UNIVERSITÉ DU QUÉBEC À CHICOUTIMI

THE AREA WIDE REAL-TIME TRAFFIC CONTROL (ARTC) SYSTEM : THE LOGICAL STRUCTURE AND COMPUTATIONAL ALGORITHMS

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WANG-GUAN

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ABSTRACT

With the high development of Chinese economy, the number of automobiles rises sharply. In order to let more vehicles pass the limited roads successfully, The Aerawide Real-Time Traffic Control (ARTC) System comes up.

Although ARTC has been studied for many years in foreign countries, its study is still in the embryonic stage in China. After investigating, we discovered that system just recently. Only some simple Intelligent transport control has been realized in quite a few cities However, in many large and middle cities, Intelligent transport control is still in a research period.

We had been thinking about this research from juniors. We spent one year doing large quantity of social examination, investigating some roads personally and inquiring a lot of material from Internet and library. On the basis of this, we made the road sate model. Several typical states are represented on this model, so it is definitely representative. We chose the comparatively simple and easily operated green wave control. One computer controls six PLC. Long-range control is realized by dialing online the modulator-demodulator. We adopted some basic vague control thought, meanwhile, combined with actual circumstances, and designed a set of practical control algorithm. We mainly used VB6.0 and PLC programmed software from OMRON Company. In the end, we completed the control program of both the upper and lower bit machine.

Of course, there are many immature and imperfect aspects in our design, I hope to get guidance and help from all people.

Key words:

ARTC, Aerawide Real-Time Traffic Control

PLC, Programmable Logic Contrllor

ITS, Intelligent Traffic System

ACKNOWLEDGEMENT

With two years' hard work, after having finished such procedures as field investigating, data check, model making, programming and debugging, etc., we finally completed our scientific research topic.

The successful completion of the scientific research is due to not only our hard work but first of all, my research supervisor, Chen-Ming, and research associate director, Wei-Kexin. During the course of the design, Mr. Wei offered us many instructive ideas. He is good at giving systematic guidance and patient enough as well. Meanwhile, he encourages and supports us greatly in spirits.

During the course of our design, we got a lot of help from Gao-Qiang, the teacher in the electron experiment center. He encourages us continuously and provides us PLC, which is essential for the experiment. So without his help, we could not make such achievements. Therefore I express my greatest thanks to them.

Meanwhile, we owe our thanks to the teachers working in automated lab for they provide us a convenient working environment. We thank Ning-Hongyun, the teacher of our department for his concerns.

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INTRODUCTION

Along with the rapidly developing economy in China, the number of automobiles is increasing sharply. In order to promote the ability of traffic ways, The Aerawide Real-Time Traffic Control (ARTC) System was developed to meet the time.

The main content of the thesis is:

CHAPTER 1 The Aerawide Real-Time Traffic Control (ARTC) System;

CHAPTER 2 General introduction of Control System of Intelligent Traffic Preface;

CHAPTER 3 Data-transfer of The Aerawide Real-Time Traffic Control System;

CHAPTER 4 Configuration of the upper bit machine and the realization of control algorithm.

ARTC is not a uncommon word to foreign scientists. However, in China, it is just in the infant period. After some research and study, we found that only few cities had put some simple intelligent traffic control into use, while many others just in the researching period.

We applied for this task and gut permission two years ago. Thus, in the first year, we used a great amount of time on investigation and study. Also on-the-spot investigation of some ways was made. At the same time, we looked up many materials so as to get useful information from Internet and libraries. Based on long time preparation work, we, on our own effort, made the traffic condition model, which

focuses on displaying conditions of several typical crossings. On the controlling aspect, we chose the green wave control, which is comparably simple as well as easy to be carried out. By using one computer to charge six PLCs, and making dialing-up connection, control in distance was made possible. On treatment, we adopted some fundamental vague controlling ideas, and combined these ideas with practicality, finally invented a settlement for practical use. On the adoption of software, our main choices are VB6.0 and PLC programming software from OMRON Company, so as to complete the controlling program of computer and PLC.

Of course, our invention and our design procedure also have some disadvantages. Part of the system may be immature and imperfect. Therefore, we do need your valuable suggestions.

CHAPTER 1

The Aerawide Real-Time Traffic Control (ARTC) System

1.1 The Aerawide Real-Time Traffic Control (ARTC) System

The Aerawide Real-Time Traffic Control (ARTC) System is an accurate and efficient comprehensive communication and managing system, which perfectly combines advanced information technology, data communication technology, electronic conductive technology, electronic controlling technology and computer processing technology, together and applied for the aim of the whole ground transportation managing system. Take it concretely in the highway transportation sphere, it combines automobile, driver, road and relative service departments together, and makes automobile move intelligently. Therefore it can help the general public on how to use traffic equipments and energy efficiently. Take it in detail, the system deals with various pieces of collected information on ways and service in the traffic managing center, then delivers results to every user of highway transportation system (including drivers, inhabitants, police stations, parking lots, transport computer , hospitals , departments giving first-aid or removing obstacle). According to the information, people on the road could timely choose their means and lines of transport, while transport department may be familiar with the traffic situation at any time so as to make dispatching justifiable. In this way, the transportation moves in the smoothest condition. Also, less traffic jams are committed. Furthermore it makes full use of transport lines and

promotes the mobility, safety, efficiency of the whole highway transportation system.

1.2 Development of intelligent traffic system in history

ITS (Intelligent Traffic System) is not a modern idea. As early as in the 1960s, American Sports Automobile Company and Ford American Company has promoted and populated an idea called "modernized highway net". By the end of 1960s, the primitive form of intellectual transformation of the computer traffic controlling technology was developed. However, it attracted few eyes and it demonstrated little importance at that time. Since 1980s, especially these few years, ITS has developed rapidly. ITS is a large-scaled comprehensive technology to make the traffic management intelligent overall. With electronic technology on sound, light, electricity, magnetism electronic computer, and automation, etc... as its adoptions, ITS thoroughly changed the original appearance of transportation and promoted transport capacity, efficiency and safety.

Transportation system is a complex system of randomization, vagueness and flexibility. Considering only in the aspects of automobile or the traffic line, we cannot solve the problem from the root. It is better to think it as a whole. Therefore, the best convenient and efficient way is to further develop and make full use of traffic signal control system and informative technology, and finally establish city intellectual traffic system. It is also the direction of traffic managing development.

Crowd ness is ITS technology, or Intelligent Traffic system. The basic definition of ITS is: By using computer technology, electronic technology, and modern network communication technology, it makes automobile and traffic guiding intellectual, so as to reduce traffic jams and traffic accidents, improve traffic condition, save energy and lighten driving fatigue, etc, finally establish the safe, convenient speedy economic traffic environment. Research proves: using ITS can promote communication ability to 2-3 times. If a car moves in the intellectual road, the time to stop will reduce by 30%, the moving time will reduce by 13%-45%, also much less traffic accidents are expected. Therefore, it is said that ITS technology is the only sound way to modern traffic management.

Signal control makes traffic control possible. Signal lamps are installed to make traffic control safe and smooth. However, they can also cause delay and accidents if they are not appropriately installed. When judging whether it is needed to install signal, the main points to remember are whether the traffic is comparably busy, whether it is disordered and whether more accidents happen. Nowadays, our city uses mainly 3 kinds of signal console in the crossing. One is single periodic signal console with mimic electric circuit and relays. Having singular function, unstable quality and lack of trust worthiness makes the traffic control too complex. The second is developed by China's traffic research department. It has more functions and is as well convenient to use. But because of its limited production, lack of quality guarantee and trustworthiness, restraint has been put to its appliance. The last one is imported. It functions well, trustworthy, but

it is also too expensive.

In order to solve the coordination problem of traffic signals, countries one after another developed a great number of traffic signal controlling system. Among them, the most representative ones are: TRANSTY System from the UK in 1960s; SCATS System from Australia, in 1970s, and SCOOT System from UK. Since the 1980s, the self-adaptable control system of traffic signal network has been developed.

