World Scientific Research Journal Volume 5 Issue 11, 2019
ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

Design Intelligent Wheelchair of Triangle Wheel and Crawler Composite Touch Screen

Longqing Zhang[1,*], Xinwei Zhang[1], Yanghong Zhang[1], Zhongning Jia[1] and Yungui Chen[1]

[1]Guangdong University of Science and Technology, DongGuang, Guangdong, 523083, China

Abstract

Based on the fact that elevators are not installed in buildings below 7 floors in most areas of our country, and in order to solve the inconvenience of the disabled and the elderly and the frail, this system designs an intelligent control system based on ARM11 system and C52 single-chip computer, which combines triangular gear train mechanism with caterpillar mobile mechanism. Wheelchair. Emphasis is laid on solving the balance and climbing problems of climbing and climbing stairs, so that users can rely on Intelligent wheelchairs to climb stairs. After testing, the system runs well, has a good interactive interface and modification settings and other functional interfaces, and has a good balance, which can better achieve the purpose of intelligent stair climbing.

1. INTRODUCTION

Wheelchair is an indispensable tool for the disabled and the elderly and the infirm to go out, but in the process of urbanization construction in China [1], due to various reasons, most buildings below 7 floors have not installed elevators, while traditional wheelchairs do not have the function of climbing and obstacle-crossing, so it is very inconvenient to go upstairs and downstairs. With the development of robotic technology, a variety of new mobile robotic wheelchairs are emerging. For the new wheelchair, climbing and obstacle-surmounting ability are important indicators to measure its performance.

In the ranks of wheelchairs on stairs, there are already products on the market in China, but some of these products need human assistance to control balance, and passengers need to turn their backs to the stairs when they go up stairs. Among all kinds of research, Wu Xiaolong, Tan Zhong and others have studied a new type of intelligent wheelchair which can climb ladders. It solves the problem that pregnant women and mothers and infants in hospitals can not deal with themselves when there are no nurses around them. The Y-type planetary wheel is used as the walking component and driving system of the climbing wheelchair to construct the wheelchair structure, and its maximum climbing angle is about 15 degrees [2]. In this paper, a tripod and crawler compound structure is adopted. ARM11 and 89C52 microcontrollers and touch screen are used in intelligent control.

2. SYSTEM STRUCTURE DESIGN

The purpose of this paper is to design a wheelchair which can climb stairs on the front. The design idea is shown in Figure 1. The design idea is divided into two categories: hardware and software. The hardware mainly considers climbing and security. The software mainly divides into two directions: control and drive, and gradually refines and solves the problem.

The hardware design mainly considers climbing and security issues. In climbing, wheelchair front wheels use triangular wheels. When wheelchair encounters stairs or obstacles, it can provide an upward angle for wheelchair, and then send the push of rear wheelchair crawler wheels to make the wheelchair have enough strength to climb stairs and cross obstacles. In

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

safety, wheelchair uses horizontal measurement module and balance pole to provide balance guarantee for users. The horizontal measurement module is installed under the seat. When the inclination angle between the seat and the horizontal plane exceeds the set range, the C52 chip drives the balance pole through the LMD18200 driver chip, which makes the inclination angle between the seat and the horizontal plane return to the safe range.

Software design mainly refers to the user operating wheelchair by operating LCD touch screen. ARM11 chip summarizes and calculates the feedback data of each C52 module, and submits the obtained data to the touch screen display interface. Users can modify the data by touching screen and control the corresponding C52 module by ARM11, and finally achieve the operation purpose.

