by a self-turn-off device and one diode anti-parallel components. Its

characteristics are: DC output voltage is continuously adjustable, the input current (line current) waveform is substantially sinusoidal, the power factor can be maintained as l, and the energy flows in two directions. (Zhou Yajun, 2008)

Grid-side converter PWM control converter is also known as "dual PWM inverter control." This regenerative energy feedback, high-performance general-purpose inverter, represents another new technology trend. Its large capacity for frequent braking or production equipment reversible running is very meaningful. But its high price, high investment, in some way limits its rate of development.

C. General vector control inverter

In the paper, steel rolling and other applications requiring high accuracy, fast response, the general universal inverter is not competent. It often uses the vector control program. But vector control often requires speed sensors, computational complexity, adjustment problems, and the larger of the motor-dependent parameters.

At present, China is working to achieve universal vector control inverter. Thus, the theoretical study of speed senseless vector control system and the practical development represents another new direction of technological development. (Zhou Yajun, 2008)

In addition to the requirements of the elevator speed static and dynamic performance of the general industrial control outside its comfort index is often an important element in the selection. The design of key drags the speed control system is to ensure that the elevator according to the ideal given speed curve operation to improve comfort elevator operation. As the elevator in the building's electricity consumption accounted for a considerable proportion of the total electricity consumption of the building, therefore, we should pay more attention to saving energy. These various factors are considered in the design, Yaskawa VS-616G5 full digital converter. It has a flux vector control, slip compensation, adaptive load torque and a series of advanced features. You can maximize the power factor and motor efficiency, while reducing the motor loss, especially for frequent changes in class load elevator occasions. (limited)

With the other, 616G5 inverter, braking can be adjusted with an S curve and zero frequency is still 150% of the output torque characteristics. With a high precision rotary encoder, control accuracy is up to 0.01-0.02%, making the elevator comfort good sense, zero speed brake and high precision leveling. There is no need for special motor, self-learning with the motor parameters or precise control of any brand of motor. High-performance IGBT has the carrier frequency 20 KHZ, so that the inverter outputs an undistorted sine wave, and the motor is always running in silent mode. (Zhou Yajun, 2008) (Changchu)

4.3.3 VS-616G5 Introduction of inverter

VS-616G5 Inverter is Yaskawa motor company for the world launch of the 21th century universal converter. This converter takes into account not only the v/f control and realization of vector control, through its own Auto-Tuning feature sensorless current vector control. It is easy to get a high starting torque and high speed ranges. VS-616G5 frequency converter's features are as follows:

1) Four kinds of control methods, including the current vector control realize standardization.

2) As a result of the latest hardware, therefore, full function, small size.

3) Perfect protection function, easy maintenance.

4) By LCD operation device, it can improve performance. (company)

4.4 Frequency converter parameter settings

By using PLC logic control unit, inverter and PLC communication using switches instead of analog.

Parameter setting principle is this:

(1) To decrease the launch impact and increase the speed of comfort, its speed ratio should be smaller, and integral time constant should be larger

(2) In order to improve operating efficiency, fast frequency should be selected as the frequency and crawl frequency to be as low as possible to reduce the parking impacts

(3) Generally, zero speed is set to 0HZ

(4) Other common parameters are according to the voltage of the inverter and the motor nameplate data directly. (limited)

▪

5 SOFTWARE DESIGN

PLC software design is the process for creating a unique software for the system and it may make the operation easier.

5.1 The PLC programming language

PLC program is an ordered set of instructions; running the PLC program, according to a certain order in which a collection of PLC instruction is indicating the operation by the character code or graphic symbols. Using the programming language, these character codes and symbols are not the same. But in essence, the instruction is a binary machine code. As with an ordinary computer, PLC programming software system, by compiling the PLC program, is compiled into machine code.

PLC provides a complete functional programming language to suit PLC applications in industrial environments. Using PLC programming language to compile the program according to different control requirements, different control program, which is equivalent to design and change the hardware wiring which is controlled by the relays.

PLC programming languages generally have five categories: Sequential Function Chart, Ladder Diagram, Function Block Diagram, Instruction List and structured text. Among them, Sequential Function Chart (SFC), Ladder Diagram (LD), Function Block Diagram (FBD) is a graphical programming language, Instruction List (IL) and structured text (ST) is the language of the text. (Five Types of PLC Language, 2005) Ladder Diagram (LD) is currently the most widely used PLC graphical programming languages, a circuit diagram of the ladder and relay control system are similar to the relatively easy to grasp, articulate program.