Modern traffic signal control system functions as follows: it can promote the traffic efficiency of roads, make the traffic safer, decease energy, consumption and pollution and collect traffic information. It is that proved that this system is one of the most important to solve the traffic problems in cities.

CHAPTER 2

General introduction Out of The Aerawide Real-Time Traffic Control (ARTC) System

The Aerawide Real-Time Traffic Control (ARTC) System deals briefly with using a computer to control the traffic lights in the crossing so as to control the time and make reasonable changes to adapt the latest traffic information. On other words, PLC is used in the system to carry out remote control on traffic lights and mimics automobiles on road when it has made a dial-up connection.

We can simply divide this system into three small ones—Computer system, small regional controlling network system and PLA system.

2.1 Contents of System

2.1.1 Upper bit System

If timely control should be realized, we should establish special supervisory system to receive and decd with information. This system should also be responsible to supervise the whole traffic situation, and further more to make out commands and deliver them to installations on the spot. Considering this, we choose VB 6.0 to design application software ourselves instead of using already-made groupware, though groupware can communicate to a computer with a PLC, it cannot communicate computer with 6 PLC's. Besides, after making programs, we thoroughly know every detail of communication procedure and operate it quickly. So this software is compatible with our design, which

can supervise the traffic lights along whole course, make quick response and conduct the traffic according to latest information.

2. Controlling treatment

The intelligence of the system can be seen when the supervisory system receives the information from crossing, it can do it automatically. So a controlling method was developed in order to deal with information.

In practical use, we design an easy and feasible treatment in the system to carry out green wave control. Green wave control is when a car is running with an invariable speed on city's main road control treatment that should let the car pass the main road without being stopped by a red light, while other automobiles should not be affected.

2.1.2 Small- range controlling net system

A relationship "one-to-one" or "peer to peer" exists between the computer and the PLC. However, we could only link one computer with PLCS. Before we start, we consulted experts in Omlong Company. They said no one in China might have made it and it was OK to buy their special software, but it might not make it as well. After turning it again and again and lots of experiments, finally we decided to use one PLC in charge of 6 other PLCS, and let the computer set direct communications link with the first PLC, which functions as an exchange. These communication links were made between the computer and these PLCS.

2.1.3 Lower bit System

PLC, with advantages of being small, reliable and quick, is widely used in the

industrial controlling system. In controlling system, PLC functions as a "down-link put" to collect data, evaluate situations, and output the solutions, while computer functions as an up-link port to store and analyse data, show the situation and information and print them out for timely reports.

PLC is specially designed for control industrial process. It is smaller, more reliable to function and resist to interference. As the main controlling facility in areas of digital controlling technology, industrial robots and procedure control, PLC is adjusted to the demand of the society.

2.2 Specific design procedure

We applied for this task and got permission when we were inexperienced sophomores. Thus, these two years is not only a time of designing, but also a learning one. So we chose to do the easy job as first, and then we took the tough ones.

In the first year, we carried out a great amount of investigation and study. We were offered on-the-spot investigation and data by traffic. From the managing department, our guide-teacher once cooperated with this department. Also Internet could offer convenience in investigating. From the material we collected, we found the task was really tough. For instance, the green-wave control in the main crossing was only being carried out on some roads of just a few big cities, such as Beijing, Shanghai, Tianjin, etc. Nevertheless, only Chengdu way in Tianjin has tried it out . Only one road in Shijiazhuan put ITS into fact. Though cities like Beijing and Shanghai were anxious to have a try of it, they didn't put it on their own agenda. After a long time investigation

and consideration, we made a model (width: 90mm, length 130mm) , which link sufficient study of road conditions including left turning, circle, with our own effort.

We took a piece of three lager board as basic frame, green flannelette as green greenbelt, grey adhesive plaster as street, strung-up yellow shining tubes as automobiles, creatively adopted tubes which shine lights of red, yellow and green alternatively as traffic lights. Actually, before we sat down to do the designs, we visited mainly real estate companies.

The next year we learned PLC programming and Visual Basic 6.0 instructions at first. We finished the task ourselves, inspired in asking advice from our teachers and some school mates. The biggest difficult was programming; we had to link one modem with 6 PLCs ; that was a task where the example is not recommended to follow. After consulted Omlong company, we chose to think out solution of our own, because they committed no assurance to their model after their recommendions because our fundings were limited. Then, our teammate GuolLiang had an idea: using one PLC to control the other six PLCS, then let it under change of computer. The solution of this problem indicates the overcome the biggest difficulty problems were saluted one by one and finally our design was perfectly done!

CHAPTER 3

DATA TRANSFER OF THE AERAWIDE REAL-TIME TRAFFIC CONTROL SYSTEM

3.1 Develop the communication software by means of Visual Basic 6.0

3.1.1 Introduction of Visual Basic

Along with the continuous enlargement areas of computer adoption, the long range communication among computers more and more widely. Therefore, modern phone wires and communication software are needed. Though there are various communication software in the market, yet most of them actually cannot satisfy the need of practical work. Because that current software can send and receive files, but sometime, they won't serve, for example, when developing an EDI applicant system, we need to store received unit into a database as a record. So under this situation we should develop our communication software instead of using others.

In the past, developing communication software was difficult for those application programmers, but nowadays it is much easier with Visual Basic 6.0 *(32 bits, object oriented)* is easy to learn for its advantages, it is popular among computer programmers and is adopted in every area. In our design, communication is one of the basic functions, so we chose Visual Basic 6.0 as the language to program our communication software. Now, let me introduce the software and show you some examples.

3.1.2 General Introduction of Visual Basic communication control equipment.

Generally two ways are used in programming communication software when using VB. One is using communication API function. The other is making use of standard control unit-Mscomm. Here we chose the second. Following is the way of using.

1. Quoting steps.

   VB provides many control units for programmers. But these units are just some basic system units. The unit we'd like to use is not provided.

   Therefore, to use MS corm we need to follow the following steps to let it appear in the Tools Menu as follows.

   1) Click "project" in menu.
   2) Select "Add".
   3) From menu option, Select "Microsoft Comm Control 6.0"
   4) Click "OK" or "Apply", then you will see "Telephone" in Tools Bar, load it and then make communication.

2. Function.

   MSComm is used for communication and data exchange when compiling a system. It also provides two ways to deal with the data :

   1) Event-driven is an effective way to deal with this communication. In many circumstances, the programmer expects to be told when there is an

event, such as arrival of a new word or a change. Whenever there is a communication event or error, programmer will know and handle it immediately by the help of MScomm. We input the program into the event district, of control, so that it could be carried out at each event.

2) Polling events and errors through checking features of CommEvent. It can be better used when the application program is not big. For instance, to a single dialing program, it is unnecessary to make instant-message to the arrival of every word. The only response should be made is "OK" sent by modem. It is also a good choice when regularly querying equipment conditions. Regularly query can be accomplished by using free keeper or DO--LOOP.

3. Features

MsComm has many features. Here we introduce only some important ones.

CommPort: set up or return back the signal of communication joint parts. The signals should be set up so as to communicate Windows system with the outside. Also signals can be returned back because of CommPort. The port signal is rising from 1 to 16, for the MSComm Control unit has the maximums 16. When signal is set more then 16, the control unit will send false information.

Settings: set up originated index by way of character string. Set or return back four indexes such as: communication speed, parity bit, data character, stop

character. Their form characters are "BBBB, P, D, and S." BBBB represents communication speed; P, parity bit; D, data character; S, stop character.

Port Open: set up or return back to conditions of communication joint ports. Before using the ports, they should be open at first, while after using, they should be closed. Their Functions are carried out though "True or False" judgment by Port Open.

Legal settlement of parity bit

Settlement	Explanation
E	Even
M	Mark
N	Default
None	No check
O	Odd
S	Space

Input: Return data back from storage device and delete it. By this, program input downloaded data and delete the used.

Output: input the going-to-output data to output storage device. When need to deliver character strings to others, we can use Output to input them into the device. However,

ordinary data delivered to the buffer zone and then sent out. When MSComm controller set up limiting feature, there will be events.