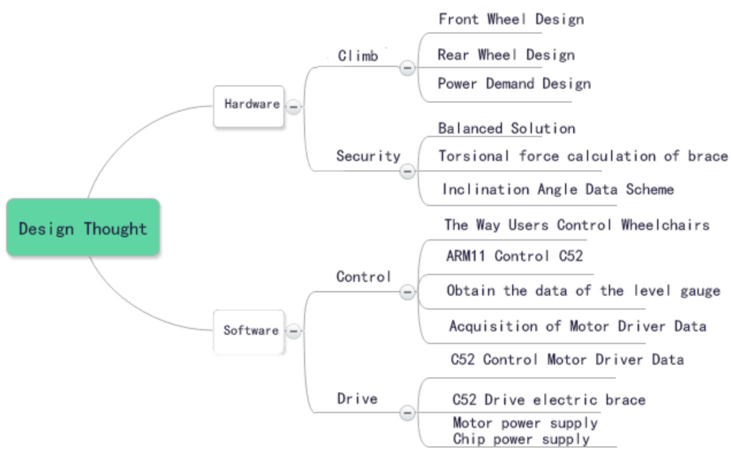

Figure 1. Brief description of design ideas

3. HARDWARE AND SOFTWARE DESIGN

The system is mainly composed of hardware and software, including the front wheelchair, rear wheelchair, wheelchair track, and the skeleton of wheelchair. The software design mainly includes the main controller ARM11, the slave controller C52 MCU and the C52 MCU, which mainly acquire the level measurement and control the driving motor, etc.

3.1. Hardware Design

Hardware design is a process of conceiving, analyzing and calculating the working principle, structure, movement mode, transmission mode of force and energy, material, shape and size of each part, lubrication method and so on, and transforming them into specific descriptions as the basis of manufacturing. The skeleton design of wheelchair is mainly designed by using Mastercam X6 software of CNC Software Inc.

3.1.1 Front Wheel Selection of Wheelchair

The triangle wheel mechanism used in the front wheel of wheelchair is light, flexible and efficient, and it can also achieve the function of climbing and obstacle surmounting. When the triangle wheel contacts the obstacle, the axis of the triangle wheel begins to rotate due to the reaction force of the obstacle, which makes the top triangle wheel climb up the obstacle [3]. The triangular mobile mechanism is used in the front wheel of wheelchair, which enables the wheelchair to climb stairs when it encounters stairs or obstacles, and provides an upward angle for the head of wheelchair.

3.1.2 Wheelchair Rear Wheel Design

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

The rear wheel of wheelchair adopts tracked mobile mechanism. As shown in Figure 3.2, the structure has strong grip and stable climbing force, which can provide the wheelchair with safe and stable climbing force when climbing stairs. Therefore, the design is based on the structure of Figure 1 to imitate.

The wheelchair's caterpillar wheel adopts synchronous belt. In order to keep the synchronous belt stable in use, it is necessary to keep the synchronous belt in the correct working position and ensure the occlusion of the corresponding teeth of the synchronous wheel. As shown in Figure 2, a single side baffle is added to the synchronous wheel at the bottom of the picture to keep the synchronous wheel in the correct working position. Synchronization wheels at the ground end do not add side shield to avoid unnecessary friction with the ground. Figure 3 is an adjustable design for adjusting the tightness of the synchronous belt. A in the yellow circle is the synchronous wheel, black is the supporting rod, and gray is the threaded rod. It is used to adjust the angle of the supporting rod.

Figure 2. Synchronization Wheel

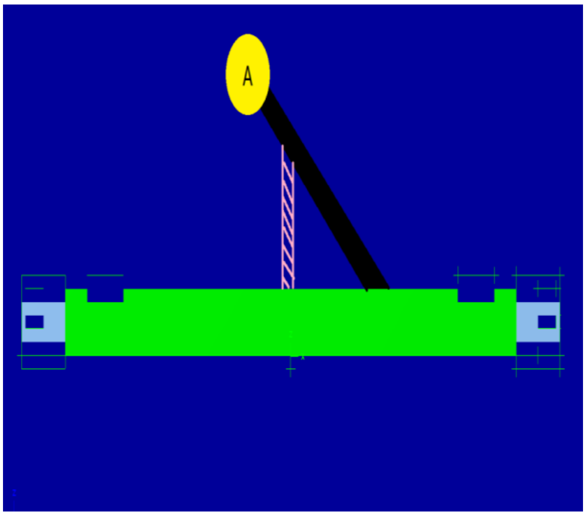

Figure 3. Synchronization Belt Tightening Adjustment Device

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

3.1.3 Power Design

To solve the problem of insufficient torque and motor power, this design adopts the mode of servo motor accelerator and decelerator. Assuming that the wheelchair weighs 100kg, the wheelchair can be designed with 100kg. Through calculation, the AC servo motor with 2600W power is selected to propel the wheelchair forward. The static friction force below 240kg can be overcome by decelerating and lifting the torque of a motor with a single power of 2600W.