The PLC program is compiled by the ladder language, and the programming software is STEP 7. The software owns a series of functions include completing the production processes, reading / writing the programmable controller CPU, monitoring program runs, the debugger, diagnosing the errors of the PLC system. (Yan, 2010)

5.2 STEP 7 Overview

STEP 7 is the standard software package for the SIMATIC programmable logic controller configuration and programming. It is part of the SIMATIC industry software.

The following versions of the STEP 7 Standard package are available: Step 7 Basic, Step 7 Professional, Step 7 Lite, Step 7 Micro, and Step 7 -200/300/1200. (SIMATIC STEP 7: the comprehensive engineering system, 1999)

The STEP7 programming software allows structured user program. The program can be broken down into a single self-contained part of the program, so that a large-scale program is easier to un-

derstand. The individual parts of the program can be simplified, standardized program organized, easier to modify. System debugging is also a lot easier. In the user program are several different types of blocks you can use:

Organization blocks (OB) are the interface between the operating system and user programs, which are called by the operating system and how the control loop and interrupt-driven program execution, and a programmable controller starts. They also handle the response to errors tissue, determine the order of execution of each part of the program for the highest priority program processing cycle organization where block OB1 is. Operating System Cycle calls OB1, and starts execution of the user program cycle with this call. (Organization Blocks and Program Structure, 2001)

Function (FC) is the user-programmed function blocks. Temporary variable "no memory" of FC logical blocks is stored in the local data stack. When FC is after the execution, the data is lost. (Zhengkang, China machine press)

The function block (FB) is the user-programmed function blocks. Blocks are a "storage" block as a memory (instance data block), and transfer some parameters about FB to background data block function block, background data block (instance DB) must allocate a block to this call for passing parameters. (Introduction about FB, 2002)

System function blocks (SFB) and system functions (SFC) is a block STEP7 provides users with a good program that has been programmed, tested, integrated in the CPU SFB function library as part of the operating system. It does not occupy space program, it is a block storage capacity, it requires a background data block, and this block shall be installed as part of the program to the CPU. (Zhengkang, China machine press)

5.3 Programming methods

In engineering, there are many ways to design a PLC application. It can be done by using these methods, but also because each designer's skill level and preferences are quite different. Now commonly used design methods of several applications are briefly described as follows:

(1) Experience Design

The empirical design method is also called trial and error method. In a typical master some aspects of control and circuit design, based on the controlled object according to the specific requirements of the control system, are empirically selected and combined. (Experience Design: When Innovation Isn’t Enough, 2006) This method is designed for the simple control system and you can receive a quick, simple effects. Specific steps of the design are as follows:

1) Determine the input / output appliances;
2) Determine the number of input and output points, select PLC model, the I / O assignment;

3) To make the system operational flowchart;
4) Select the PLC instruction and programming;
5) The preparation of other control procedures required;
6) All aspects of a program are written in reasonably linked to obtain a program to meet the control requirements.

Figure 8: Real Structural of PLC SYSTEMS (PLC systems, 2013)

(2) Logic Design

For industrial electrical control circuit, there are many relays and other electrical components to achieve. The relay of AC contactor contacts has only two states, namely: open and closed, hence the algebra of logic design of electrical control circuit "0" and "1", two values are entirely possible. The method is designed for PLC program, according to digital electronics, logic design method, which uses logical expressions describing the problem. After obtaining the logical expression, based on a logical expression the ladder diagram is drawn. (Logic Design L)

(3) Sequence control method

Those systems that are controlled by the sequence of operation, it is ideal to use sequential programming control design method. Sequence control method is based on strong regularity, although programming is quite long, but the program structure is clear, readable. When using sequential control programming, the design method, a functional diagram is a very important tool. Function diagram can be clearly a conversion sequence and the transition conditions of the working demonstration system step function, the step (s). (A model matching design method for sequence control systems, 1991)

Figure 9: PLC Operation flowchart (PLC components, 2008)