3.2 Comprehension introduction of PLC

3.2.1 Development of PLC

1. Speedy development of technology, new products appear one after another.

Along with the continuous development of electronic technology, computer technology and communication technology PLC also develops fast in its frame and functions. Then, new products appear one after another. On average, about 3 or 5 years, the old type will be replaced thoroughly by new ones.

There are two trends in PLC development, one is essentially adapted to the use of complex single computer, digital controlling machine tool and industrial robots, etc, because it is smaller, faster and improved functions (specially on calculation, data process, communication, etc), cheaper and tend to be micro. The other is developed into high-grade mainframe computer, which combines control and management together, with more functionality on communication and network and this would form a cell control system with a computer.

2. Development of various intelligent modes, strengthening the process control function.

Intelligent I/O model is a component function based on a microprocessor. Its CPU runs parallel with the main CPU. So with little possessing time of the main CPU; it is beneficial to speed up scanning. Intelligent I/O model is made up of mimic I/O, PID

circuit control communication control, mechanic movement control (such as axle locating, etc), fast number recording, breaking up input, BASIC and C language components. Its appliance functions the control procedure better. Some PC's procedures control are also self-modifiable and adjustable in the way; the adjusting time to is then reduced.

3. Combination of PLC and personal computer

Up till now, personal computer is used as the programmer, processor or workstation. Nowadays, PLC is developed towards the functionalities of a personal computer. Mainframe PLC adopted a powerful microprocessor and large-capacity storage and combined logic control, mimic control, calculation and communication closely together. Therefore, PLC personal computer, industrial control computer gathering and scattering control system are intermingled with each other on functions and appliances. Thus, the control system achieves continuous improvement in cost-performance ratio.

4. Better communication and network

PLC communication and network refers to information exchanges that can be made between PC and PC, PC and computer; therefore it may be considered like a unit using a scatter-concentrate control. Almost every PLC product presently has a communication function. They can transfer information with distance of several kilometers, even scores of kilometers. Nowadays, it is a special BIB network. Communication paper's approaching to MAP will make convenient communication and net connect between different PCs, or PC and computer.

5. Development of new programming language and aids for error conditions

In order to satisfy the requirement of high reliability, improvement and development of new programming language was made, important functions of outer equipment, design of procedure pictures and new programming functions were put into practice; Enduring-Error function was added, for example, interchange I/O automotive, voting by two (when compare output condition with PLC logic conditions, there is an error, the output should be broken up), voting by three for I.O conditions(vote for the I/O condition by both hardware and software)

3.2.2 PLC application program

Programmable control is used between relay control devices and industrial computers controlling procedure when controlling requirement is much more complex with more input and output. Prior to controlling system in a large controlling system, it can also work under the arrangement of superior computer. Small programmable controller mainly used for computer automation while largely used in automotive production lines. If we divide PLC applications by type, we find the following five types :

1. In switching logic

It is the most fundamental control function of programmable controls, and can be used to replace relay control devices (such as machine tool control, electric motor control center) and order control and program control, such as blast furnace adding system, elevator control, leather conveyer control in mines. It is apparent that this

controller can not only be used in a single computer control, but also in a computer group control and automotive manufacture control.

2. In closed process control

Modern large programmable controller all equipped with PID program. Some companies separates it from the controller. For instance, PROLOOP project controller which can carry out PID control, parallel control and group control provides three choices: single circuit, multi-circuit and self modification. Suppose the time used for every circuit is 36ms, using GE series can supervise 256 circuits at most. PID has already been widely used in boilers, radars, reactors, water processors, etc... It can also control the closed process and speed.

3. In number control of mechanic processing

Programmable control intermingled with Number Control (NC) and Computer Control (CNC) can make bit control possible, with the purpose to realize free Communication between the controller and CNC devices on data. Clients can develop programs by themselves and deliver it to CNC through window software. Some experts predicted that after a few years, CNC system will develop into a controlling and managing system with PLC as its main body.

4. In robots control

Along with the formation of automotive network, robots were used more and more. Programmable controller can be also used to control robots. For example, Robots produced by Simens Company (Germany) adopted its two 16-bit controllers:

SIMATCS5_130W and RCW1 and combined them into a new RCW1. A control device can control a robot and deal with its mechanical movement.

5. In forming multi-level control system

In these years, along with the development of computer controlling technology, foreign countries are busy developing network system. Some famous producers of this controller built their own multi-level controlling system separately and they are planning to approach MPAC manufacturing automation papers.

3.2.3 Structure of PLC

The hardware of programmable controller is made up of computer, extended input and output devices, and external equipment.

1. Computer

The computer is made up of CPU, storage devices, input and output devices, extended input and output ports and electrical source. Each section makes direct connection with inner system general circuit made up of electrical circuit, control circuit, address circuit and data circuit.

2. Input and Output extended devices

Input and output devices are extended part of the input and output unit of programmable control. When the input or output points or types surpassed the limit of computer, input and output extended devices can be connected so as to solve the problem. Based on the input and output unit in the computer, extended devices has two types: simple and intelligent. Simple type has no central processing unit in the computer.

It mainly depends on scanning procedure of computer's program. Intelligent type has a control processing unit managing the input and output processing of on-the-spot lode, without dependent to computer's scanning procedure.

3. Expansion devices

Programmable controller stalls expansion devices such as programming device, color screen, printers, etc.

* **programming device**: an expansion device which can program, justify the external devices of programmable controller, offers a communication window between man and computer. Through programming device, a new user's program can be input into the RAM of the programmable controller, or the actual programs in the RAM can be compiled, also sa upervision can be made to the working conditions of programmable controller.

* **Color Screen**: Usually macro or medium programmable controllers are compiled with a color screen, which used to mimic information of procedures, such as the processing picture of producing picture, real procedure figures, tendency figures and alarm figures, etc, so as to have a clear idea of the present controlling conditions.

* **Printer**: Programmable controller can also be equipped with printer to record the figures of procedure and system, also the chart of accidents to be used by the police, etc.

Other expansion devices can also be equipped, for instance, floppy disk drive or tape drive using for the storage of user's appliance program and data; EPROM writing in device can be equipped to write program into an EPROM memory.

3.3 PLC's control scheme on port

3.3.1 Vehicle

In order to achieve the effects of vehicle run on roads, we use the yellow light emitting diode representing vehicles driving on roads. Emitting diode is arranged to turn on or off regularly in certain order which represents the movement of vehicles.

Serial input shifting register SET instruction OMROW PLC is firstly adopted, like figure 3.1 :SET-mnemonics; 200and 201 refer to the initial and last channel number of serial input shifting register separately . As the 21 registers from 20015 to 20104 are used, 200 and 201 is filled. As the reset input point of serial input shifting register, normally open switch 20105 represents the output after emitting diode of the last vehicle turns off. 25502 is OMRON PLC/S special register whose function is to send out a pulse every second, that is, close for 0.5 second, then disconnect for 0.5 second which can be used as the clock input point of serial input shifting register. Normally close switch 1300 is used to determine whether the vehicle meets red light. Close when meeting red light, then stop shifting.

Secondly, we should send a 1 to channel 200 in the first scanning period after the program's operation. Only in this way can shifting instruction transport this 1 to the necessary register. Here move instruction MOV illustrated in figure 3.2 is used: mnemonics is MOV; 001 is the number needs transferring. According to the pattern's regulation, # is needed to add. 200 is the channel number being transferred to shifting instruction should take that there is numbers in channel as prerequisite. Here we need to

use move instruction MOV a contract number to certain channel. But once move instruction is started, a number is sent to channel every scanning periol, so a particular relay 25315 needs putting ahead whose function is to keep closed in the first scanning period after being electrified, then opened right away. In this way, it ensures that only one is sent into channel..