The data of AC servo motor are as follows:

Motor Model: 130STM10025 Power: 2600W Torque: 10NM

Rated Speed: 2500RPM; Rated Voltage: 220V

According to the formula: power (kw) = torque (NM) * speed (r/min) / 9550

Moving speed (km/h) = rotating speed (r/min) * final radius of action (m) * 0.3768

Kg = N/9.8 N = Torque (NM)/Ultimate Action Radius (m)

The radius of the main drive wheel of the crawler wheel is 5 cm.

Obviously, with 1/12 planetary reducer, the torque can be increased to 2400N, which ensures that the motor can propel objects below 240kg.

3.1.4 Security Design

The wheelchair is balanced by balancing poles. When going up stairs, the wheelchair surface maintains a safe and stable angle in the first quadrant[5]. The angle between the pole and the chair surface is 60 degrees, which enables the wheelchair to maintain the inclination of the rear pole in the first quadrant when climbing stairs within 30 degrees.

The electric pole is placed cross-wise, which effectively reduces the volume of wheelchair, greatly reduces the staircase restriction for wheelchair to travel, and makes the rear pole and chair seat in 90 degree angle when wheelchair is supported. The lower end lock of the electric pole dies on the lower skeleton of the wheelchair. The fixed lower end and the upper end are divided into front and back ends. The front end adopts half-tooth screw, which enables the seat and the front end to change the angle freely. On the basis of the back end using half-tooth screw, a place for coordinating the change of the angle between the pole and the seat is excavated at the seat connection. The sliding groove that produces a change in distance [6]. The problem of the angle change between the seat and the support rod and the distance change between the front and back support rods when the support rod expands and contracts are solved.

3.2. Software Design

This system uses Tiny6410 of ARM11 series as the main control version, and controls the balance of wheelchair by STC89C52 slave control and SCA100T double inclination sensor. As shown in Figure 4, the user controls the ARM11 chip through touch screen operation, and the ARM11 chip transmits instructions to the C52 chip, and completes the corresponding motor control, monitoring control, balance control and so on. Corresponding to the left and right AC servo motor drivers, the corresponding C52 chip is used to control and collect the feedback information from the driver and feedback it to ARM11 chip; the wheelchair self-monitoring and the surrounding environment monitoring are all collected by a separate C52 chip and processed urgently according to the information; the wheelchair seat and the horizontal surface are presented. The C52 chip, which monitors the level measurement module separately, will drive the electric brace to adjust the seat.

3.2.1. Communication Design

By using the master-slave communication mode of RS485, as shown in Figure 5, the master-slave communication relationship between ARM11 chip and several C52 blocks is established, and the ARM11 chip is connected with the motor driver for special occasions.