5.4 PLC compared with other control systems

1. PLC and relay control system

A traditional relay control system for certain production machinery, fixed production process is designed, hard-wiring installation is made only to perform a given logic control, timing and counting functions, i.e. only volume control switch, once you change the production process, a relay control system must be re-wiring, and therefore poor adaptability, and bulky, installation and maintenance are not convenient. Since the PLC application of microelectronics and computer technology, a variety of control functions are implemented by software, as long as changing the program, the production process can be adapted to changing requirements, so adaptable. (The Difference Between PLC And Relay Logic, 2008)

2. PLC compared with SCM control system

SCM control system applies only to simple automation projects. Hardware mainly includes limited CPU, memory and IO interface; the software is mainly limited by the CPU and the type of programming language. PLC is the core of a modern single-chip microprocessor. Although the use of the microcontroller, as a hardware development and software development process control member, has a advantage of low cost, but after all, from the microcontroller to between industrial control devices. While the PLC is also essential to the software development process, but the language used in a large difference between the two, the main microcontroller in assembly language development software, the language used is complex and error-prone, with long development cycle. With a dedicated instruction PLC programming system is easy to learn, you can develop and debug the scene. Then the microcontroller, PLC input and output are closer to field devices, without adding too much of the middle part, which saves the user time and the total investment. Generally, microcontroller or MCU application system is only for a specific goods and services. Compared with the PLC, the con-

trol system is versatility, compatibility and scalability are quite poor. (SCM compared with the PLC, 2008)

3. PLC and computer control system

The PLC is designed for industrial control design, and a microcomputer for scientific computing, data processing and design. Although both technically have adopted computer technology, but due to the use of different objects and environments, PLC microcomputer system is better than other control systems for industrial control, anti-interference ability to adapt the project site temperature and humidity environment. In addition, PLC for industrial control uses a dedicated programming language, easy to modify, and it has a better monitoring. The computer system will not have the above characteristics. The general operating environment is demanding high-level language programming, and it requires users to have considerable knowledge of computer hardware and software levels. People in the application of PLC do not have specialized training in computers that can be operated and programmed. (PC-Based Controls vs. PLC-Based Controls for Machine Automation, 2010)

4. PLC compares with the traditional Distributed Control System

PLC evolved by relay logic control system. The traditional distributed control system DCS (Distributed control system) was developed by the instruments in the loop control system that distributed control system, which handles the analog loop to adjust and so have certain advantages. With the development of microelectronics technology, computer technology and communication technology, in terms of functionality, speed, intelligent modules on communication and networking, has greatly improved, and starts with a small computer into a network, in order to constitute a PLC for distributed control systems important components. With the growing network of communication, the Internet and computer PLC and PLC, they can form large-scale control systems. Various types of DCS is also now facing the threat of the high-end PLC. Due to the continuous development of technology PLC, DCS's unique past, some complex control functions now all have substantially PLC and PLC with a simple operation advantages. The most important point is that the price of PLC and DCS systems cost is unmatched. (Yan, 2010) (Comparison of Control System Using PLC & PID, 2009)

6 LIFT MARKET ANALYSIS IN CHINA

Due to large-scale economic construction, especially the booming industry to develop a broader market, the numbers of lifts produced reached 45000 units in China in 2001. By the end of 2009, the number in the lift has reached more than 100 100. This created a new peak in the history of lift industry and is referred to as the "third reform" in the industry. At present, China's economic development needs all kinds of lift, almost all can be produced in China. Thus, a thriving lift market has formed in China. In the 1980, with the sustained and rapid development of economy, Chinese lift demand is bigger and bigger. According to statistics, in the world an average of 1000 people has one lift. If we want to achieve this standard in China, we need 800 000 lifts more. In 1980, just to update, it is required 60 000 units once a year. The momentum of housing construction is still keep-

ing grow, the lift market supply and demand keep a balance and potentiality is huge. (Minxun, 1998.5)

6.1 Lift uses situation in the world

By the end of 2007, the world has a total of about 9.17 million lifts (among them 8.73 million sets of vertical lift). In vertical lift, Europe accounted for 49%, America accounted for 18%, Japan and South Korea accounted for 11%, China accounted for 9%, India accounted for 5% and the other countries accounted for 8%. In using escalators, Europe accounted for 23%, America accounted for 16%, Japan and South Korea accounted for 23%, China accounted for 28% and the other countries accounted for 10%. (Association, The situation of development about lift in the world, 2010.)