Figure 3.1

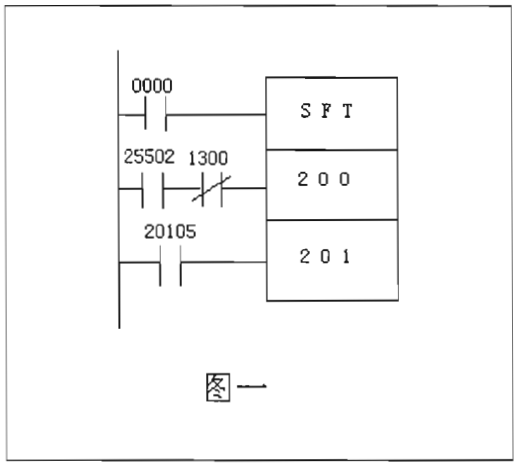
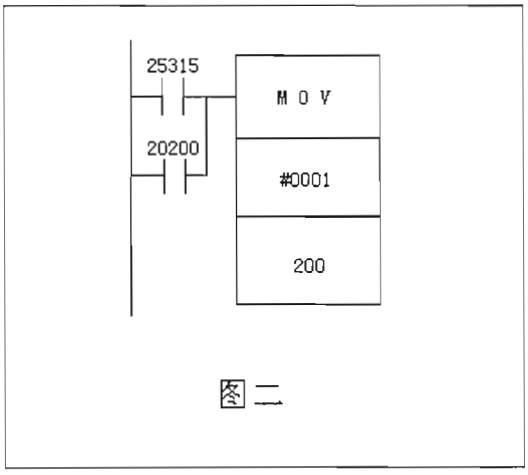


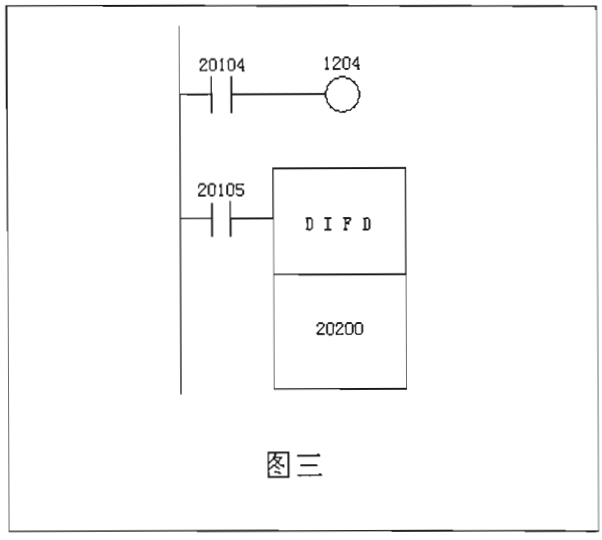
Figure 3.2



To realize vehicles' circulating movement, when the emitting diode representing

the last Vehicle turns off, it is necessary to turn on the light representing the first vehicle again. Continue shifting, thus the cycle can be realized. Here trailing edge differential instruction DIFFL is used.

Figure 3.3

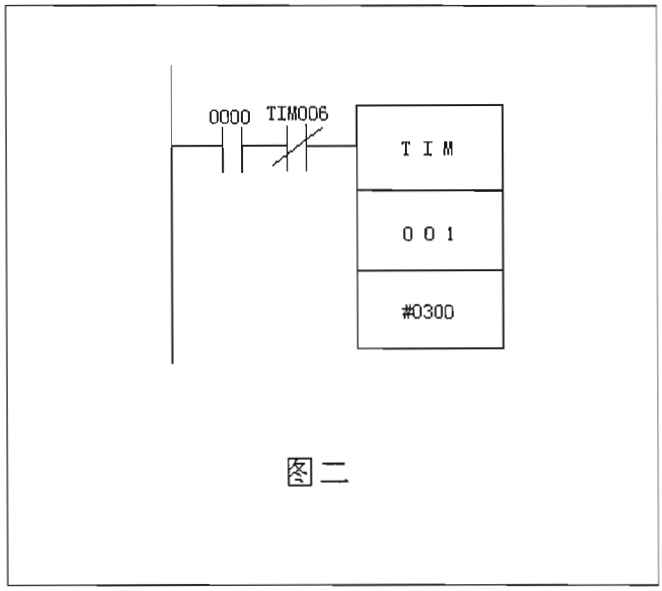


Like figure 3.3, trailing edge differential instruction: mnemonics DIFL auxiliary register, which sends out an out an output when the emitting diode representing the last vehicle turns off, value of register 20105 turns from 1to 0. Grasping the instance when the normally close switch 20105 turns from close to register 20200, making shifting instruction reset and thus cycle is over.

3.3.2 PLC's control on port

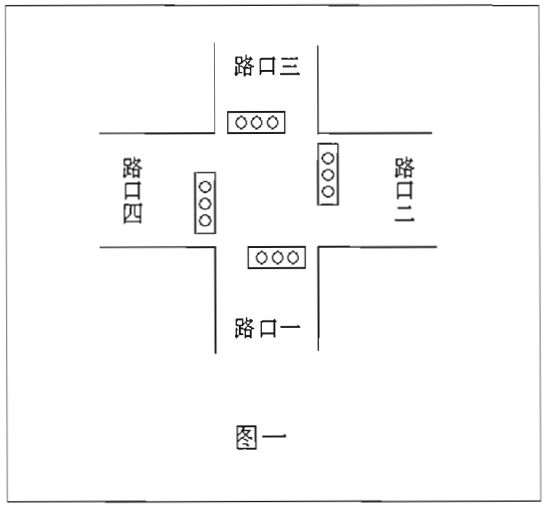
This time we are going to compile a program controlling traffic lights at the crossings. We mainly use timer.

Figure 3.4



Life figure 3.4, timer: mnemonics—TIM; number of the timer—001; range---000---127; clocking time ---#0300. Each unit refers to 0.1 second. Initiate switch---normally open switch 0000; TIM 006---normally close switch can function as resetting the cycle when the last timer disconnects and stops clocking.

Figure 3.5



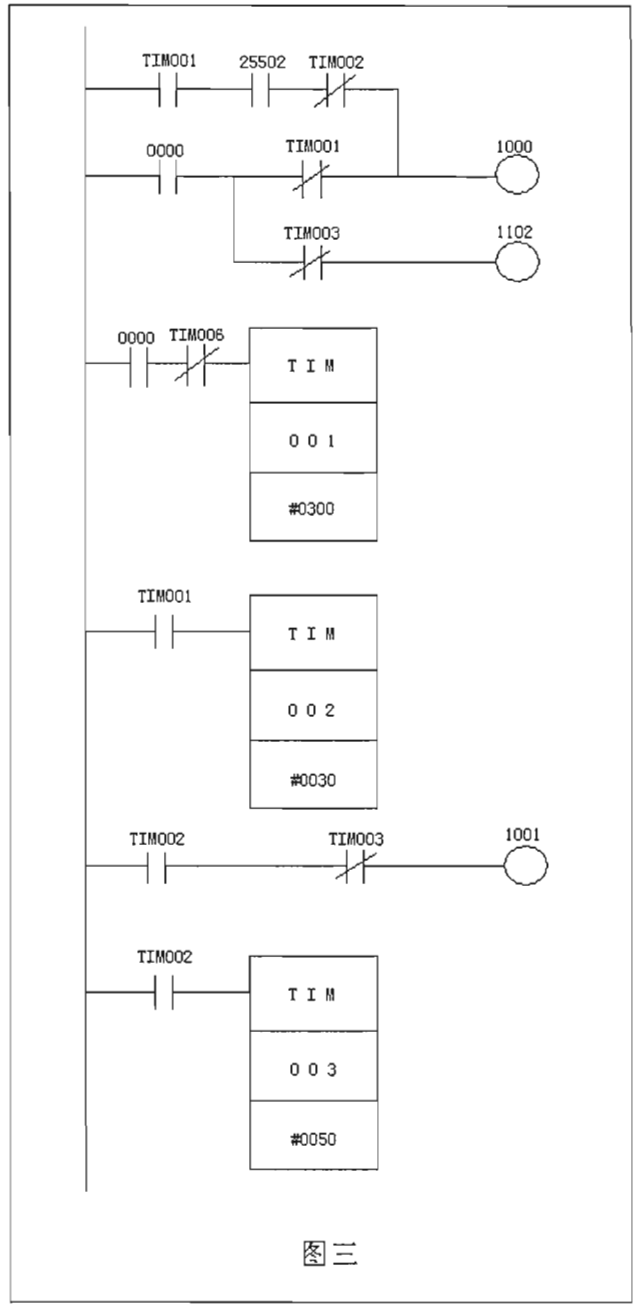
Following the red and green lights:

The hypothesis is that, like figure 3.5, output 1000, 1001, 1002, of PLC represent the green, yellow, and light at No.1 crossing separately; 1100,1101,1102, of PLC represent the green, yellow and red light at No.2 crossing. Conditions of No.3 and No.4 crossings are almost the same as No.1 and No.2 crossings'

Like figure 3.6 the normally open switch 0000 is master switch. When it closes green light 1000 of No.1, crossing and for 30 seconds. When it reaches clocking time, the normally close switch TIM 001 disconnects, while the normally open switch ITM 001closes. Special register 25502 (close for 0.5 second, disconnect for 0.5 second) starts functioning, making the green light flicker. At this time, timer TIM 002 disconnects; green light 1000 of No.1 crossing turns off; the normally open switch TIM 003 disconnects; yellow light 1001 of No.1 crossing and red light 1102 of No.2 crossing turn off, and then green light of No.2 crossing and red light of No.1 crossing emit bright.

Following the above sequence, we know that when yellow light of No.2 crossing turns off, timer TIM006 's clocking time is over; the normally close switch TIM006 disconnects. Timer TIM001 resets, realizing the program's cycle.

Figure 3.6



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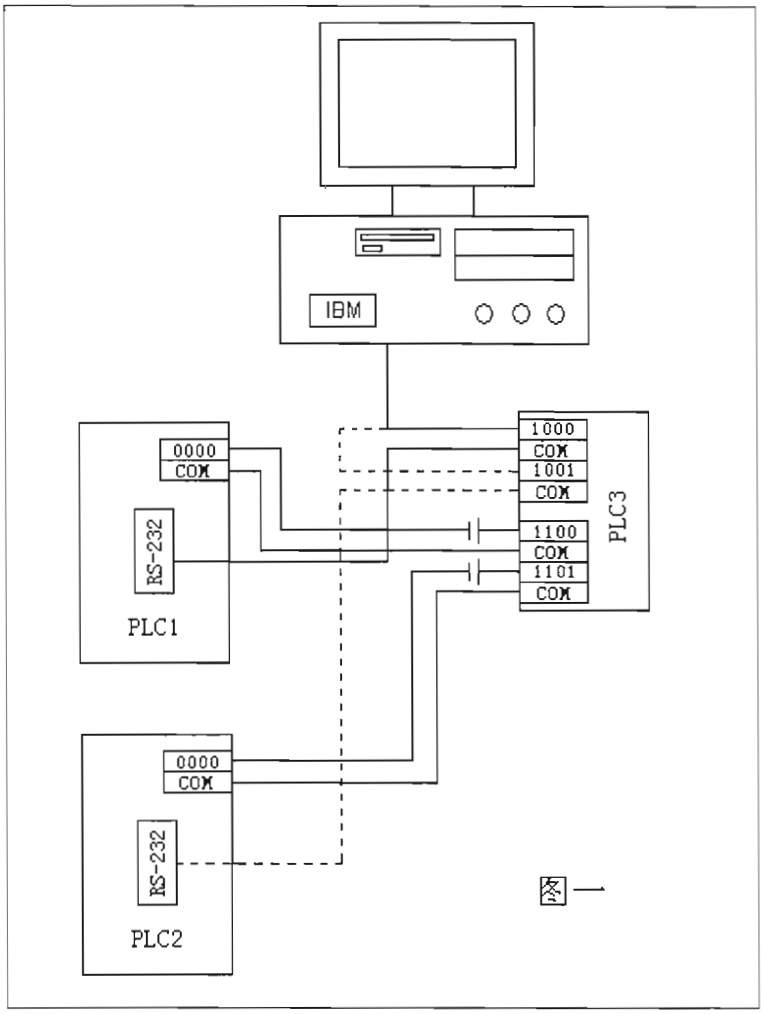
3.4 Mini-PC_PLC control net

3.4.1 single PC-several PLC

During the experiment, we not only need to write data to PLC, but also to read data from PLC, for example, the approaching location of vehicles on the roads, timing of the red light and green light etc... If the upper bit machine is connected with PLC at a rate of 1:1, one can read data according to the previous scheme, but if upper bit machine is connected with PLC at a rate of 1:N, one cannot read data directly as before. The first reason is that when upper bit machine send signals to the following PLC simultaneously, as each PLC cannot select appropriate signal, so all the PLC will respond to the signals sent out by upper bit machine and that will result in confusion. The second reason is that as each PLC will offer a return code after receiving the demands, so when they receive the demands simultaneously, they will return codes simultaneously, thus disordered codes will come up to the upper bit machine which would not be able to recognize. So it cannot identify each PLC's state and real time control is impossible.

The most effective method to solve this problem is to use the special RS-422 adapter provided by OMRON Company which can select the received signals and transport the signals sent by upper bit machine to different PLC to each PLC separately, and meanwhile transport the information returned by each PLC to upper bit machine correctly, thus the connection between upper bit machine and PLC at a rate of 1:1 is realized.

Figure 3.7



Because of the limited experiment conditions， we did not obtain a RS-422 adapter. But after analyzing RS-422 adapters' working principle carefully, under the teacher's guidance, we set up another scheme by ourselves by means of which we could connect an upper bit machine with PLC at a rate of 1:N without an adapter.

Its guiding thought is to use one PLC controlling the following PLC, making them connect with the upper bit machine at different time. In this way, at each time, there is

only one PLC communicating with the upper bit machine, thus disordered codes can be avoided.

In the following, I will illustrate the working principle of this scheme, like figure 3.7. describing the principle of two PLC connecting with the upper bit machine; actually it suits several PLC as well.

Connecting upper bit machine with the communication signal line of PLC1 and PLC2 has the same rule as connecting at a rate of 1:2. However, only the data line connecting the No. 2 needle (jack) of both sides needs handling because the data sent to upper bit machine from PLC is drawn out of upper bit machine, it turns into two strands which correspond to two PLC. Connect them with output point 1000 and 1001 of PLC3 separately. Then connect to RS-232 port No. 2 jack of PLC1 from COM port of 1000, and connect to RS-232 No. 2 jack of PLC2 from COM port of 1001. In this way, output point 1000 and 1001 of PLC3 can be closed at different time, thus PLC1 and PLC2 can communicate with upper bit machine at different time. (Note: in figure 3.7, solid line describes the connection between upper bit machine and PLC1 while dotted line describes the connection between upper bit machine and PLC2.) Output point 1100 and 1101 of PLC3 are separately connected with output 000 of two PLC separately as the input point of PLC1 and PLC2.

Program in PLC3 is like figure 3.8. When normally opened, switch 000 is close, timer TIM003 begins clocking for 10 seconds, meanwhile, connects output point 1000 and 1100. Keep connecting for 2 seconds and then disconnect. When TIM003 reaches

clocking limit, TIM005 begins clocking for 10 seconds. Meanwhile, connect output point 1001 and 1101. Keep connecting for 2 seconds and then disconnect. When TIM005 reaches clocking limit, disconnect the normally close switch TIM005, reset TIM001, carry out the program cycle.Program in PLC1 and PLC2 is the same, like figure 3.9.

When connecting output 1100 of PLC3, input 0000 of PLC1 is close. Program begins operating. Timer TIM001 begins clocking for 0.5 second, which is left to ensure output 1000 of PLC3 when clocking time reaches, normally open switch TIM001 closes instantly. In this instance, an output is rising along differential DIFU to the auxiliary register 20200, making the normally open switch 20200 close for a scanning period. The communication move instruction of PLC1 starts operating.

Communication move instruction: mnemonics, @TXD, DM0000 refers to the initial address of the data need transporting; #0000 refers to control word; #0002 refers to the bytes need sending.

