Design and Implementation of Two-wire Electronic Tag Picking System

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Abstract

The paper introduces a new electronic tag device and describes system structure, design of software and hardware, critical circuit and communication protocols in details .Two-wire bus transmission is designed to replace the conventional RS485 four-wire transmission, which saves 50% of the conductive wire material. The experiment proves the feasibility of the system and the load capacity of the two-wire bus.

***Keywords:** electronic tag; two-wire; pick operation*

1. Introduction

Picking operation is the most onerous and error-prone work in logistics distribution center. The traditional way of picking is that warehouse pickers find the appropriate shelf according to the invoices, which need pickers to be very clear of the position of the goods. Obviously, it seems not easy to take care of a large-scale storage. That leads to excess workload, low efficiency, and error-prone, and at the same time, leading to management inconvenience and management inefficiency. Electronic tag picking system is a way to improve the quality of traditional logistics operations and the efficiency of traditional logistics effectively.

Foreign research of electronic tags picking system has an early start, especially L-PICK auxiliary picking system designed by the company of AIOI. The system's core technology is based on TW (two-wire) system, involving patented packaging chips and patented score technology. Domestic research in the field of assisted picking system started late, mainly clustered in coastal economic belt where economic is more developed, and most technologies are introduced. For example, Shanghai ZEJU Logistics Equipment Co., Ltd. electronic tags using RS485 four-wire communication bus production. Relative to the two-wire electronic tags, it is not easy for wiring and error-prone on the shelves. Duan Cun-hui[2] et al proposed layered system whose signal was transported by RS485 bus. Wang Yu-quan[3] et al introduced the TCP/IP to RS-232 technology, selected the RS-485 as the communication bus. So there is a gap with foreign TW two-wire picking auxiliary systems in technology.

The system of the paper uses a DC power line carrier technology to achieve the two-wire bus transfer, making wiring easier, less error-prone and saving in the cost of wire material on the shelves. In addition, it narrows the gaps with foreign electronic tags auxiliary picking system in technology. Enhancement of fault detection function based on actual needs makes the system more perfect.

2. System Composition and Operating Principle

System is shown in Figure 1, composed by the host computer, controller and terminal.

The host machine is made up by the PC institutions. Controller is based on the embedded controller STC89C54RD+. The application of the terminal is composed of electronic tags. Host computer and the controller communicate through the switch using TCP/IP protocol. The advantage of network communication is easy-to long-distance transmission, the data not easy to be lost, the communication high reliability and anti-interference ability. As each controller is connected through the network interface with the host computer, it is convenient for expansion of the system. The communication protocol between the controller and the application of the terminal is master-slave half-duplex communication protocol. Each controller is connected with the terminal of the next layer by three-channel. Every channel can withstand 40 electronic tags, so each controller can control 120 electronic labels, multi-channel helps to improve the power and stability of the system. During the operation, PC will send the order information through the network to the specified controller. Then the controller receives data and command from PC to select the specified goods on behalf of the electronic tag and sends the data to the electronic tag. The electronic label lights up the corresponding indicator to guide picking workers picking. Press the Enter key after completion of the picking, feedback information to the PC. When the order is complete, the feedback information generates reports.
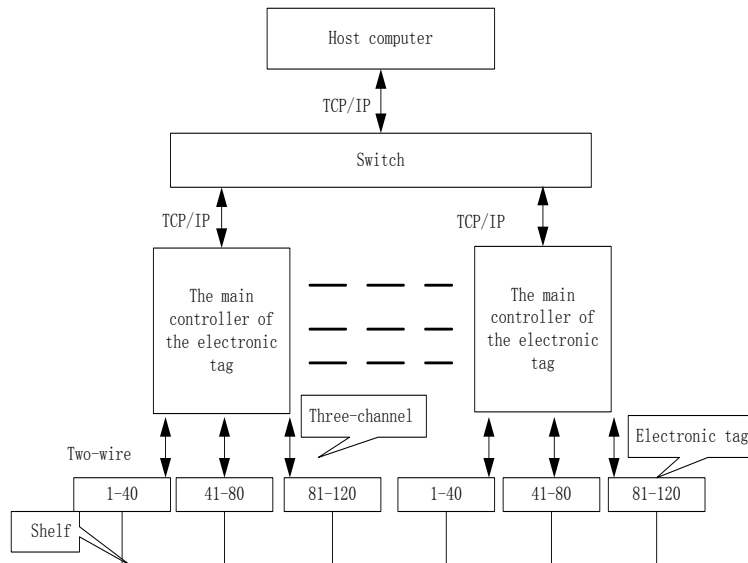

