The design of wireless communication and positioning system of electric vehicle based on CAN bus

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Abstract: Because the throughput of the traditional wireless communication and positioning system of EVs is reduced, which can not meet the needs of users, the wireless communication and positioning system of EVs based on CAN bus is designed. Using the central control board to collect the real-time status, exchange information data, select the tps5430 switching power conversion chip to realize the two-way transmission with MCU address and data; under the support of hardware structure, optimize the initialization procedure, use the toa positioning principle to complete the positioning and ranging, extract the effective information, and realize the design of the wireless communication positioning system of the programmable electric vehicle based on CAN bus. Using computer simulation software, the performance of the system is tested. The results show that when the traffic load increases to 45mbps or higher, the throughput curve of the traditional system gradually shows a downward trend, while the throughput of the designed system does not change significantly after the traffic load increases, which can meet the needs of users.

Keyword: CAN Bus; Additional range electric vehicle; Wireless communication location

1 Introduction

Automobile manufacturing industry is a strategic industry related to the national economy and people's livelihood, social stability and economic development, and it is an important part of China's national economy. In recent years, the severe energy crisis, environmental degradation and national strategy put forward an urgent demand for the research and development of electric vehicles. Countries around the world have formulated national policies for the research and development of electric drive related technologies and the development of electric vehicle industry [1-3]. Electric

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control system is one of the most core technologies of electric vehicles. Because of the complexity of system structure and working conditions, it is difficult to break through the key technologies of electric control system , which seriously restricts the promotion and application of electric vehicles . Electric vehicles are not only related to automobile itself and infrastructure construction. According to the relevant definition of the Ministry of science and technology, China's strategic emerging industries include energy conservation and environmental protection industry, new generation information technology industry, biological industry, high-end equipment manufacturing industry, new energy industry, new material industry, new energy automobile industry and other seven major industries[4-6]. Most of the industrial strategic emerging industries are related to the development of electric vehicles. The production, manufacturing and sales of electric vehicles, infrastructure supporting links, after-sales service links, battery rental / sales / service links, electric vehicle warranty and financial services and other links will have a profound impact on the industrial structure . The incremental electric vehicle is equipped with vehicle charging power unit and auxiliary power unit to drive the vehicle with electric energy. When the electric energy is sufficient, the battery provides all the energy needed for the vehicle to run. When the electric energy is insufficient, the auxiliary power unit works to provide the energy needed for the vehicle to run. The matching internal combustion engine has small power, and its efficiency and emission can be controlled in a better state. The fuel consumption rate and harmful emissions can be significantly reduced. The battery capacity is large , which can provide a long driving range of pure electric vehicle , and there is no driving range anxiety problem due to the existence of auxiliary power system . The battery capacity is significantly smaller than the battery capacity of pure electric vehicle , The manufacturing cost is greatly reduced , the available types are diversified, and the use cost is relatively low; the internal combustion engine can provide the heat required by the air conditioning power and vehicle heating, reduce the battery consumption, and increase the pure electric driving mileage of the vehicle; there is no need to build large charging facilities, and night charging can be used , which is conducive to the peak valley regulation of the power grid, and improve the operation quality of the power grid[7]. This paper studies the wireless communication and positioning system based on CAN bus, optimizes the system performance, and meets the user's requirements for the use of EVs .

2 Hardware Design of Wireless Communication Positioning System for Range-increasing Electric Vehicle Based on CAN Bus

2.1 Central control panel

The central control board is the core of the whole control system. It is the brain of the whole charger and exchanges data for each unit.The central control board communicates with human-computer interaction unit and integrated measurement unit through 485 bus; communication with card reading unit through 232 bus; the central control board and the integrated measurement unit are respectively connected with the S + and s-contact points of the charging gun, and communicate with the electric vehicle BMS through the CAN bus; the central control board drives the indicator light, emergency stop switch and drain circuit through the IO port; the sampling circuit is driven through the AD port, and the insulation detection circuit is driven through the serial port[8-10].