The following is a general introduction about using VB to compile a short program to receive data sent by PLC automatically.

1. First, set up a window.
2. Set up an MSComm control port on the window. Set its attribute as follows: name is MSComm1; CommPort is 2; Settings are 9600, e, 7,2; to make this control port receive data automatically, it is essential to set Rthreshold as 1.

3. Set up a Textbox control port on the window. Set its attribute as follows: name is txtplc; MultiLine is True; ScrollBara is 2.
4. Set up a CommandButton control port on the window. Set its attribute as follows: name is cmdend; Caption is END.
5. Double knock MSComm1 control port. Add the following code under OnComm incident.

```
Private Sub MSComm1_OnComm()
Select Case MSComm1.CommEvent
Case comEvCD
Case comEvCTS
Case comEvDSR
Case comEvRing
Case comEvReceive
txtplc.Text = txtplc.Text + MSComm1.Input
Case comsend
End Select
   End Sub
```

6. Double knock the window. Add the following code under Load incident.

```
Private Sub Form_Load()

MSComm1.PortOpen = True

End Sub
```

7. Double knock cmdend control port. Add the following code under Click incident.

```
Private Sub cmdend_Click()

MSComm1.PortOpen = False

End

End sub
```

Figure 3.8

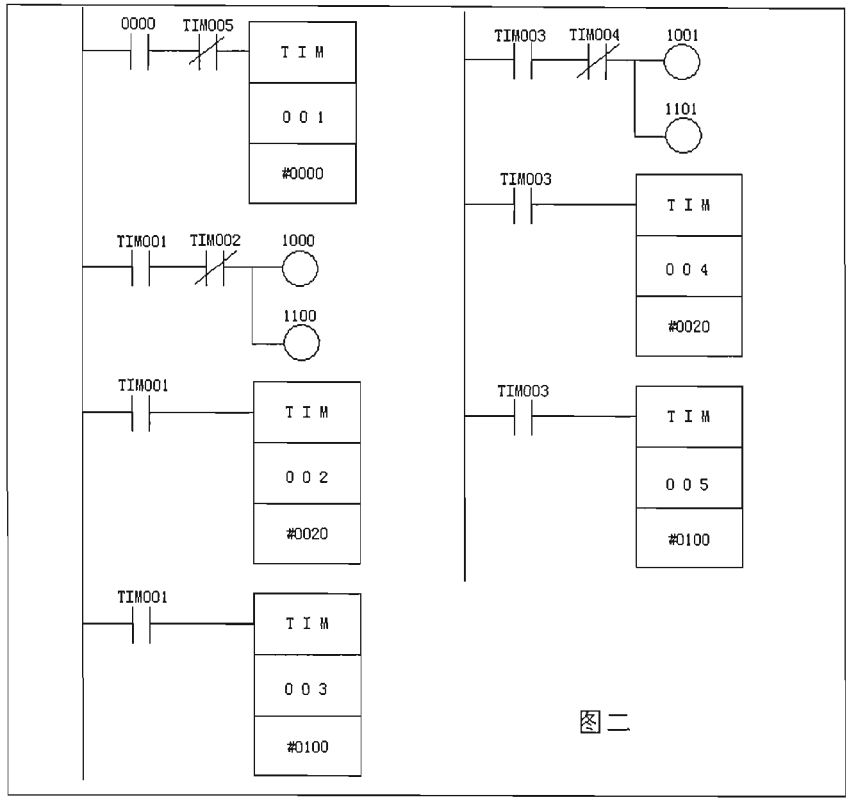
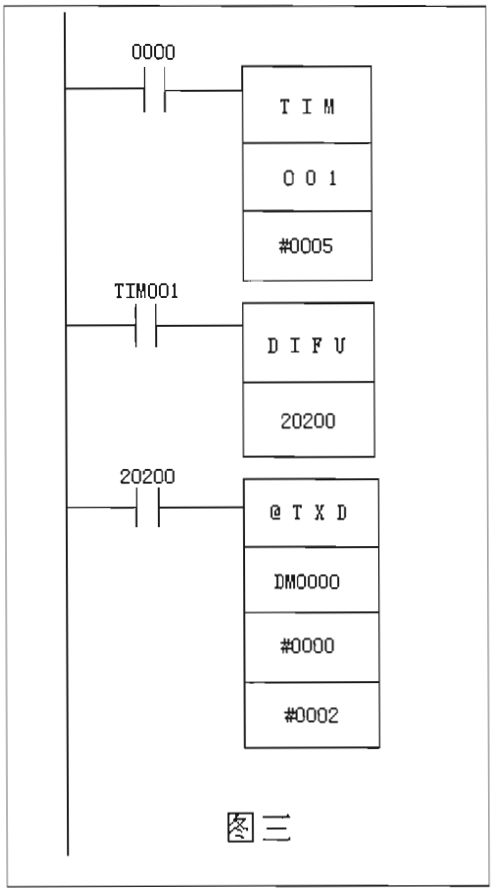

0000
TIM005
T I M
0 0 1
#0000
TIM001
TIM002
1000
1100
TIM001
T I M
0 0 2
#0020
TIM001
T I M
0 0 3
#0100
TIM003
TIM004
1001
1101
TIM003
T I M
0 0 4
#0020
TIM003
T I M
0 0 5
#0100
图二

Figure 3.9

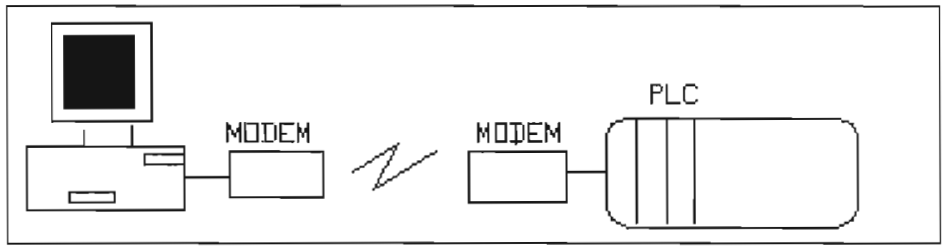


3.4.2 Long-range communication between PC and PLC by means of Modem.

OMRON PLC makes it possible to connect MODEM with PC. After connecting PC with PLC separately by using MODEM, run communication software in PC, thus long-range control and program debugging can be realized. The connection way of MODEM can be divided into two kinds: dial-up connection or private line arrangement. The following description is about the dial-up connection.

System's scheme

Figure 3.10



1. Experiment apparatus

   (1) Computer: one. It is necessary that the computer can operate " super terminal" software or other communication programs.

   (2) MODEM: two. One of them that connect with PLC must be external set. To ensure communication quality, Baud rate should be 9600 bps. So MODEM's does not need to be too high, 14400bps is OK. MODEM of Hayes Company is recommended. If products of othe companies are used, make sure that they are completely compatible with Hayes' AT instruction group, especially the definition of S register. There is no special need on MODEM connecting with PC computer. Internal set or PCMCIA type on NOTEBOOK is accepted while using SSS software connection, as to monitor MODEM's connecting state, so one had better use the external set.

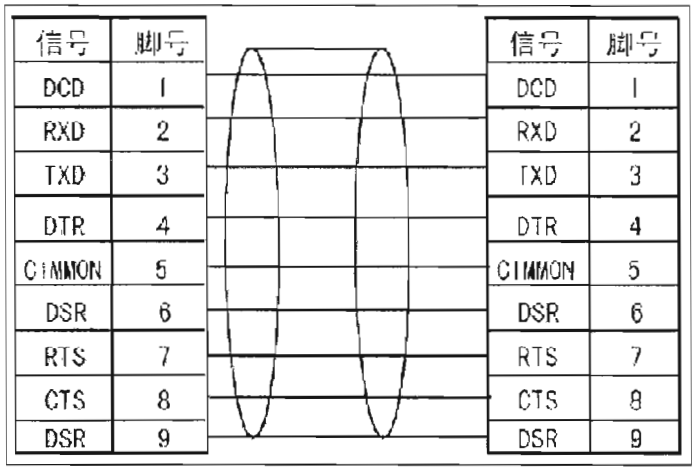
2. PLC: one OMRONCPM2A.