For new global trend about installation of vertical lift in 2007, Europe accounted for 21%, America accounted for 8%, Japan and South Korea accounted for11%, China accounted for 40% and the other countries accounted for 20%. For the newly installed escalators, Europe accounted for 23%, America accounted for 16%, Japan and South Korea accounted for 23%, China accounted for 28% and the other countries accounted for 10%. Besides China, several countries have important roles in the global new lift installation market have: they are Russia, India, Turkey, Brazil, Argentina, the United Arab Emirates, Saudi Arabia, Iran, etc. (Association, The situation of development about lift in the world, 2010.)

6.2 Challenges of Chinese lifts

A) Enterprises lack of competitiveness

For some lift enterprises, especially for private lift enterprises management is not standard, technical level is low, there is a lack of professional and technical personnel and management personnel. They spent money to expand production, but they are not willing to spend money to hire professional and technical personnel. So they use the OEM business way, but their lift quality and after-sales service are not good for their customers. (The trend of chinese lift, 2010)

B) Unreasonable competition in the market

Because some lift enterprises do not observe the lift industry competition rules, take improper ways, such as maliciously reducing price and making the market price chaotic, the result is declining lift quality and it is difficult to ensure the after-sales service. (The trend of chinese lift, 2010) According to some data, currently, some areas have a poor quality lift called "assembled lift" in China. In result, people always could find some accidents about lift by newspapers or TV news in China. In recent years, the Chinese government has taken measures to supervise the lift manufactures. The government formulated rules control the lift quality and management and intensified the efforts on the supervision and management. Accidents decreased a lot, but the problems still exist. (Chaoying, 1998.5)

C) Maintenance market is not standard

Currently, China has more than 650 000 lifts. In 2015, China produced 135 000 lifts. The lifts will increase more than 100 000 every year. According to the speed of development, and lift saturation is about 1.3 million in China, the lift market still has 6 to 7 years of growth. Due to the number of lifts increased, the huge demand brings hot markets. At the same time, it gives opportunities to the lift maintenance companies. (The trend of chinese lift, 2010) Many of maintenance enterprises are private companies. Most of them have a nonstandard management and lack professional and technical personnel, or have other problems. In order to survive and develop, they always use lower price to make up maintenance market. On the other hand, maintenance personnel is uneven, some staff without training, and they have no ideals to ensure the equipment safety. Their technology is not well and it is difficult to maintain the designated position. The lift failures can't be solved well. In addition, some lift component manufacturers produce are nonstandard. Counterfeit and poor lift accessories are also the reason for the bad lift safety.

D) Safety of Lifts

At present, lifts as special equipments are very common, so they all use safety components. The products must be designated agencies state audit certification including all components of the lift. The lift safety system is yearly checked and the daily maintenance is necessary. If all users know that the normal lift knowledge, when some situation happens, it cannot cause too much panic, and take timely correct protective measures, and it also could avoid or reduce the damage in the accident. (Chaoying, 1998.5) (The trend of chinese lift, 2010)

6.3 SWOT analysis for the market of the lift in China

1. Strengths

With development of the rapid Chinese economy and the process of urbanization, Chinese lift industries has experienced a period of rapid development. At present, Chinese lift output and growth rates are the most in the world. There is the most population in the world and keep a balance of growth rates in China. Chinese GDP is the second most country in the world now, and after 10 years later, Chinese GDP will exceed the USA's GDP. Chinese demands of the lift will keep a continued growth in the next 10 years.

2. Weaknesses

All kinds of lift companies came into Chinese market, every company wants to occupy the Chinese market of lift, and it must bring fierce competitions. Big companies depend on their advanced technology and management can defeat small companies easily. If small companies want to survive in the market, they have to use "unusual ways" to attain the market of the lift. Such as confusing the price of the lift and reducing manufacturing costs and so on.

3. Opportunities

With the rapid development of Chinese second-tier cities, and continuously push forward the process of urbanization. The most of Chinese will leave their village and go to cities to live. More city populations need more houses. Due to the shortage of urban lands, the house will be higher and higher. At the same time, the quantities of the lift will be more and more. At the next years, Chinese government will increase the investment to affordable houses to poor persons. Therefore, Chinese will still have the biggest market of the lift for a long time and there still has a great potential.

4. Threats

The most of Chinese lack the consciousness of safety. Persons usually know that some accidents of the lift happened by newspapers. Last year, accidents of the lift took total 37 lives away in China. The financial crisis affects every industry including the lift industry. Lots of companies have to go bankrupt and lots of their employees lost their jobs.