Figure 1. System components

3. The Key to the System

3.1. The Main Controller of the Electronic Tags

The controller uses STC89C54RD+ as the control core, and it can realize the function of accepting the orders from PC, uploading data information from the terminal device, selecting channel, allocating each tag address, and detecting fault transmission information.

STC89C54RD+ which launched by the company of STC is a new generation of high speed, low power, super anti-jamming microcontroller. The code is fully compatible with the

traditional 8051 SCM, the operating frequency range form 0 to 40MHz, equivalent to an ordinary 8051 0-80MHz. In addition to the integrated 256 bytes of internal RAM, the chip also integrates the 1024 bytes of extended RAM address range 0000H-03FFH.

Figure 2 is a system block diagram of the controller, wherein the microcontroller module uses its I/O ports to simulate the SPI interface. Through the SPI interface, the microcontroller is connected to the network chip of W5200 to complete the communication between the controller and the PC. TCP/IP protocol is used between the controller and the PC for the communication protocol, and the PC is regarded as the server and each controller is regarded as a client. For the data of EEPROM after power failure will not be lost, it is used to store each controller's hardware address, IP address, port number, destination IP address and destination port number. Since the controller needs to achieve store-and-forward function (store the data information sent from the PC and electronic tags), it should have enough memory space. The system uses the 6264 to expend eight thousand bytes of memory space. 8255 is used for expending I/O in order to have sufficient I/O pins to exchange data information with peripherals. Then GM8123 chip controls serial port expansion mode with the expansion of the I/O pins. A full-duplex serial port is expanded into three standard serial ports by the chip of GM8123. Thus the controller will have three channels which are connected with the application terminal of the next layer.
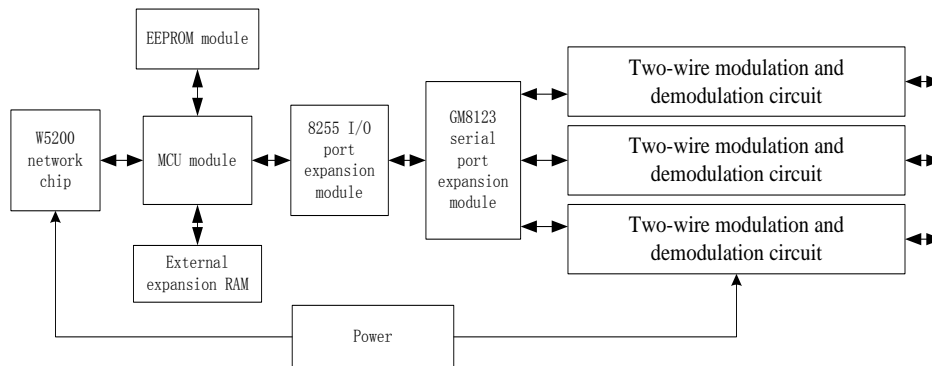

Figure 2. Controller system block diagram

3.2. Two-wire bus design

The so-called TW two-wire system is that the electric power and signals are transported by the same two wires. The advantage of the two-wire communication to the RS485 four-wire communication is:

(1)Compared with the four-wire bus, two-wire bus saves conductor material for half of the original.

(2)Comparing to the four-wire bus, two-wire bus wiring is not easy to go wrong. In addition, shelves wiring becomes simple and the cost of construction is low. The two-wire system is less susceptible to interference and suitable for long distance transmission.