ISSN: 2472-3703
DOI: 10.6911/WSRJ.201911_5(11).0023

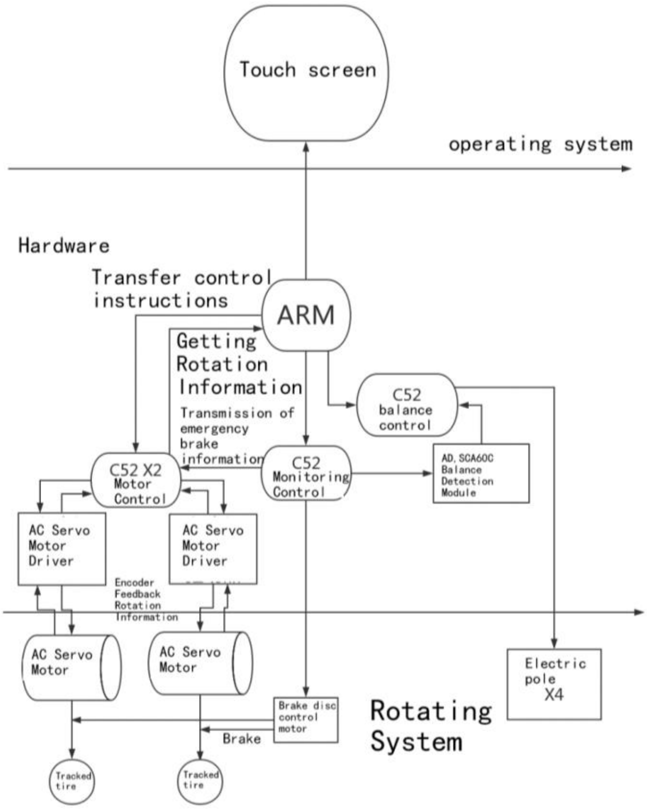

Figure 4. System Overview

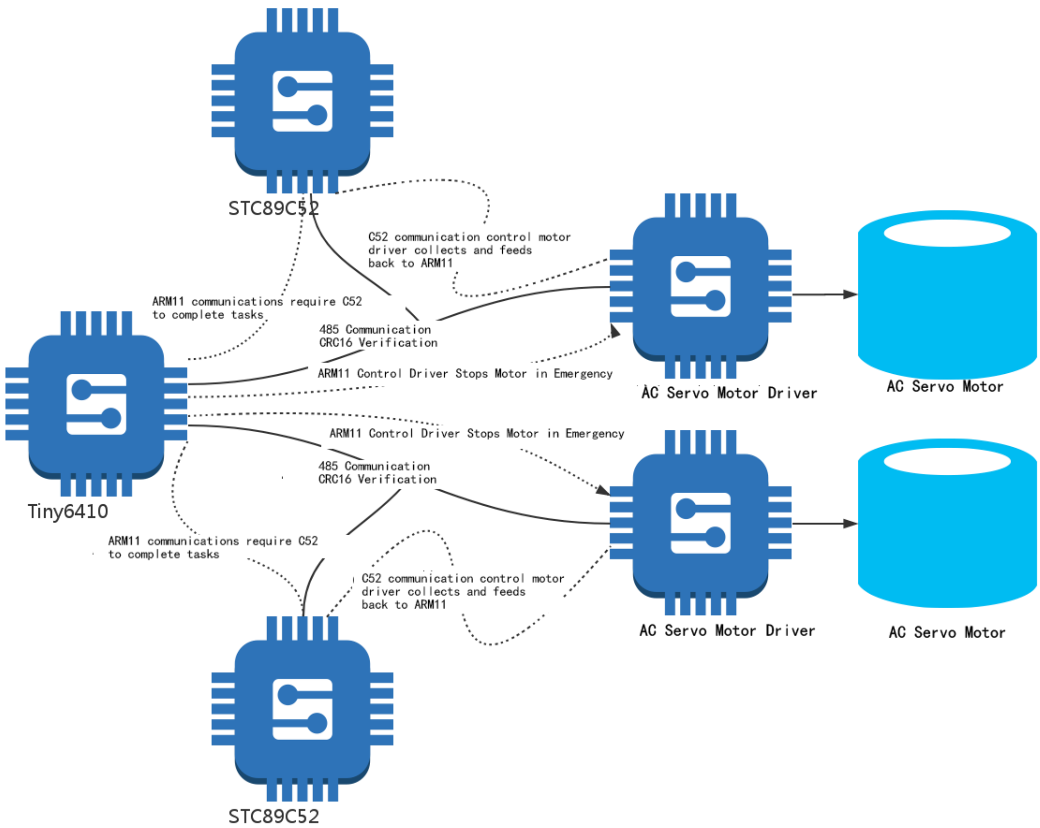

Figure 5. ARM11-C52-Motor Driver Control Chart

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

In order to ensure the correctness and integrity of data transmission, the system communicates with ARM11, STC89C52 and motor drivers through RS485. CRC16 is used to check the data and calculate the data polynomially. The result is attached to the frame. The receiving device performs a similar algorithm. The sending end calculates the value of CRC16 and transmits it to the receiving end for receiving. The end recalculates according to the receiving result to verify whether the transmission object and the transmission content are correct [7]. In order to improve the work efficiency in practical use, the calculation of CRC16 check code is validated by table lookup method.

3.2.2 ARM Control C52 Module

Users control wheelchairs through touch screen and issue operation commands to ARM11. According to user's instructions, ARM11 sends further instructions to corresponding STC89C52. The specific control flow is shown in Figure 6. After acquiring the information of the QT operation interface, ARM11 conveys operation commands such as balance, motor control, braking to corresponding C52. ARM11 continuously updates C52's instructions according to C52's feedback information, in order to further meet the requirements of user's operational commands. When users issue emergency braking orders, ARM11 directly sends braking instructions to the motor driver, which saves the process of passing C52 and ensures the timely braking instructions.