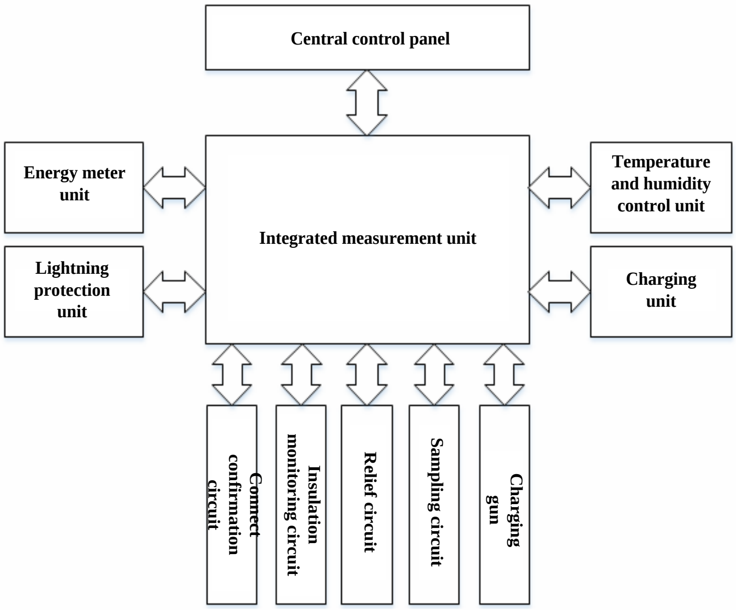

Figure 1 Communication block diagram of integrated measurement unit

The integrated measurement module is used to collect the necessary data in the charging process: the measurement of the output voltage and current of the charging unit, the judgment of the connection state of the charging gun , the measurement of the ambient temperature and humidity, the real-time data measurement of the electric energy meter, the data measurement of the lightning protection module, and the communication with the BMS to collect the real-time state data of the battery. The data is uploaded to the controller through the RS485 bus interface and the central control board .

2.2 Circuit design

Tps5430 is a DC-DC power supply chip with outstanding comprehensive performance, which has the advantages of high conversion efficiency, high output current and over-current protection function.The 12V DC supplied by the auxiliary power supply is input from VIN pin, and after the chip conversion, the pH pin outputs 5V DC. The output voltage of 5V is determined by R7 of 10K Ω and r10240 of 3K Ω . Inductance Li and capacitance C2 filter the output circuit, making the output voltage more stable; diode d11349 provides protection for the circuit . circuit diagram as follows：

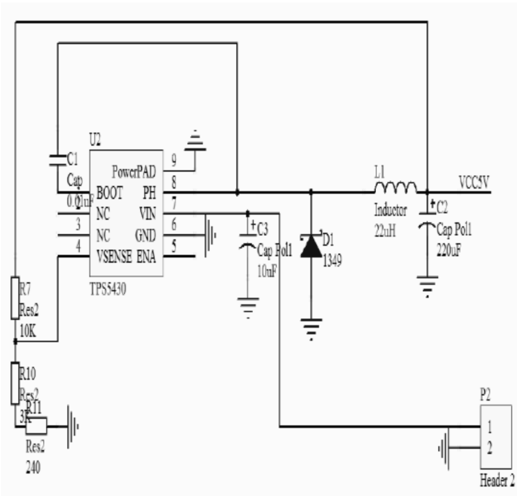

Figure 2 5V power circuit diagram

The power chip reg1117-3.3 is selected to convert 5V voltage into 3.3V voltage. After the 5V voltage input is filtered by low frequency and high frequency, the 3.3V voltage is output at 2 or 4 parallel terminals, and then the 3.3V voltage output is more stable by low frequency and high frequency filtering.

The circuit uses the clock chip ds3231 to provide timing for MCU. Ds3231 is a high-precision clock chip produced by the American credit semiconductor company, As shown in figure 3 , Can provide accurate information from year to second; with C bus interface, it can realize two-way transmission with MCU address and data; with low power consumption, it can use its own pin to connect dry battery as standby power supply, and continue to provide timing function when the main power supply is disconnected, etc.

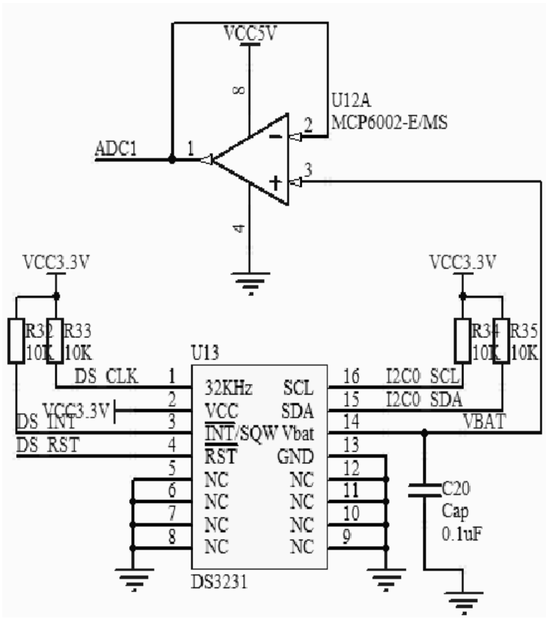

Figure 3 DS3231 External interface circuit diagram

As shown above , the standby power supply uses one-way filter power supply to supply power to RTC . After the main power supply is cut off, the RTC standby power supply will supply power to the RTC to ensure the continuous timing function. Reset is realized by connecting the external circuit. On the premise of normal operation of the clock circuit, LCP1788 is connected to the low level through the corresponding pin, so as to realize the RESET of the single chip microcomputer. That is to say, the reset can be realized by inputting the low level at its reset pin and keeping it for more than several machine cycles. JTAG interface is used as the test and debugging interface for the central control board, which is convenient for debugging in the programming process, as shown in the figure below:

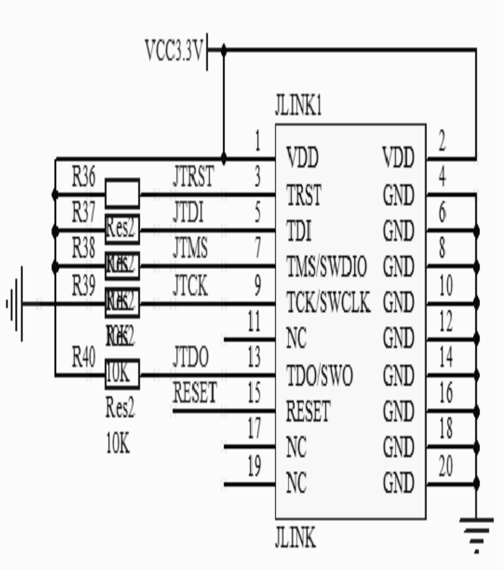

Figure 4 JTAG interface circuit diagram

JTAG interface provides 5 signals to connect with lpc1788, namely TMS, TDI, TDO, TCK and trst. TMS / swdio is the pin that j-link outputs debugging mode signal to lpc1788; TDI is the data input pin; TDO is the pin that receives LCP1788 data; TCK is the clock signal sent by the emulator to the target board; TRST is used to reset JTAG simulation mode. Pin 3, pin 5, pin 7, pin 9 and pin 13 are connected with pull-down resistance and grounded, and pin 1 and pin 2 are connected with 3.3V power supply. At this point, the optimization of the hardware part of the system is finished .

3 Software Design of Wireless Communication Positioning System for Electric Vehicle Based on CAN Bus

3.1 Initialization design

After the system initialization, for the positioning base station, it has been waiting for the UWB signal. After receiving the UWB signal sent by the tag, it immediately enters the interrupt processing, runs the sds-twr algorithm, sends the distance data to the tag and continues to return to the status of waiting for the tag. For the tag, it circulates the UWB signal to the four base stations in turn, and after receiving the information returned by the base station, it passes the SDS- TWR algorithm calculates the distance from four base stations, calculates the arrival time difference according to the TDOA model, and sends it to the main base station through UWB communication, and the main base station sends the data to the upper computer through WiFi . Manually place each base station on each coordinate axis and origin of the space rectangular coordinate system, and the system can start to run the self built coordinate system software.. In the positioning system, the label needs to calculate the coordinates of its own location according to the coordinates of the base station. Therefore, before starting the positioning, the position coordinates of the base station are required to be known. Because the system adopts the method of self building coordinate system by software, it is time-consuming and laborious to choose the manual fixed-point measurement method in advance, and may cause large errors. In the process of system initialization, each base station is manually placed on the coordinate axis of the spatial rectangular coordinate system. Base station 1, that is, the location of the main base station, is the origin of the coordinate. Other base stations can get the distance between the main base station and the main base station through the UWB communication module, and calculate the location coordinates. After the location coordinates of each base station are known, the positioning system can work normally. The specific process of system initialization is as follows: for the base station, hardware initialization is the first step, and then all the base stations are initialized to wait for the tag signal; for the tag, after the hardware initialization, enter the coordinate initialization process, send the coordinate initialization flag to the primary base station, and then wait for the return information of the primary base station until the primary base station sends the coordinate initialization information backLabel begins the first positioning process; after receiving the coordinate initialization flag sent by the label, the primary base station communicates with other base stations for ranging, and measures the distance between these base stations and the primary base station, and returns the distance information to the label as the coordinate value of each base station in the coordinates, completing the initialization of coordinates.