Load power depends on the power provided by the two-wire modulation and demodulation circuit. Due to a controller with three channels has three modulation and demodulation circuit, the stability of the system and the load capacity have been improved. As shown in Figure 3 for the two-wire modulation and demodulation circuit, as the power of the bus is very large and the on-off frequency of modulation circuit is relatively high, we choose N channel enhancement mode MOS tube as the modulation switch. The noise coefficient of MOS pipe is

small and the power consumption of it is low. In addition, MOS pipe has the advantage of wide range of working voltage. DE as the communication flag signal works normally in low level state, and when you want to communicate DE is set to high level. Communication starts after one millisecond delay. After the completion of the communication, DE is set to low again. Due to the signals on the bus which is modulated by the MOS tube are opposite to the ones sent by the TXD, the inverter 74LS04 is added after the TXD to make the bus signals follow the host's change.
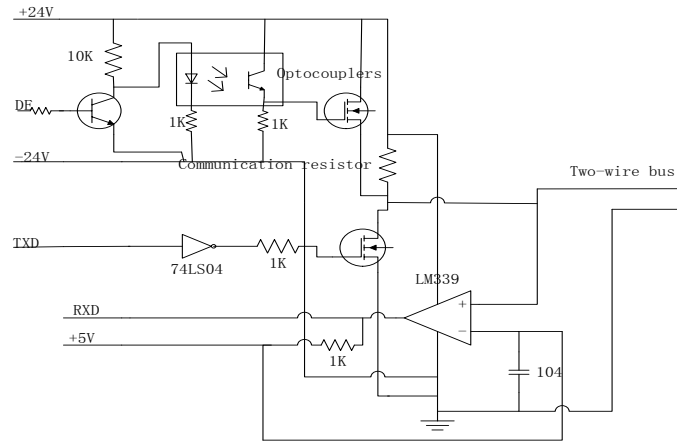

Figure 3 .Modulation and demodulation circuit of controller's two-wire bus

3.3. Terminal equipment electronic tags

As pickers' interface, the electronic tag terminal uses AT89C2051 MCU as the control core. It configures high brightness LED display, receiving the command and the data information transferred from the controller by the two-wire modulation and demodulation circuit. After the electronic tag deals with the command and data information which is sent from the controller, it will light up the LED indicator according to the result of the processing. Thus the pickers go to pick goods prompted by the indicator and press the corresponding button to turn the LED indicator down when he finishes picking. At the same time, the electronic tag unit will send the information which the led goes out to the controller timely, and then the information will be transferred to the host by the controller.

The signal which is separated by the two-wire modulation and demodulation circuit in the two-wire bus is transferred to the microcontroller AT89C2051, and then the microcontroller AT89C2051 depends on the received information to determine whether its own address is called. If it does not call itself, it will not act, and the multi-machine communication control bit which called SM2 is 1. At this time, only when ninth bit which is called RB8 of the received information is 1, the AT89C2051 can be promised to receive information.

On the other hand, if it calls itself, the AT89C2051 will set control bit SM2 of the multi-machine communication into 0. Thus AT89C2051 can receive information at any time and send its correct address to the controller. Then in case the controller receives the correct address of the electronic tag, it will set the ninth bit called TB8 of its sending message as 0. At this time, due to the other electronic tags' multi-machine communication control bit which called SM2 is 1, their control chips AT89C2051 are not promised to receive message. In this case, the controller communicates only with the electronic tag which matches the address. After the communication, the controller will set the ninth bit called TB8 of its sending message as 1 again.

The two-wire modulation and demodulation circuit of the electronic tag is shown in Figure 4. The diode 1N4007 is used to insulate interference of the signal. The positive input of the LM339 is the signal input of the bus and the negative input of it is five volts as a comparison reference voltage. Pull-up resistor is connected to the output, guaranteeing the signal of output is a TTL signal. In the way, the signal can be separated from the bus.
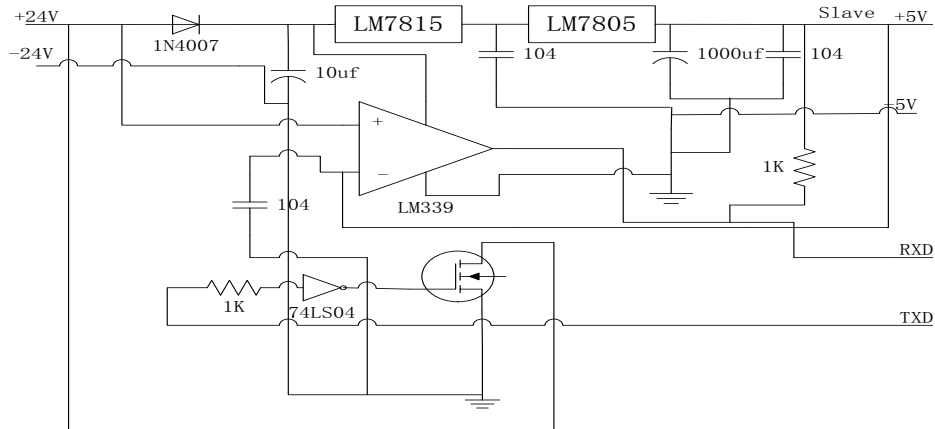