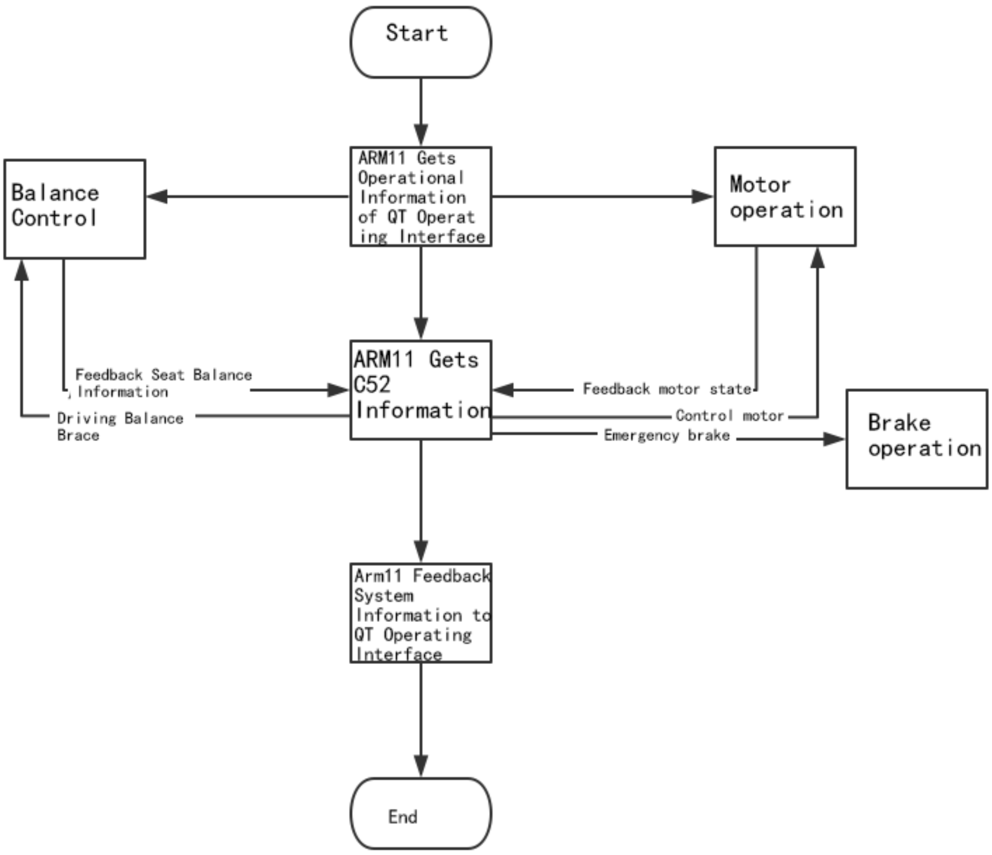

Figure 6. Flow chart of ARM11 control C52

3.2.3 Motor Driver Module

The wheelchair is driven by AC servo motor, which is controlled by driver. The control flow is shown in Figure 7. According to C52, target speed, target acceleration, rotation direction and

ISSN: 2472-3703
DOI: 10.6911/WSRJ.201911_5(11).0023

other information are communicated through 485 serial port, and the information of current speed, current motor temperature and current acceleration are fed back to C52 by driver. Finally, C52 integrated information is submitted to ARM11 chip.

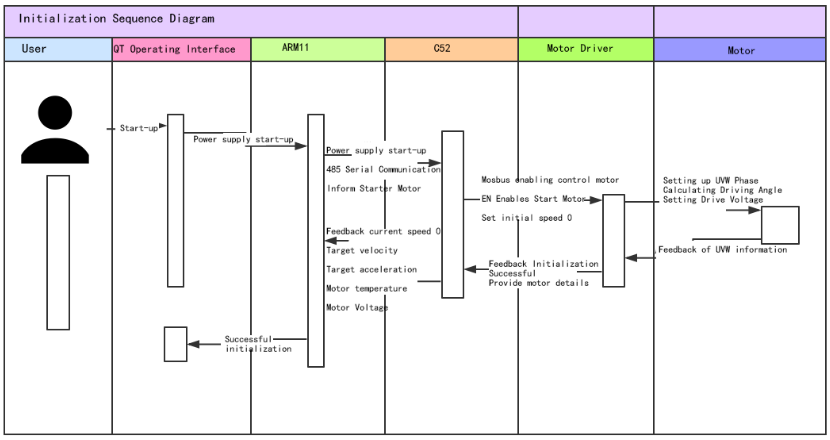

Figure 7. Sequence diagram of motor drive initialization

3.2.4 Balanced strut module

The balance module is set for wheelchair seat position, and the balance information is acquired in real time through the horizontal measurement module SCA100T. As shown in Figure 8, the user starts the wheelchair self-balancing, tells C52 by ARM11, and collects data from C52 to calculate the level measurement module. When the tilt value exceeds the predetermined value, the user drives the pole motor by relay to restore the balance of the seat.