3.2 Location and ranging

When radio waves propagate in different environments, the degree of signal loss is also different . The ranging technique based on signal intensity calculates the distance of the transceiver based on the loss of radio waves in propagation. The loss of signal can be divided into loss caused by distance, loss caused by complex terrain and multipath loss. The ranging technique based on signal strength mainly estimates the distance between the receiver and the receiver according to the relationship between the signal intensity and the distance. The distance between the two ends is obtained by calculating the flight time of the radio waves at both ends. The main idea is that when the radio waves emitted by the transmitter reach the receiver, the receiver also sends a radio wave, and the transmitter calculates the distance by the delay of the transmission and reception time, As shown below ：

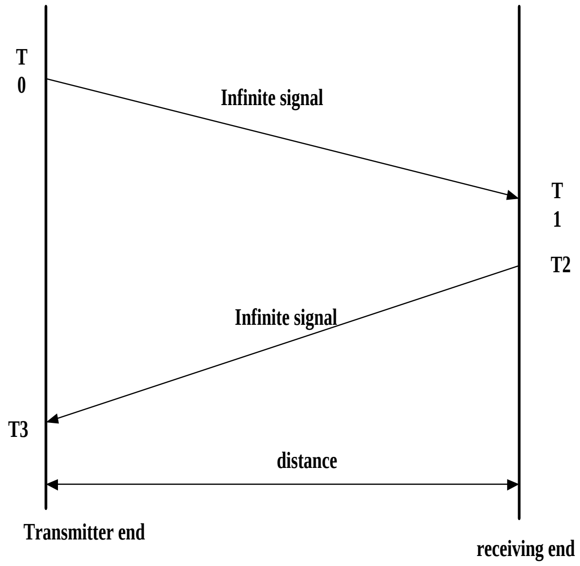

Figure 5 TOA Positioning principle

As shown above, you can get the following formula ：

$$d = \frac{\left[\left(T_3 - T_0\right) - \left(T_2 - T_1\right) \times v\right]}{2} \quad (1)$$

In formula, v is the speed at which radio waves travel, T_0 , T_3 is the time when the transmitter transmits and receives the signal, T_1 , T_2 is the time when the receiver receives and transmits the signal respectively .

The distance between the transceivers is estimated by calculating the time difference between the transmitter and the receiver, let the velocity of the signal be

v_1, v_2 is the distance between the transmitter and the receiver is d , The time difference between the signal arriving at the receiving end is $T_2 - T_1$, there are ：

$$\begin{cases} L = \left(T_2 - T_1\right) \times s \\ d = \dfrac{v_1 \times v_2}{v_1 - v_2} \end{cases} \quad (2)$$

In order to meet the positioning requirements, different positioning algorithms should be selected according to different applications. The location accuracy of the algorithm based on distance measurement is high, but it is easy to be affected by the outside. In order to ensure the accuracy of the distance, the results need to be modified , which will lead to the complexity of the algorithm and the high cost of hardware . So choose the appropriate location algorithm according to the situation .

If the absolute time of device A and device B is not strictly synchronized , Measuring distance will cause error , To avoid this error , SDS-TWR Algorithm , Its principle is similar to that of two-range ranging , The transmitter transmits the signal after encountering the object , The signal immediately returned , The transmitter detects the reflected signal, and the time interval between the transmitting and receiving can be obtained , This time interval is the time when the signal goes through the two-way distance. When the time is multiplied by the speed of the signal, the distance information can be calculated . Algorithm flow chart ：

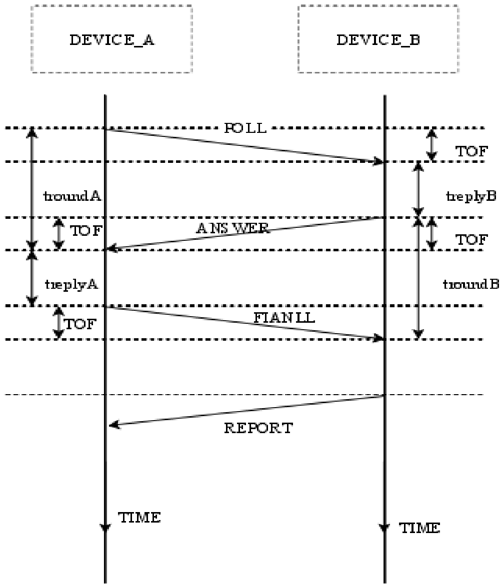

Figure 6 SDS-TWR Schematic diagram of ranging principle

Equipment a sends a signal to equipment B and records the value of the moment. B receives the signal and records the value of the moment. Then it sends a message to a and records the value of the moment. A receives the signal and records the value of the moment. A sends the signal to B again and records the value of the moment. B receives the signal and records the value of the moment. A and B record the value of the moment three times respectively .