Figure 4. Modulation and demodulation circuit of the electronic tag

If the light does not work during the operation, it will bring great influence on the sorting operation. In general, when boot self-checking begins, pickers only use the naked eye to judge whether the indicating lamp is good or bad. It will increase the picking workload. During normal operation, if the indicator does not work, the pickers can not judge the bad one. However, with the functions of fault judgment, the operator can use the PC to detect the failure indicator light. As shown in Figure 5 for the fault detection circuit. IN is the control terminal of LED indicator. The positive input of the LM339 is the voltage of the indicating lamp. The negative input of the LM339 is the reference voltage which can be adjusted by sliding rheostat. If the electronic tag works normally, the output of the LM339 is 1, otherwise is 0. At the end, the output value of the LM339 is transferred to the controller by the microcontroller AT89C2051, and the controller store the fault information and forward it to the PC.
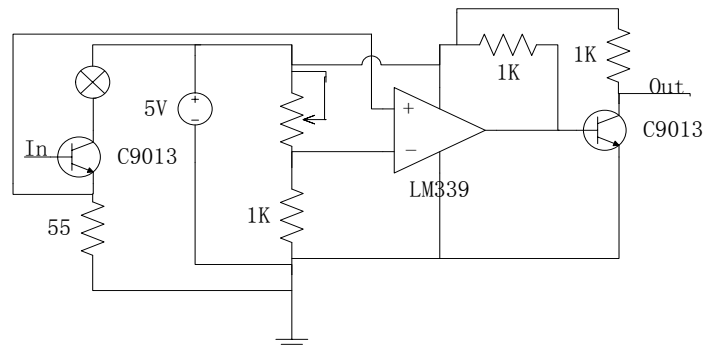

Figure 5. Fault detection circuits

4. The Software Part

4.1. Communication protocols

The communication protocol is the basis of data communication, then TCP/IP protocol is used between the PC and the controller and master-slave half-duplex communication mode is adopted between the controller and the electronic tag. Only one electronic tag is allowed to exchange data with the controller at the same time, and the sequence in time of sending and receiving data is very crucial. If the sequence in time goes wrong, it will cause the system to a standstill. Protocol format：

IP address of controller	Passage n	address	Command byte	Data instructions

While the system is running, all the controllers as clients send a connection request to the PC which is seemed as the server, and then the server binds all the controller's IP address to establish a connection. When communication begins, the PC will choose the specific controller and send the channel number, the address of electronic tags, command and data instruction to it. Then the controller makes corresponding processing according to the received command.

(1)The command byte 0x01 is the control instruction of light; Data 0x01 represents that the electronic label indicator light is bright. At the same time, the controller will store the address of corresponding electronic tag into a querying array and query the address in the array every 100ms. When the controller queries that the indicator light is turned off, the address of corresponding electronic tag will be removed from the array, and then the controller will send the message to PC to realize feeding information back in time. Data 0x01 stands for that electronic label indicator light is turned off.

(2)The command byte 0x02 is a fault feedback instruction. The feedback information is composed of 0x00, 0x01 and 0x02. If the light is not turned on, the feedback information will be 0x00 and 0x01, representing that the electronic tag is abnormal. 0x02 stands for that the electronic tag works well.