The level measurement module SCA100T sets up a certain alarm line. The number of alarms is counted after the collection of C52. When the number of alarms exceeds the safe range, C52 restores the work through relay-driven electric brace [8]. During the period, the report data of the level measurement module is observed and continuously fed back to ARM11. Until the user reports that the seat has been restored to the horizontal position by setting the interface to stop the automatic balance or the horizontal measurement module, the C52 stops the relay and the motor stops and expands.

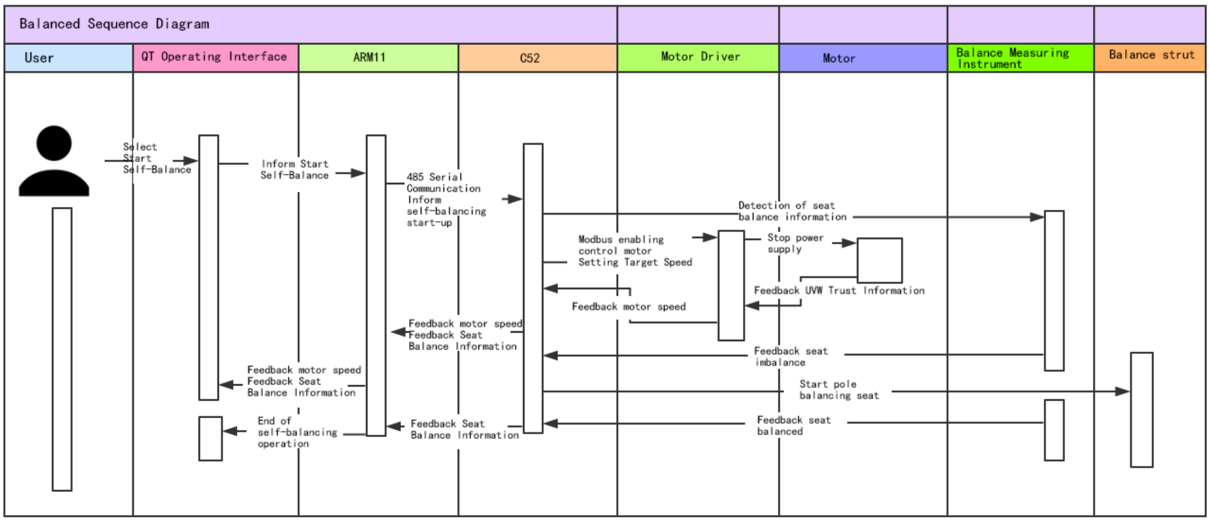

Figure 8. Balanced Sequence Diagram

World Scientific Research Journal Volume 5 Issue 11, 2019
ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

4. SYSTEM IMPLEMENTATION AND TESTING

This system is based on the cooperation of ARM11 and C52 MCU. The driving motor of wheelchair is controlled by C52 MCU. The communication protocol adopts the Modbus protocol, which is commonly used in industry. The balance of wheelchair is obtained by the level measurement module SCA100T. At the same time, the system has a good man-machine interface, and has the function of control and modification.

4.1. Motor Test of Wheelchair

The AC servo motor used in wheelchair is controlled by driver. The driver obtains the corresponding target operation code, operation data and CRC16 check code from C52, so as to achieve the speed required by users. The test is shown in Figure 9. The PC receives motor data and C52 transmits Modbus communication code to verify the correctness and accuracy of C52 control driver. Among them, the black line represents the temperature, which is stable at 24 degrees Celsius; the red line represents the speed, and the full speed operation and the braking test are carried out during the test. As shown in the figure, the starting and braking performance of AC servo motor is excellent; the green line represents the output pulse width, and the higher the proportion, the faster the motor speed is, and the change and speed line are close to each other, proving the intersection. The control response speed of the flow servo motor is fast, and the expected goal is achieved.