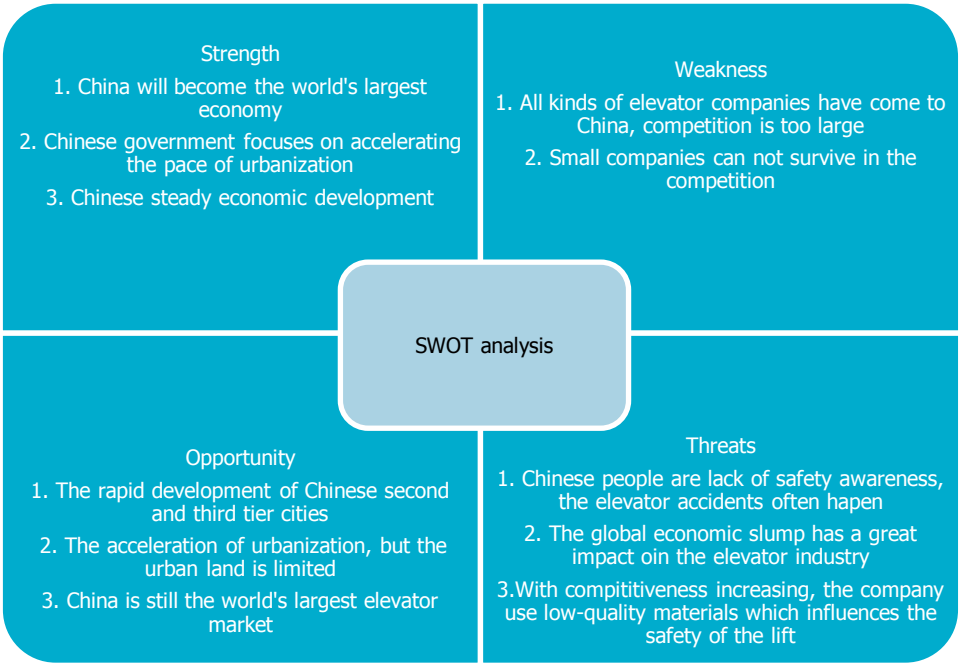

Figure 10: SWOT analysis for Chinese lift market (The trend of chinese lift, 2010)

7 LIFT DEVELOPMENT TRENDS

In the face of an increasingly severe market environment, each enterprise first considers how to survive. To survive it is necessary to enhance the competitiveness of enterprises. There are factors that can change the rules of competition. Technological change belongs to one of the most significant ones. How to maintain its leading position in the lift technology and to keep the enterprise's competitive advantage? Enterprise managers must first have clear knowledge of lift technology development, and formulate the lift technology development strategy, before they can make the enterprise not only to survive but also develop. (Analysis report about chinese lift from 2010 to 2015, 2010)

7.1 Environmental protection

In today's world the existence and development of relations has been clearly realized: no environmental protection no life. The green concept has been deeply rooted in the hearts of the people in the whole world. The green concept is always the lift development trend. The experts have predicted that who is the first to launch green products, then they can grasp the market competitive initiative. The development trend is mainly as follows: improving the design of the product, making the production of non-pollution, having low energy consumption and low noise, no leakage, no electromagnetic interference, no oil pollutionof the guide rail. Lift decoration will use no (little) environment pollution materials. The motor of the lift will use the renewable power generation technology. Lift parts have no impact on the environment in the process of the production and use. For example, brakes must not use the asbestos, and materials can be recycled. (Association, 2010-2015 China lift market analysis report, 2010)

7.2 The lift information and networking

How the lift control system is combined with the network technology will be the future trend of lift design mainstream. In the 21st century, how to provide customer satisfaction of products and services has become related to the enterprise survival. To link the Internet in lift is to provide customers with a higher-quality service. In order to survive and develop in the future, the lift manufactures will need to build a connection between the public network systems and the lift website (lift platform). The lifts link the Internet is order to realize the following functions:

A) Using the Internet to put all the lift regulation there, to ensure the safe operation of the lift and the safety of passengers. When the lift fails, the lift sends a signal to the customer service center through the network to make the maintenance personnel have timely and accurate knowledge of lift failure causes and relevant information. In the first time, the maintenance personnel went to scene to repair the lift. At the same time, personnel could use networking comfort passengers who were trapped in the lift. Maintenance personnel can also use the lift network to scan each lift component to find potential problems, it can reduce the risk of the lift accidents. (Networiking makes the system smarter, 2012)