4.2. Program design of controller and electronic tags

The controller mainly achieves the function of connecting with the server, communicating with the PC, choosing the channel. The controller flowchart is shown in Figure 6. The electronic tags complete the function of communication, fault feedback and light tips. When the signal is separated from the two-wire bus, the two-wire bus does not provide electricity to the electronic tags and the capacity supply the power. As the power of capacity is limited, the communication rate can not be too low. The system uses 9600 bit/s as the communication baud rate.
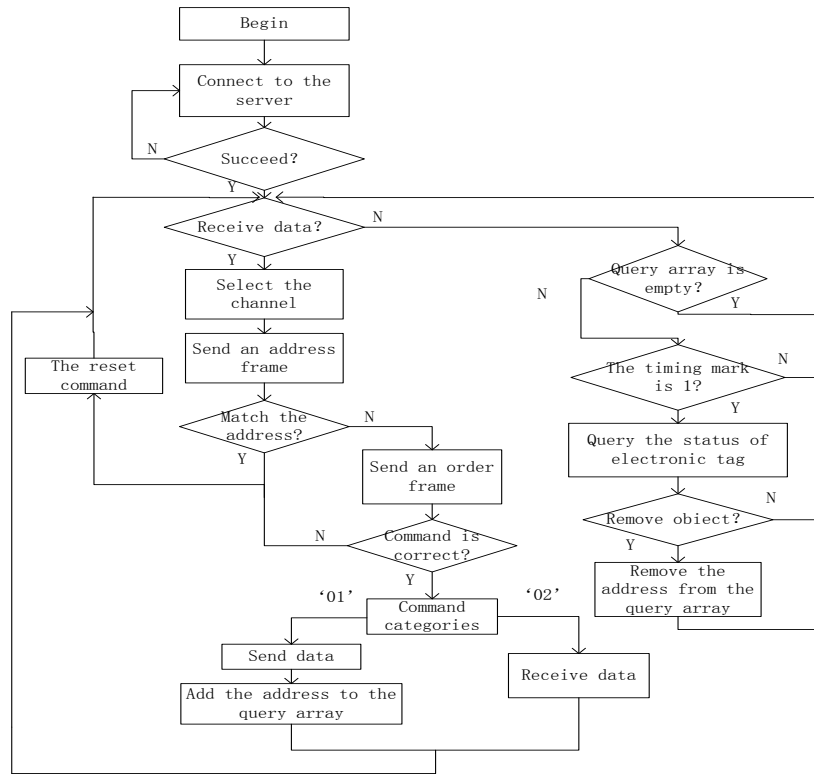
Figure 6. Controller's program flow chart

5. Experimental Results

As shown in Figure 7, the system is processing the orders come from the PC. The lower right-hand corner of the figure is a waveform diagram of the two-wire bus. The blue waveform is the one which modulated on the bus and the yellow waveform is the one which demodulated by electronic tag. Experiments show that controller can stability control 120 electronic tags, and the system reaches the level of actual production needs.
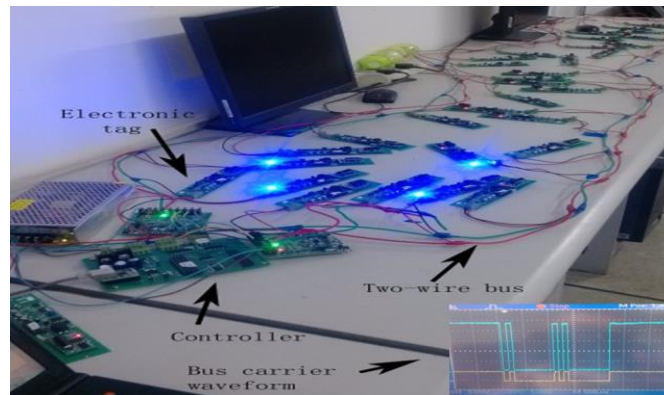

Figure 7. Physical map of system

6. Conclusions

It makes the sorting job simple using the computer to control the system. Using network technology makes the system more convenient in extension. Three-channel is used as the output of the controller to increase the load capacity. The introduction of TW two-wire bus technology makes wiring easier on the shelves and save 50% of the conductive wire material.

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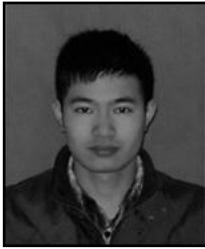
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