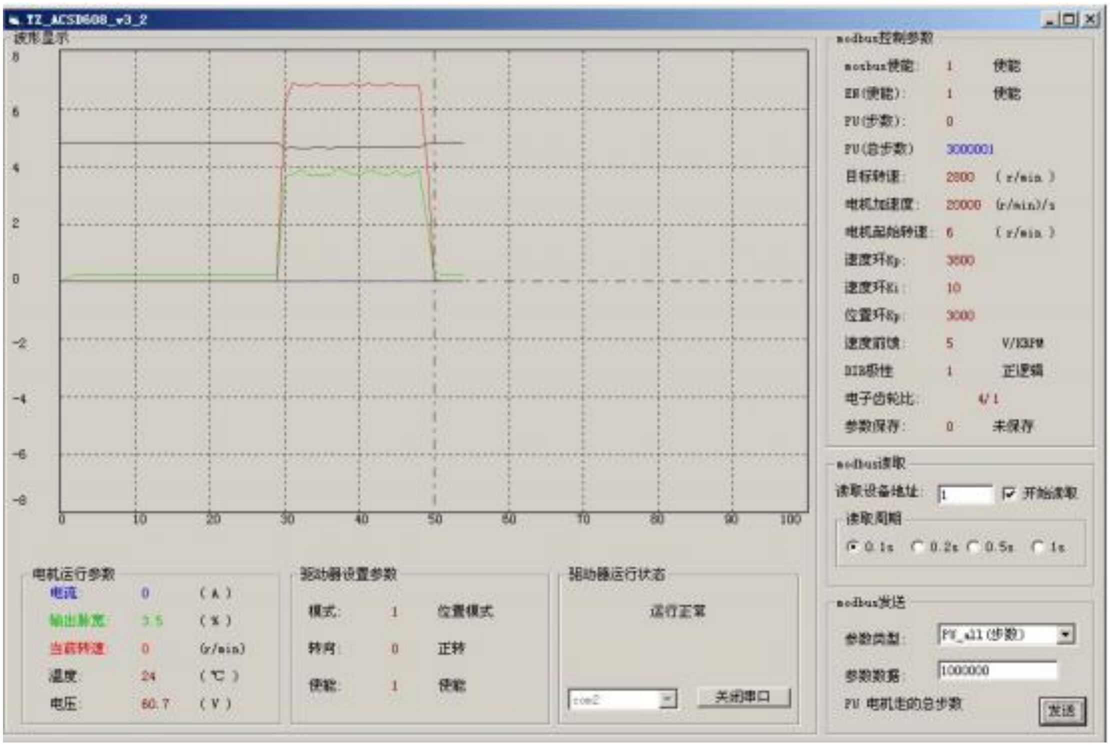

Figure 9. Test Chart of AC Servo Motor

4.2. Wheelchair Balance Test

Through the horizontal measurement module SCA100T to obtain the horizontal value, and according to the numerical control of the balancing strut, after testing, the balancing strut will automatically expand when the inclination angle exceeds the set range until the upper limit or the horizontal measurement module restores the inclination angle to the set range. As shown in Figure 10, C52 reads from the horizontal meter that the current tilt of the meter is 29.7 degrees with the horizontal plane. There are TTL level alarm pins on the horizontal

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

measurement module. C52 can get the information of the tilt angle more quickly than the preset angle, and adjust it accordingly according to the information.