3. Operating procedures:

   (1) Wiring:

A. The extra cable got by buying MODEM can be used as the cross communication wire between the computer's COM port and MODEM. If one want to make by himself, connect as follows:

Figure 3.11

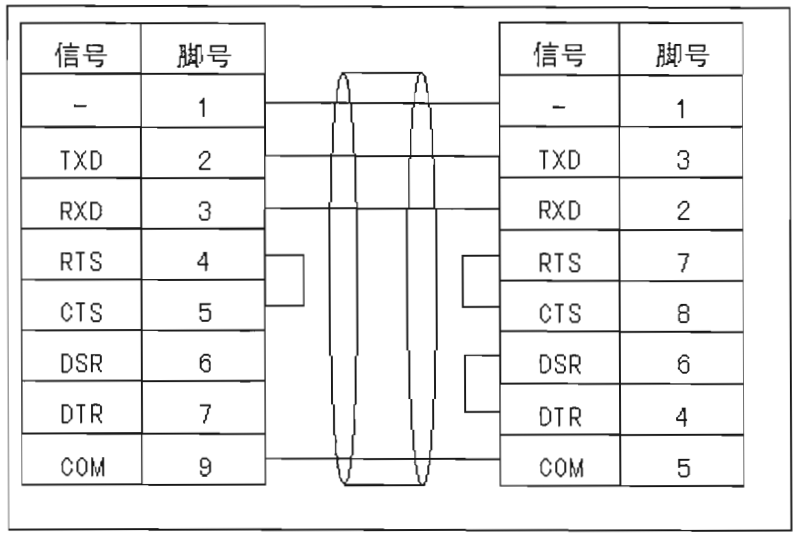


Compatible machine COM opening, 9-jack DTE Serial communication interference, 9-needle DCE

B. As OMRON PLC RS232C opening or CPM1A-CIF01 is all 9-jack socket, they cannot connect with MODEM directly. A 9-jack—9-enddle transfer cable made by users is needed. Wiring as follows:

Figure 3.12

PLC's side 9-needle DTE MODEM's side 9-jack DT



(2) Installation of MODEM

A. Installation of the two MODEM can be exactly the same. MODEM of the upper bit machine is set by communication program, while the lower bit machine can be set by "super terminal" or by using Visual Basic serialization. Set Baud rate 9600, even check, 7-bit data bit, 2-bits stop and RTS XON/XOFF flow control.

B. Use "AT&V" demand when setting is over. At this time, MODEM's present installation is shown. AT command is needed to reset MODEM as follows:

B1 E1 L1 M1 N1 Q0 TV1 W0 X4 Y0 &C1 &D0 &G0 &J0 &K0 &Q5 &R1 &S0 &T5 &X0 &Y0

S00 : 001 S11 : 095 S12 : 050 S18 : 000 S25 : 005 S26 : 001 S36 : 007 S38 :

020 S44 : 020 S46 : 138 S48 : 007 S95 : 000

As some of the previous parameter is approved tacitly by MODEM, so some of MODEM's present installment may not need changing, such as B1, E1, etc. users only need to make corresponding change when the parameter is different from the installation of the above figure.

Note: &D must be set 0, and S00 be 1.

C. Disconnect lower bit machine MODEM and computer and connect MODEM with RS232 port of PLC or RS232 adapter of CIF01, etc., meanwhile insert a phone line.

(3) Installation of PLC:

In PLC's DM region, set PLC as upper bit machine chained mode. If it is connected with RS232C port; set DM6645 as 0000, that is adopt standard installment when connected with upper bit machine; set DM 6645 as 0001, if users want to set by themselves, then detailed Installation can be carried out under DM6646. In a word, the Installation of parameter of PLC, MODEM, upper bit computer and its relative RS232C must keep consistent.

(4) Picture design:

A. Open a new Visual Basic project. Set an MSComm control part as the serial communication channel at the list.

B. Add a clock control port. Set its Enabled attribute as True, its Interval attribute as 500, that is its executive cycle is 500 millisecond.

C. Arrange 2 Option objects. Fill its Caption attribute in COM1 and COM2 separately. It is allowed that users can choose the serial communication port they want to use.

D. Arrange 4 Text control port which will be used separately as telephone number's inputting area, PLC command, inputting area for transporting strings of characters and the display area of PLC's return information.

E. Arrange 5 Label objects, whose Caption is set separately as "port select", "phone number", "command", "content", "return information", which can be used a smarks.

F. Arrange 8 buttons. Fill " dail" , " call off " "send" " receive" "game over " and three "clear" separately in its Caption attribute.

G. Figure 3.13 is made just according to the above procedures.

selection of port

telephone number

command

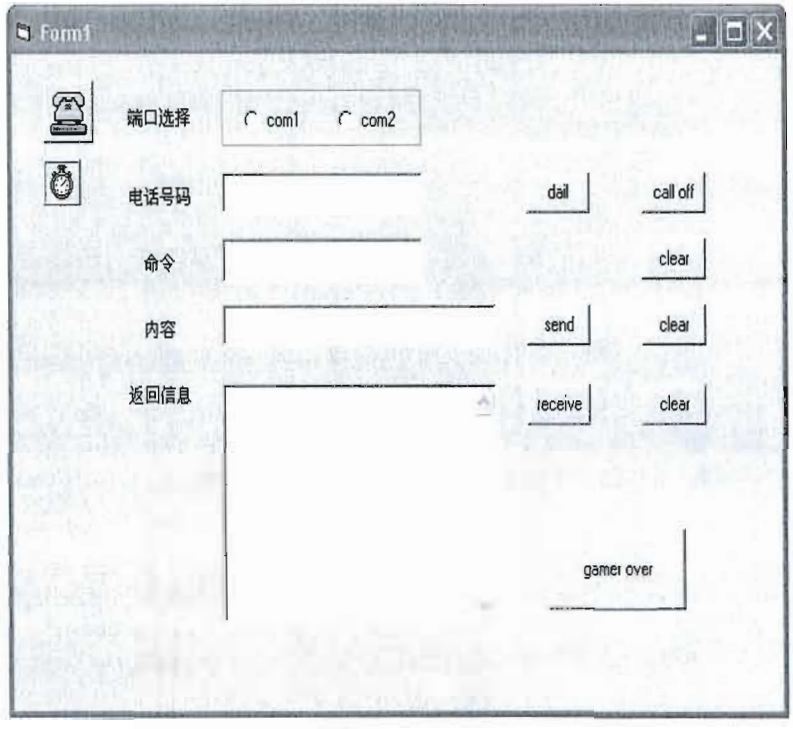
content

return information

content

return information

Figure 3.13 Picture design of the long-range communication between PC and PLC by means of modem



(5). Function design

A. Double click MSComm control part and then an editing window on program code of OnComm incident will ppear:

```
Select Case MSComm1.CommEvent
Case comEvCD
Case comEvCTS
Case comEvDSR
Case comEvRing
```

Case comEvReceive

Case comEvSend

End Select

B. Double click "timer" control part. Write the procedures for reading.

txtReceive. Text = Comm1. Input + txreceive.text

C. Double click "send" control part. Fill program to let data transport according to the requirements of PLC communication agreement.

```
txt = "@00" & txtCommand.text & txtSend.text
a = Len(txt)
Comm1.Output = text & OCheckSum(txt, a) & "*" & Chr(13)
```

D. Double click "dial" button. Fill the following program code under Click incident:

MsgBox "Telephone number is wrong. Please check! ",vbCritical+vbOKOnly,

```
"System's information."
Exit Sub
End If
Comm1.Output = "ATDT" & Text1.Text & Chr(13)
```

E. Double click "call off" button. Input the following program code under Click incident.

```
Dim Time&
Time = 200
Comm1.Output = "+++": TimeDelay Time
Comm1.Output = "ATH0" & vbCrLf
```

Because MODEM needs a certain period of time while carrying out the demand, a time-delay function Time Delay is used whose function is to wait for a certain period of time before carrying out the next demand after carrying out the first one. Program of the function is as follows:

```
Public Declare Function GetTickCount Lib "kernel32" () As Long
Public Function TimeDelay(Time)
t = GetTickCount()
Do
  DoEvents
Loop Until GetTickCount - t > Time
End Function
```

F. Double click “game over” button. Write END in the editing window on its incident program to finish the system. Till now, we finish he program design on the long-range communication between upper bit machine (computer) and lower bit machine (PLC) by means of MODEM.