B) The lift online transaction. Nowadays, traditional marketing system is P2P (personal to personal selling). Traditional marketing systems have to pay a lot of money for personnel salary. If use the lift online transaction, it can effectively reduce the cost of sales. Enterprises can show the lift characteristics of products, functions, shapes and sizes online. Businesses could produce lift according to the customer's requests. If the user needs, he can also get the quotation immediately. There is a contract for the purchase and sale on the Internet, through the payment of the online bank, it is easy to complete the purchase and sale. Of course, customers can also download some useful informations about the situation of product through the Internet. In conclusion, it is easy for your picking out and buyingon the Internet. (Association, 2010-2015 China lift market analysis report, 2010) (Tao, 2010)

7.3 Bluetooth technology applied in the lift

The personnel who installed lifts know that some works are easy to make mistakes. Such as radiate, laborious work and so on. If the control panel and connect in via Bluetooth technology are to realize the wireless call system, the call is going to be another revolution in the lift control at the same time bring to the customer great benefits.

A) The installation period will be reduced by more than 30%. Its direct benefit is to reduce installation costs. (The design of lift control system, 2010)

B) The lift use Bluetooth technology to control its system which will further improve the lift machine reliability. The failure rate is reduced, and it further improves the control precision. At the same time, the lift will be more comfortable, more accurate flat layer. In other hand, it is also possible to check the state of the lift through the network. In the future, especially the lift maintenance in advance can be done better and more comprehensively, and it can further accelerate the speed of the lift. (The design of lift control system, 2010)

C) As you known that old lifts are easier to reformed, it will reduce the time and money. According to the statistics, there are 50,000 old lifts in the retrofit market every year. Using the Bluetooth technology it will have a huge social benefit and enterprise benefit.
Solving the compatibility problems between the lift system and equipments. (The design of lift control system, 2010)

7.4 Cost performance

With the rapid development of lift technology, we realized that Chinese per capital income is low, so persons are particularly sensitive to the price, in this condition, market urgently needs a simple, reliable, affordable lift. In the future, this kind of lifts will take up aggregate demand by more than half in China. Such a lift is characterized by meeting the minimum requirements for customers, but the

price is very low, and it has low failure rate, high reliability, durability and easy to use. (Association, 2010-2015 China lift market analysis report, 2010)

7.5 The lift traction machine drive technology for energy saving

The first: AC asynchronous motor with gear retarder driving

The traditional way of traction is better than old traction machine in energy saving, but the traction machine also has many disadvantages. For example, it needs big volume, quality is heavy, high energy consumption and low efficiency (0.55 0.65) and the retarder requires a lot of lubricating oil, it is easy to cause pollution. (What's the Difference Between AC Induction, Permanent Magnet, and Servomotor Technologies?, 2008)

The second: AC asynchronous motor without gear retarder driving

This drive way is better than the first one because it doesn't need retarder, thus it improves the efficiency, reduces lubricating oil and avoids the serious pollution. (What's the Difference Between AC Induction, Permanent Magnet, and Servomotor Technologies?, 2008)

The third: Permanent magnet asynchronous motor with gear retarder driving

Because the permanent magnet motor uses the permanent magnet as fixed pole, so it is different with asynchronous motor. Thus, it can reduce grinding loss of the iron and copper, the COSφ has also improved. It enhances the efficiency and energy saving more than the asynchronous motor but it still needs to use lubricated oil and affects the environment. (Chaoying, 1998.5) (What's the Difference Between AC Induction, Permanent Magnet, and Servomotor Technologies?, 2008)

The fourth: PM traction machine

The PM traction machine is the most advanced traction machine at present. It covers the advantages of permanent magnet synchronous motor and doesn't need the lubrication. PM traction machine's operation performance is greatly improved, it belongs products including energy saving and environmental protection. In other hand, it can save about 30% energy than the AC asynchronous traction machine. Thus, it has won the popularity of the industry and customers. (Chaoying, 1998.5)

7.6 New elevator technology in the future

With the development of science and technology, energy conservation and environmental protection are more and more important. It is better than that of the current energy saving technology of the lift.