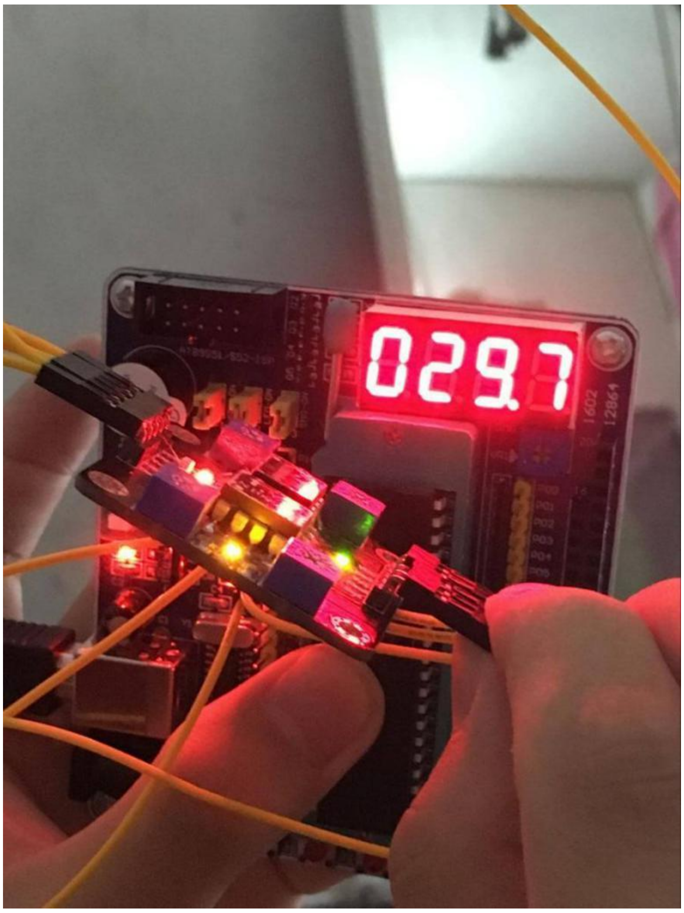

Figure 10. C52 Acquisition Level Measuring Instrument Data Test

4.3. Interface Testing

The user controls the wheelchair through LCD touch screen. The user adjusts the wheelchair driving by selecting acceleration, deceleration, braking, and can understand the speed of the wheelchair and the temperature of the motor in the operation interface. Four warning signs in the upper right corner of the system interface, namely four exclamation marks, represent different crisis situations: black circle exclamation marks represent abnormal wheelchair driving, communication problems between ARM11 and C52 or between C52 and motor driver, red circle exclamation marks represent excessive temperature of motor, yellow triangle exclamation marks represent electricity. Electrical power is insufficient; black triangle exclamation marks represent abnormal wheelchair balance, reminding users to restore automatic balance.

In addition, users can modify the settings in the upper left corner and enter the settings page shown in android app. The speed of the first half of the page is the speed that the motor arrives directly. During the testing process, the speed of the motor is accelerated or decelerated by pressing the acceleration or deceleration button each time after the user modifies the data. Degree modification. The second half of the system modifies the inclination angle of the pole. When the system runs, the user can choose the desired inclination. When the angle chosen by wheelchair balancing is not the self-balancing angle of the pole, the upper right corner of the operation interface will appear black triangle exclamation mark. The user must click save and then exit after the operation modification. Otherwise, the modification will be cancelled.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201911_5(11).0023

5. SUMMARY

This system aims to create a wheelchair that can go up stairs on the front, and focuses on solving the following problems: selecting the motor type from the thrust demand, controlling the motor drive by C52 chip under the command of ARM11 chip, adjusting the head elevation angle of front wheel triangular mobile mechanism and realizing the thrust measurement of compound mobile mechanism by C52 chip; Module data and the way to drive the electric push rod. The system runs well and realizes the original intention.

ACKNOWLEDGMENTS

This research was financially supported by Guangdong Provincial Innovation and Entrepreneurship Training Program Project NO.201713719017, Innovation and Improve School Project from Guangdong university of Science and Technology NO. GKY-2015CQPT-2,Internet of Things Technology and Application Experimental Teaching Demonstration Center Project NO.CQ2018007,also supported by College Students Innovation Training Program held by Guangdong university of Science and Technology NO.1711034, 1711080, and NO.1711088.

REFERENCES

[1] Guo Zhe. System design and development of omnidirectional motion electric wheelchair [D]. Zhejiang University, 2014.

[2] Wu Xiaolong, Tan Zhong, Wu Xueming, et al. Research and design of a new type of climbable intelligent wheelchair [J]. China Medical Equipment, 2015 (6): 12-15.

[3] Wang Jian. Dynamics Modeling and Control of WT Wheelchair Robot's Stair Climbing Process [J]. 2014.

[4] Guo Jianhua, Jiang Hongyuan, Hu Qingming, et al. [J].Journal of Harbin Engineering University, 2015 (1): 123-126.

[5] Ding Yaolong. Comparison of the curative effect of two kinds of plate fixation for comminuted fracture of lower tibia [J]. Armed Police Medicine, 2015 (1): 88-90.

[6] Yuan Wei. Design and research of high-speed data transmission system based on RapidIO [D]. China University of Geosciences (Beijing), 2015.

[7] Xu Meng. Design of DC/AC power module test system based on C language [J]. Electronic Design Engineering, 2016, 24 (2): 105-106.