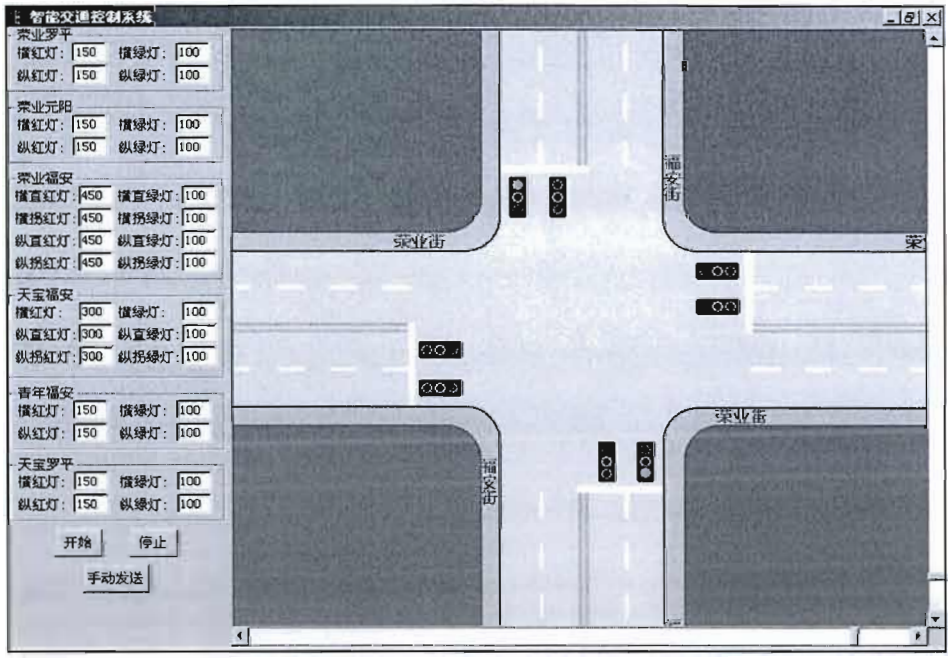
CHAPTER 4

Configuration of the upper bit machine and the realization of control algorithm

4.1 Configuration of the upper bit machine

We designed a set of control configuration program by means of VB6.0, like figure 4.1. On the configuration picture, we designed an emulation graph of a transport system according to the model's actual condition. It reflects the model's working state at real time. Meanwhile, on the left side of the window, we can set the state of red and green lights at each cross artificially. When auto control cannot meet the control needs, artificial interference is allowed.

Figure 4.1



4.2 Control algorithm

Sample when vehicles run into specified roads. Transport the data to upper bit machine. Calculate the distance between the vehicle and the traffic lights it approaches in the upper bit machine. According to the speed of the vehicle, figure out the time the vehicle needs to get to the traffic lights (mark as t). If t is less than the traffic lights' operating cycle (mark as T), no adjustment is made. Stop when meeting the red light and start when meeting the green one. If t is more than T, sample the traffic lights' present state and their state when the vehicle approaches the traffic lights. Transport the data to the upper bit machine. Adjust the traffic lights' time after calculating. Return the adjusted data to PLC, making the vehicle meet the green light when approaches the traffic lights, thus green wave on main roads are realized.

We do not sample every vehicle run into the specified roads, but a sample is made for a certain period of time.

No adjustment on the traffic lights is made within 5 cycles after the previous adjustment. We try to make traffic lights return to their original state. The adjustment is made within certain range. Do not lengthen or shorten time excessively. Otherwise, secondary roads may be held up for too long time.

1. Sample only one vehicle.

Sample when the vehicle runs into the specified road. Determine position of the vehicle and whether the traffic light is red or green that the vehicle approaches. By use of the distance between the vehicle and traffic lights, and speed of the vehicle as well,

figure out the time (mark as t) ended for the vehicle driving from this position to the traffic lights. If t is less than T, no adjustment is made. Stop when meeting the red light and start when meeting the green one. If t is more than T, figure out the surplus time (mark as t') after the vehicle has run throughout the whole traffic lights' cycle, that is t'=t-xT (x is a round figure, t'>0). In this way, one can figure out whether it is red light or green one when the vehicle approaches traffic lights. If it is a green light, no adjustment is made, while if it is a re done, within adjustment range, lengthen or shorten certain numerical value the green light or red light to make the vehicle meet the green light when approaches the traffic lights.

2. Sample several vehicles.

   (1) Sample the first vehicle driving into the specified road range and the last one allowed. Figure out the time balance between the first vehicle and the last one approaches the traffic lights (mark as tc). Figure out whether the time used is more than T. If it is less than T, no adjustment is made. Stop when meeting the red light and start when meeting the green one. If it is more than T, figure out whether it is red light or green one when the vehicle approaches traffic lights. If it is a green light, figure out whether the green light's surplus time is more than tc. If it is more than tc, no adjustment is made while if it is less than tc, within the adjustment range, lengthen red light or green light, trying to let all the vehicles pass. If it is the re light, adjust traffic lights' time within the adjustment

range, trying to let all the vehicles pass. If impossible, try to make as many vehicles as possible pass.

(2) When vehicle enter the roads with straight and left-turning traffic light, sample them and figure out the distance between vehicles running straight and turning left, and traffic light. Though this, calculate the time needed to get to traffic lights (time needed by vehicles driving straight forward to traffic lights is marked as tz, while time needed by vehicles, turning left to traffic light is marked as tg). Traffic lights may be red or green. If tz< T and tg<T, no adjustment is made. Stop when meets red right and start when meets green light. If tz>T and tg<T, or tg <T and tg >T, adjust according to the previous one. If tz=tg>T, consider whether traffic lights are red or green. If straight forward light is green, vehicle driving straight forward run; while if left run. If traffic lights are red, while if left-turning light is green, vehicles turning left run. I f traffic lights are red, within adjustment range, adjust traffic lights' time, trying to let vehicle of a certain said pass first. If tz>T, tg>T, tz=/ tg , when they approach traffic light, left-turning light and straight forward light are green, no adjustment is made. But if when they approach traffic lights, left-turning light and straight forward light are red, within adjustment range, adjustment range, adjust traffic lights' time, trying to let vehicle of a certain side pass first . As within 5 periods of the traffic lights' adjustment is allowed, so it is possible to be held up. Therefore in this system manual operation is allowed to lengthen the green

light's time of the side being help up in order to relieve such bottleneck phenomenon. Return the time to its original state when vehicles run normally.

CONCLUSION

The research topic is mainly concerned with the green wave control in the Aerawide Real-Time Traffic Control System. On the basis of setting up an intelligent transport control system platform personally, in view of the control demands of green wave control, we designed a set of easily operated control algorithm. After the examination of this platform, it proves to be good.

According to the system's actual circumstances, we divided it into upper bit system, regional control net system and lower bit system. While in the upper bit system, mainly the monitor configuration and control algorithm is realized; regional control net system is mainly in charge of transporting the data collected by lower bit controller to the upper bit machine, meanwhile, transport the control order of upper bit machine to lower bit machine, thus real time control of the system is realized. After receiving the upper bit machine's control order, according to its own control program, the lower bit machine completes the control over the signaling machine.

After year' s hard work, fortunately we fulfilled the initial design demands pretty well. We set up a set of basic intelligent transport control system platform and it proves to work well.

Certainly, we do not deny that there are still some deflects in the whole system, and there is still something in the control contents needing perfecting, so we expect the guidance and help from not only teachers but also students.

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