1. Using more intelligent elevator group control scheduling system, precise control to reduce the waiting time, elevator nearby dock can reduce the elevator running, it can improve the efficiency of transportation. (Analysis report about chinese lift from 2010 to 2015, 2010)

2. Solar energy (wind energy, geothermal) driven elevator

Solar could provide energy to keep the operation of elevators. Solar is one of the clean energy so that could protect the environment and this technology has already been into the laboratory. It is supposed to reach further to improve the photoelectric conversion efficiency of solar panels. (Tao, 2010)

8 CONCLUSION

Lift, as the common tool, is widely used in the world now. In another word, it is very important in our lives. So we choose lift as our thesis topic. After that, we begin to search the details about the lift, and we know some components about the lift, such as car, hoist way, counterweight frame, etc. And there are many kinds of lifts for different uses, for example, passenger lift, hospital lift, freight lift and so on.

From the research about the history of Chinese lift, we know that Chinese companies have produced more than 610,000 lifts, and with the economic development, Chinese market need more and more lifts, it is a big market demand. With increasing number of the demand, it is very easy to improve the technology of the lifts. Currently, PLC control system has become the mainstream of the lifts, it owns high operational reliability, easy maintenance, strong anti-interference design and debugging cycle is short.

Then we do some researches about PLC control system, to design the system, we must select some hardware firstly, next, we could begin to design the software about PLC control system. And we know something about the PLC programming language and STEP 7 can be used to design the software.

The lift market is also a important part of the thesis, so we choose Chinese market as our main market to do some researches. And we compare Chinese market with others, we find some challenges about Chinese lifts.

In addition, we also want to know the future of the lift, which kinds of technology can be used in the lift, and how convenient it is. And maybe we can get some new things to save energy, which is the same as saving money.

In conclusion, we expect the future of the lift, and we want we can see some technologies which have been mentioned above. And it must make our lives more convenient.

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APPENDIX

Table 11: GB/T10058-1997. (Fusi, 1991.8)

lift type	Rated speed (m/s)	Leveling accuracy (m/s)
AC dual-speed lift	0.25 Or 0.5 km	≤±15
	0.75 Or 1.0	≤±30
AC-DC fast lift	1.5 —2.0	≤±15
AC-DC high speed lift	≥2.0	≤±5

Table 12: Inverter specifications (company)

Voltage		200 V	400 V
Capacity range		1.2 —10 KVA	1.4-460 KVA
	Voltage and frequency	200 V : Three-phase 200/208/220 V	
		400 V : Three-phase 380/400/415/440/460 V	
Electricity	Admissible voltage changes	+10% —15%	
Source	Frequency allows changes	±5%	
	Control mode	Sine wave PWM control: sensorless vector control (no PG) sensorless vector control (PG) V/f control with sensors and v/f control (switch parameter)	
Control characteristics	Starting torque	150%/1 HZ (no PG) 150%/0 r/min (PG)	
	Speed control range	1 :100(no PG) 1:1000(PG)	
	Speed control accuracy	±0.2%(no PG) 0.02%(PG)	
	Speed of response	5 HZ (no PG) 30 HZ (PG)	

	Torque limiting		Have
	Torque accuracy		±5%
	Torque response		20 HZ (no PG) over 150 HZ (PG) more
	Frequency control range		0.1 —400 HZ
	Frequency accuracy		Digital instruction ±0.01%(-10 C-+40 C)
	(Temperature change)		Analog instruction ±0.1%(25 C-±10 C)
	Frequency setting resolution		Digital instruction 0.01 HZ/100 HZ
	(Operations resolution)		Analog instruction 0.03 HZ/160 HZ
	Output frequency resolution		0.01 HZ
	Overload		Rated output current 150 %/min
	Frequency setting signal		-10V-10V 0-10V 4-20mA
	Acceleration/deceleration time		0.01-6000.0 s
	Braking torque		About 20% with brake selection 150%
	Inhibition of high harmonic power	DC reactor	200 V 24 KVA 400 V 26 KVA option
		12 - Phase rectifier	Cannot change
	Main control functions		Instantaneous stop start, control, torque control, the zero-point servo control
Action settings			Liquid crystal display
Connect boards can choose			10 Species (up to available 3 blocks)

Protection function	Motor protection, inverter overload, instantaneous over-current, voltage, overvoltage input phase