3.3 Location Information Extraction

GPS chip communicates with MCU through serial port 2. As long as the GPS chip is powered on, the GPS chip will continuously transmit data to MCU in NMEA-0183 format, and the amount of information is very large. The main task of GPS software design is to analyze NMEA-0183 protocol, and then extract the required data according to the needs. First, judge whether the GPS information is available, that is to say, judge whether the GPS chip has searched more than four satellites and can accurately locate them; then write the corresponding program algorithm to extract the current longitude, latitude and speed information of the module, process these information, then extract and process them again, so that the vehicle status can be monitored all the time.GSM / GPRS chip communicates with SCM through serial port 1. SCM can control GSM / GPRS chip by following the format of at command through serial port. So far, the design of the wireless communication and positioning system of the electric vehicle based on CAN bus is completed. The following simulation experiments are designed to verify the performance of the designed system .

4 System Function Testing

In order to verify the performance of the wireless communication positioning system, a comparative experiment is proposed to simulate the operation process of the designed system, compare its throughput under different traffic loads with the original system, get the test results, and complete the function test .

4.1 Performance test preparation process

During the experiment, the throughput of the system needs to be detected, which is completed by using Tamosoft Throughput test performance test software. Tamosoft throughput test can simulate TCP and UDP data flow in real time, calculate important indicators, and generate test results in the form of numbers or charts. The specific parameters of the experimental platform are shown in the table 1 below ：

Table 1 Experimental Platform Parameters

Name		Specific parameters
subject	Model	DT-610L-JH61MAI
	structure	Rack
Memory	Memory type	Non-ECC
	Maximum memory capacity	64 G
	Number of memory slots	4
	Memory size	4 G
Display performance	Display chip	C236
network	network controller	Gigabit Ethernet
mainboard	Expansion slot	PCIE
	Chipset	C236
	Embedded network controller	Gigabit Ethernet
storage	Number of internal hard disks	4
	Disk array card	R121i supports raid0, 1, 5, 10

	CD drive	DVD
	Hard disk type	SATA; SSD; hybrid hard disk

From the data in the above table, it can be seen that the experimental platform can meet the test requirements, input the original values in the operation interface, test the system performance, in order to ensure the accuracy and preciseness of the test results, other experimental variables are the same except for the experimental objects .

4.2 Performance Test Results Analysis

After completing the preparation of the above experiments, the results obtained are compared with the original system, and the specific control results are shown in the following figure :

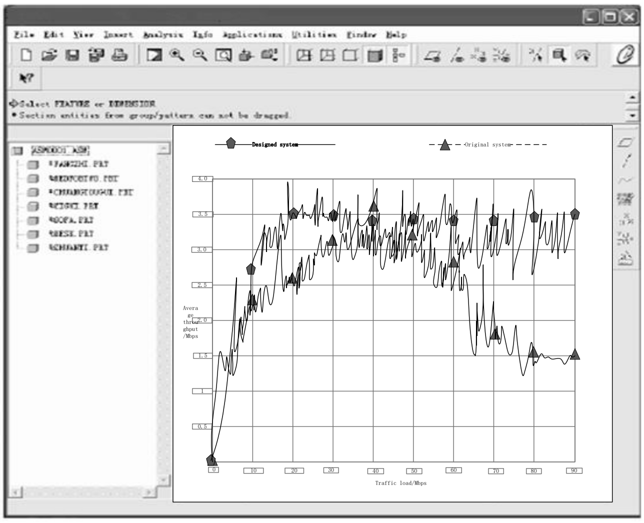

Figure 7 Test results diagram

It can be seen from the above results that when the traffic load is kept at 0-45 Mbps , the throughput of the original system is almost the same as that of the designed system, and the network utilization increases with the increase of network traffic . However, when the traffic load increases to 45mbps or higher, the network congestion is caused by too many packets in the network, resulting in the gradual change of the network throughput curve of the original system, showing a downward trend, which proves that when the network traffic load is too large, the original system can not maintain normal operation and can not meet the user's resource demand . The designed system throughput curve changes smoothly, does not cause network congestion due to the increase of traffic load , and can meet the needs of users .

5 Concluding remarks

Because the throughput of the traditional wireless communication positioning system of EVs is reduced, which can not meet the needs of users, this paper designs the wireless communication positioning system of EVs based on CAN bus. Through the design of hardware and software, the design of wireless communication positioning system is completed, and the performance of wireless communication positioning system is optimized. It is hoped that this research can contribute to the development of the electric vehicle. In the research process of the wireless communication positioning system of the electric vehicle based on the CAN bus, the long positioning time leads to the reduction of the efficiency of the wireless communication positioning of the electric vehicle based on the CAN bus. Therefore, in the future research, the positioning time is the research focus to further improve the effectiveness of this system.

6 Fund projects

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